Relating Benefits from Using IS to an Organization's Operating Characteristics: Interpreting Results from Two Countries

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ABSTRACT: To obtain the greatest benefit from its information system, an organization must determine which applications will provide the most benefit to organizational performance. This study reviews data collected from 310 manufacturing firms in Israel and 197 such firms in the U.S. For each firm, data were obtained about the benefits derived from using information systems, as perceived by a senior manager, and the organization's operating characteristics. Data were pooled across both countries. No meaningful relationship was found between the benefit a firm derives from its overall information systems application portfolio and its organizational operat-

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ing characteristics. However, for two individual applications, the benefit derived is linked significantly to the organization's operating characteristics. Thus the model relating benefits from information systems to the organization's operating environment, first demonstrated by data collected in Israel, is confirmed by the data collected in the U.S. The model applies across both countries, even though there may be differences between the two countries, for example, in culture, size of businesses, and relationship with customers and suppliers.

KEY WORDS AND PHRASES: information economics, information technology value, international information systems, manufacturing systems, organizational operating characteristics.

INFORMATION SYSTEMS (IS) ARE VITAL TO THE OPERATION AND MANAGEMENT of manufacturing firms. To obtain the greatest benefit from IS, a firm must determine which applications can contribute the most to the company's performance. Recent articles have reported conflicting results about the productivity gains from investment in IS. Different studies have shown positive returns, no returns, or even negative returns from such investments. Many prior studies focused on entire industries (or a nation's entire economy), and most treated the information system as a whole, ignoring any particular characteristics of an individual organization that might have an impact on the benefit obtained from using IS. Barua, Kriebel, and Mukhopadhyay [5] found that the benefit gained from using IS should be reviewed at lower levels of the organization, closer to the actual operations, rather than at a higher, integrated level (i.e., total performance of the organization). Other studies [9, 21] found that different organizations may obtain different benefits from using similar IS.

This paper explores the relationship between the benefits senior managers perceive to be derived from IS and the "operating characteristics" of individual manufacturing firms. Two independent data sets are used: one from Israel and one from the United States. The following section outlines the objectives of this research. Next, we provide some background to explain why the perceptions of managers are relevant and why certain IS applications were selected for study. We then describe our research questions, propositions, and methodology. After presenting the results of statistical analysis, we provide some interpretation, conclusions, and suggestions for future research.

Research Objectives

THE OBJECTIVES FOR THIS EXPLORATORY RESEARCH ARE TWOFOLD. First, through the use of two independent samples, this paper suggests that the benefits derived from using IS (as perceived by a senior manager in an organization) depend on the organization's operating characteristics (e.g., number of suppliers, lead time for purchase order, lead time to customer). Bartezzaghi and Francesco [4, p. 46] called such characteristics "operating conditions" and found that they have an impact on the performance of manufacturing organizations:

> [P]erformance so defined depends on a series of production system structural characteristics (that come from design and management choice of the system itself, besides, of course, from a series of technological and environmental constraints). There are some significant parameters that, taken together, describe the functioning characteristics of the production system. These parameters, which can be called the operating conditions, are, for example, time variables, such as lead time and throughput time; physical measurements, such as lot size; relative parameters such as capacity utilization, percentage of defects, manpower efficiency, etc.

If an organization's operating characteristics are found to affect the benefit derived from using information systems, this linkage can help explain how information systems contribute to organizational performance. Our samples, one from Israel and one from the United States, are important because they demonstrate this linkage, even though there may be differences between the two countries as a function of different cultures, different types of business, different relationships with customers and suppliers, and so on. We found demographic differences between the companies in the two samples: For instance, the firms in the United States tend to be larger. Nonetheless, the model relating perceived benefit from an IS application to the organization's operating characteristics is shown to hold across both countries.

The second research objective is to show that the relationship between benefits derived from using IS and an organization's operating characteristics is stronger for a specific IS application than it is for the entire IS applications portfolio (considered as a whole). These findings support the suggestion (as outlined below) of Barua et al. [5] that benefits from IS can be measured at lower operational levels of an organization but may be hard to identify at higher levels in the organization's hierarchy. While Barua et al. [5] used more objective data items such as income statement information, market share, return on assets, and capacity utilization, this research makes use of managers' perceptions of the value IT adds to organizational performance.

Background

TO COMPREHEND THE VALUE THAT INFORMATION SYSTEMS PROVIDE to organizations, we must first understand the way a particular organization conducts business and how information systems affect the performance of various component activities within the organization. Information economics can be useful in making these assessments. Jacob Marschak [24] wrote much of the pioneering work in the economics of information. Marschak investigated the linkages between teams, information processing, and decision making. He laid the foundation for much of the modern work in information economics and the way organizations process information.

Marschak defines organizations in terms of teams. A team is a group of persons who make decisions and are commonly rewarded as a result of their joint decisions. A team's or organization's success depends not only on the individual decisions made, but also on externalities not under their control. Externalities may include competitive pressures, the price of capital and labor, regulatory issues, and other socioeconomic factors that introduce risk into the organization. Because each organization is different, it is affected differently by external forces. In an attempt to compensate for these external effects, organizations create systems that monitor the environment and provide information to decision makers, thereby *reducing the risk associated with decision-making*. Different organizations create different information systems to support decision-making. Marschak suggests that the decision-maker balances the cost of inquiring against the cost of the information system. Consequently, organizations are faced with building information systems that are cost effective with respect to the value of the decisions those systems support in that particular organization's operating environment.

As the level of uncertainty surrounding the decision-making process increases, the decision-maker needs more information [21, 27, 33]. Specifically, the decision-maker needs pertinent information about each alternative, possible state of nature to make the best decision. Uncertainty increases if there are many possible states of nature whose likelihood is similar. Appropriate information can reduce erroneous decisions and consequently reduce task complexity [6, 19].

Consider a firm that has a large number of raw-materials suppliers, where differences (in prices, lead time, quantity discount, etc.) prevail among the suppliers and where the organizational objective is cost reduction. The purchasing manager must examine a large quantity of data to compare the suppliers and make the best purchase decision. The manager might reduce the price of raw materials by about 15 percent by using a computerized application to support such decisions [30, 37]. The level of uncertainty/complexity involved with this decision process is high because of many and diverse vendors. Implementing a sophisticated purchasing decision support application can reduce this uncertainty. Yet, if raw material costs are only a small portion of the total cost of producing the product, then even if the firm makes the best decision concerning suppliers, this decision will only slightly reduce total costs and will have minimal impact on the organization's performance! For instance, if the materials cost is 5 percent of total product cost, the savings will be only 0.75 percent (15 percent times 5 percent) of the cost of the finished product. Here, a system that helps the purchasing manager compare and evaluate more suppliers to get the best purchase price is not particularly valuable, even though the uncertainty/complexity involved in making the decision is very high.

There are, clearly, different kinds of information systems, with different functions. The nature of the organizational system's interface with the information system is also crucial. Barua et al. [5, p. 7] suggest that the "value chain" as presented by Porter [28] takes a closer look at how IT may affect particular activities and can provide a starting point for detailed IT impact analysis. Porter [28, p. 33] states that a company's value chain comprises the "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) together with support activities (i.e., corporate infrastructure, human resource management, technology development, and procurement) and are the means whereby a firm can seek to implement its cost leadership or differentiation strategies. The primary activities by definition are performed at the lower level of the organization, near or on the shop floor. Porter and Millar [29] further refine this framework into a model that incorporates the role of the information systems application portfolio in the organization and focuses on the value chain that is present in the delivery of services or products. It seems, therefore, that the benefit IT can provide to the organization's performance is the value added to the organizational primary activities at the lower levels of the organization. Support activities, while important, tend to have only indirect impact on organizational performance and were not considered here. (Although Porter classifies "procurement" as a support activity, he acknowledges that the purchase of raw materials can have an important impact on production. We would classify purchasing raw materials as part of "inbound logistics," a primary activity.) The question to be asked is how a particular organization uses the IT portfolio to affect the firm's particular value chain that ultimately can affect that firm's productivity.

If the value of information systems is so closely tied to the organization's activities, the perceptions of teams involved in these activities is crucial. Marschak suggests that the value of information produced by an information system, in support of a decision, is that information's value to the decision-making team.

The Conceptual Model

WE DRAW UPON THE FOREGOING IDEAS IN SEVERAL WAYS. First, Marschak's work supports looking at the decision-maker's perception of the value obtained from an IS. Second, Marschak further suggests that, to develop an appropriate IS, the organization must consider the degree of risk or uncertainty associated with a decision, as well as the value of the decision to the organization. Third, all of these authors suggest that different organizations may obtain different benefits from the same IS application. Fourth, based on Porter [28] and Barua et al. [5], the benefit IS contributes to the organization should be identified and measured at the lower level of the organization, where the primary activities take place (see figure 1).

Various factors influence an organization's operating decisions, primary activities, use of IT, and perceptions of its managers. These factors include "operational characteristics" related to uncertainty and those related to the impact of a decision on organizational performance, other organizational characteristics, and environmental circumstances. The organization itself comprises, among many other things, primary activities, managers/decision-makers, and information systems. Information-technology use is a function of the available information technology itself [1, 15, 16, 26] and how well people believe they can use the technology [13]. The use of the technology affects, in different ways, the various elements of the organization's primary activities. How IT affects these activities depends, in part, on the operating characteristics of the organization itself (e.g., [34]). These primary activities affect the performance of the organization Porter [28]. In addition, the primary activities coupled with the eventual performance of the organization, through the IS application portfolio, inform management's perceptions of the activities and the organization's perfor-

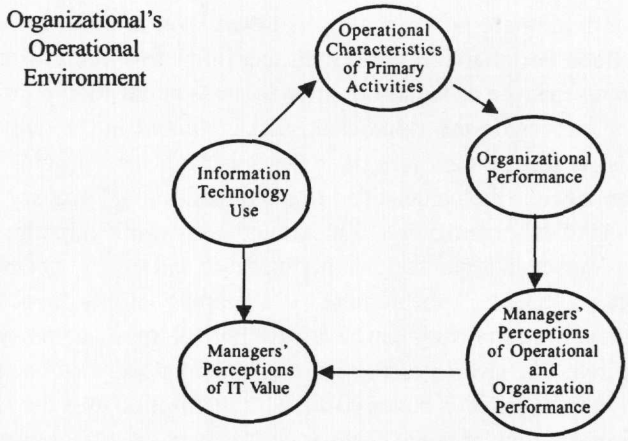

Figure 1. An Organization's Operational Environment Colors the Perceptions of Performance and Value Within It. The use of information technology affects an organization's primary activities as well as managers' perceptions of the value of that technology. Each of the primary activities in turn affects organizational performance and hence management's perceptions of that performance. These perceptions also affect managers' perceived value of the information technology.

mance. (The IS applications gather measurements of the results of primary activities and measurements of overall organizational performance). These perceptions and an understanding of how the information technology is used in the organization form the basis for management's understanding of the value of the information technology. Hence, IT's impact on organizational performance can be understood by evaluating management's perceptions of IT use when viewed through the lens of the primary activities. The operational decision becomes an input to a primary activity (or a chain of such activities); that activity leads to an output that contributes to overall organizational performance. This model illustrates just how indirect the relationship is between a low-level operating decision and the impact on organizational performance, as suggested by Barua et al. [5].

In this study, we review information systems found in manufacturing organizations in Israel and the United States. Many studies have looked for a relationship between investment in IS and the performance of the organization. Some failed to find a relationship between the investment in IS and the performance of the organization (e.g., [22, 36]. Others had difficulty finding a positive relationship [23, 32]. Brynjolfsson [8] called this phenomenon the "productivity paradox." Later, Brynjolfsson and Hitt [11] found a linkage between investment in IT capital and IT labor and the organization's productivity. Examining the country level, Dewan and Kramer [17] found a positive relationship between the level of investment in IT in a particular country, and the productivity of that country. These findings are very important, since they demonstrate that investment in IT does provide a positive return on investment. Yet, more investigation is needed to document the nature of the linkages between IT investment and benefits before these findings can be useful for information systems planning.

Research Questions and Propositions

KNOWING THAT THERE IS A POSITIVE RELATION BETWEEN INVESTMENT in information systems and the performance of the organization is very important for any consideration of investment in IS. Without this knowledge, there would be no reason to consider investing in these systems. In this study, look at the use of information technology (e.g., in decision-making) from two points of view: IT's impact on managers' perceptions of organizational performance and on managers' perceptions of the value of the technology. We want to explore the following propositions:

> *1. There is a relationship between organizational operating characteristics and the benefit, as perceived by a senior manager, the organization may gain by using an individual IS application.*
>
> *2. There is little or no relationship between the organization's operating characteristics and the perceived overall benefit the organization gains by using the entire IS (all the IS applications portfolio as one entity).*

Research Method

A SURVEY OF 310 MANUFACTURING ORGANIZATIONS WAS CONDUCTED in Israel in 1991–92. A survey of 197 manufacturing organizations was conducted in southeastern Michigan in 1997–98. Questionnaires were filled out by interviewers during structured, personal interviews with senior managers. Table 1 summarizes the demographics of the samples.

The questionnaire contained three parts. First, senior managers were asked specific questions about their organization's operating characteristics (e.g., number of suppliers, relative share of raw materials cost in the cost of the final product, number of customers, average lead time to customers, number of products, number of production lines, volume of sales, and number of employees). Next, they were asked to rank the benefit their organization gained by using specific IS applications. Finally, they were asked to assess the overall benefit their organization derived from using the entire IS application portfolio. The response scale ranged from 1 to 7 (where 1 = very low benefit and 7 = very high benefit). 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 [2]. Still, the limitation of studying the perceived benefit is well known; it is subjective, since it reflects the value the individual associates with the information system.

While it is difficult to gauge the real benefit of IS applications, we attempted to obtain these data. We conducted a pilot survey in several organizations but could not determine the real benefit the organization gains by using IS because the data on performance differences, before and after the implementation of an IS application, were unavailable. Accordingly, we decided to employ the perceived benefit approach.[1] The use of two independent samples tends to minimize the problems associated with using the perceived benefit provided by the respondent. The consistency in results

Table 1. Sample Demographics

	Min.	Max.	Median	Mean	St. dev.
Israel					
Volume of annual sales ($US million)	1	400	33	41.78	39.52
No. employees	10	2,400	100	200	321
United States					
Volume of annual sales ($US million)	1.5	2,200	32	93.9	226.1
No. employees	34	35,000	175	578	2,605

found for two unrelated samples may even suggest that "perceived benefit" had a comparable interpretation in each country. It is highly unlikely that senior managers in two different countries (and in many different organizations) would have the same biased perceptions. Therefore, it appears reasonable to conclude that the perceived benefit is in fact a good estimate of the real benefit.

As a senior manager, the respondent was not only a user of IS but was also able to ascertain the benefits gained from using IS in different functional areas within the organization. If we view perceived usefulness as the "degree to which an individual believes that using a particular system would enhance his or her job performance" [14, p. 477], then we can assume that a senior manager's perceived usefulness refers to the entire organization, and that his or her perceived value of the information pertains to its impact on the organization's objectives. Obtaining responses from senior managers provides a reliable means to measure the benefits from IS. Based on ANOVA, we found no significant differences in the benefits perceived based on the respondent's role within the organization in both samples.

To avoid bias due to differences among interviewers, a principal researcher trained each interviewer. First, the candidate interviewer observed the researcher conduct two or three interviews. Next, the interviewer conducted two or three interviews in the presence of the researcher, and only then began interviewing independently. Table 2 summarizes the variables used in this study in the two samples.

Data

STRUCTURAL EQUATION MODELING WOULD HAVE PROVIDED THE MOST EFFECTIVE estimation technique for a series of separate multiple regression equations estimated simultaneously. However, in such situations, "theory," prior experience, or research objectives allow the researcher to distinguish which independent variables predict each dependent variable. Since we were unable to justify specific causal relationships theoretically, and since we had no prior knowledge concerning which operating

Table 2. Descriptive Statistics for Sample Operating Characteristics

Operating characteristics	Min. (Max.)	Median	Mean (St. dev.)
A: Israeli sample			
Relative share of raw materials in the cost of the final product	2% (85%)	44%	43.65% (15.31%)
Number of suppliers	1 (5,000)	45	177 (526)
Average number of purchase orders per month	1 (3,000)	47.5	122.5 (249.2)
Lead time for a purchase order	1 (160)	37.3	40.18 (27.93)
Suppliers differences in lead time	N/A	N/A	N/A
Suppliers price difference	N/A	N/A	N/A
Quantity discount	N/A	N/A	N/A
Accumulated quantity discount	N/A	N/A	N/A
Number of customers	1 (10,000)	150	672 (1,746)
Number of sales transactions per month	1 (9,999)	200	1,089 (2,328)
Percentage of production for customers orders	0% (100%)	82.5%	65.7% (38.54%)
Average lead time to customers (in days)	1 (720)	15	39 (73.91)
Average number of levels in the bill of materials	1 (70)	3	3.310 (4.503)
Days raw materials stay at the company	0 (360)	60	66.27 (56.80)
Number of production lines	1 (50)	4	5.716 (6.478)
Average number of days to complete a work order	1 (540)	7	25.83 (49.87)
B: U.S. Sample			
Relative share of raw materials in the cost of the final product	1% (80%)	40%	38.05% (17.25%)
Number of suppliers	2 (3,000)	60	234 (493)
Average number of purchase orders per month	1 (5,000)	155	439.4 (909.5)
Lead time for a purchase order	1 (180)	14	25.54 (27.96)
Suppliers differences in lead time	N/A	N/A	N/A
Suppliers price difference	N/A	N/A	N/A
Quantity discount	N/A	N/A	N/A
Accumulated quantity discount	N/A	N/A	N/A
Number of customers	1 (170,000)	100	1,327 (6,842)

(Continued)

Table 2. Continued

Operating characteristics	Min. (Max.)	Median	Mean (St. dev.)
B: U.S. Sample			
Number of sales transactions per month	1 (800,000)	200	10,146 (80,246)
Percentage of production for customers' orders	0 (100)	95	72 (35.820)
Average lead time to customers (in days)	0.13 (730)	21	55.13 (102.87)
Average number of levels in the bill of materials	1 (20)	3	4.489 (4.389)
Days raw materials stay at the company	0 (548)	20	35.46 (70.82)
Number of production lines	1 (90)	6	9.93 (14.38)
Average number of days	1 (730)	14	60 (117.1)

N/A = not applicable: dichotomous variable.

characteristics affect the benefit derived from a specific IS application, we used multiple regression analysis to best represent the dimensionality of the construct in a parsimonious manner. Multiple regression meets our research objective of providing a means of objectively assessing the degree and character of the relationship between IS applications (customer order management and suppliers/raw-materials purchasing) and several operating characteristics of the organization. The assumed relationship is linear association based on the correlations among the characteristics and the IS applications. The results we find will facilitate theory development and are of strategic importance for organizations. However, we recommend that future research improve upon the constructs, by specifying and estimating a structural model including hypothesized relationships among not just the IS applications and operating characteristics we study here, but others that might be investigated.

Prior to model building, we conducted a careful analysis of the data to lead to a more accurate assessment of dimensionality. Important issues we addressed were dealing with missing data, identification of outliers, and testing of the assumptions underlying the multiple regression analysis technique. The complete-case approach was chosen to deal with missing data; we included only those observations with complete data. The resulting samples were not reduced to an inappropriate size, as the extent of missing data was small. We used a multivariate assessment of each observation across our set of variables to identify potential outliers. The Mahalanobis D^2 distance measure identified just a few observations that were significantly different in each data set [18]. These outliers were examined and we decided to eliminate those cases not consistent with the remaining cases.

Our next step involved ensuring that the data met the assumptions underlying multiple regression analysis. This is particularly important in our case because of the complexity of the relationships owing to the use of a large number of independent variables. In our initial analysis, we observed a few cases with large regression residuals unduly affecting the regression estimates. Statistically significant residuals, falling outside 95 percent confidence intervals, were classified as outliers. Furthermore, a review of the values for Cook's distance measure confirmed which observations were influential and warranted further study based on a rule of thumb to identify observations with a Cook's distance of 1.0 or greater [35]. After closer examination, we determined that all outliers represented unusual observations and decided to remove them. We ran the regressions without these observations to determine their effect on the analysis.

Even though large sample sizes tend to diminish the detrimental effect of nonnormality, we still analyzed the plots to determine whether the assumption of normality of the error distribution was reasonable for all variables included in our analyses. Based on a frequency distribution of the standardized residuals, using a stem and leaf display, we checked for obvious departures from normality. The residual plots indicated no reason to question this assumption since we observed that 95 percent of the residuals were between +2 and –2. The normality assumption appears to be more plausible after the outliers were removed. Although the most common way to assess linearity is to view regression residuals of the variables and identify any nonlinear patterns in the data, we assess linearity in two ways. First, the linearity between dependent and independent variables was examined through a visual analysis of partial regression plots. Specifically, partial regression plots allowed us to examine the pattern of residuals and determine which specific variable(s), if any, violated the linearity assumption. This is a useful technique since we have several independent variables. Our plots did not exhibit any nonlinear pattern to the residuals, thus ensuring that the overall multiple regression equations were linear. Next, we examined a multivariate statistical test for linearity to complement the visual examination of the residual plots; we found no problems. Our analysis again is through an examination of residual plots to diagnose the presence of unequal variances. The residuals, analyzed for systematic behavior, showed no pattern of increasing or decreasing residuals. These findings do not provide a basis for rejecting the assumption of constancy of the residuals across values of the predictor variables. Therefore, it was not deemed necessary to apply any variance-stabilizing transformations.

No impact of multicollinearity was evident, based on a diagnosis using the variance inflation factor (VIF). The VIF values were very small, indicative of low intercorrelations among variables and inconsequential collinearity; no VIF value exceeded 10.0. In addition, an examination of the correlation matrix for the independent variables did not reveal the presence of high pairwise correlations. That is, we found no sample correlation coefficients greater than 0.70 for two independent variables, which is a guideline warning of potential problems with multicollinearity [7].

Variables

USING MULTIPLE REGRESSION ANALYSIS, WE DEVELOP THREE EQUATIONS showing how organizational operating characteristics are related (1) to the benefit gained by using "customer order management," (2) to the benefit gained by using "supplier/purchasing management," and (3) to "overall benefit gained by using all IS applications." Additional organizational characteristics could have been included in this study, such as span of managerial control, extent of local/regional autonomy of the operation, and age of the firm. Yet, since this study is primarily exploratory in nature, we investigate our propositions using only one category of organizational characteristics ("operating conditions" as defined by Bartezzaghi and Francesco [4]). Based on the results, future research might try extending the approach to include other organizational characteristics.

The customer-orders management system is the application that processes each customer order (technical specifications, packaging requirements, supply time to customer, details on long-term contracts like "blanket order," etc.) from the date the order was accepted by the organization until the date of delivery to the customer. Using this application helps the organization supply orders according to the customer's specifications, to shorten the supply time, and to provide timely information to customers about the status of their orders; in each case, the organization can increase its sales. The suppliers and purchasing application manages all the details regarding the organization's suppliers and each raw-materials purchase order helping the organization plan the purchase of raw materials. This information enables purchasing managers to evaluate and negotiate with vendors better, helping the organization obtain better prices for raw materials, minimize inventory carrying costs, and reduce disruptions to the production process from raw-materials shortages.

Results

THREE ESTIMATED MULTIPLE REGRESSION MODELS WERE USED TO TEST the first proposition. For each IS application and the overall IS portfolio, ordinary least squares (OLS) was used to estimate the regression coefficients (b_i) in an equation of the form:

Model A: The Customer Management Application Regression

$$Y_1 = b_0 + b_1 \text{ Dummy} * \text{Country} + b_2X_2 + b_3X_3 + \ldots B_{17}X_{17} + E_1$$

Model B: The Suppliers and Purchasing Application Regression

$$Y_2 = b_0 + b_1 \text{ Dummy} * \text{Country} + b_2X_2 + b_3X_3 + \ldots B_{17}X_{17} + E_2$$

Model C: The Overall IS Applications Portfolio Regression

$$Y_3 = b_0 + b_1 \text{ Dummy} * \text{Country} + B_1X_1 + b_2X_2 + \ldots B_{17}X_{17} + E_3$$

Note that the error terms—E_1, E_2, and E_3—in the three models may be correlated since the same individual at each firm provided the three perceived benefit measures, and the same independent variables are used in each model. Nonetheless, OLS still provides efficient estimates whose values are reliable. The reader should also note that the respondents' reports of the benefit from the overall IS portfolio may be correlated with their reports of the benefits from the two specific applications we studied. The customers and suppliers applications are part of the overall IS portfolio; some of the observed variance in Y_3 may be explained through the correlated effects of Y_1 and Y_2. Still, there are many other applications in the typical manufacturing firm's IS portfolio. The impact of only one or two applications on the overall benefit is likely to be slight. Given the exploratory nature of our study and the lack of any accepted theory to suggest which operational characteristics might affect the benefit from a specific IS application, we chose to use simple models that have straightforward interpretations in a manufacturing setting. As more is learned about the linkages between operational characteristics and benefits from IS, a more comprehensive model might be developed.

As shown in the first row of Table 3, we have sufficient statistical evidence to conclude that the overall regression relationship between using the customer management application and the suppliers and purchasing application, and the set of operational characteristics is significant at the 0.05 level of significance ($F = 12.73$, $p = 0.000$; and $F = 15.61$, $p = 0.000$; respectively). In addition, R^2 adjusted = 34.5 percent indicates that the estimated regression equation does a good job explaining the variability in customer management application and supplier application (R^2 adjusted = 39.8 percent). In each regression equation, the adjusted R^2 was large enough to suggest a meaningful relationship between the organization's operating characteristics and the benefit derived by using each of the IS applications. These findings offer support to proposition 1.

The models were fitted with a constant term for its predictive value only, since it does not have a managerial interpretation. That is, there is no situation in which all operating characteristics are absent, so the intercept has no managerial use but it does help generate a more accurate prediction. To determine which of the operational characteristics contributed significantly to each IS application, a separate t-test was conducted for each of the characteristics in the models. First, we see in Table 3 that the relationship between both IS applications and country is significant ($t = 2.27$, $p = 0.024$; $t = 5.79$, $p = 0.000$). We discuss these results below.

Customers

The "average number of purchase orders per month" ($t = 2.07$, $p = 0.039$), "lead time for a purchase order" ($t = 2.48$, $p = 0.014$), and "percentage of production for customer orders" ($t = 11.42$, $p = 0.000$) have significant impacts on the customer order management application. The production of customer's orders depends on the availability of raw materials. As the lead-time for raw materials lengthens, planning and managing the percentage of production of customer's orders become more complicated and more information is needed. When a company produces for inventory, customers buy "off the shelf," eliminating the need for an IS application that helps plan and monitor customers orders. Thus, the higher the percentage of production for customer's or-

Table 3. The Regressions Results for the Benefit the Organization Gains from Using Individual IS Applications

	Customers' application	Suppliers' application
Significance of the regression	F = 12.73	F = 15.61
	P = 0.000	P = 0.000
R^2	37.5%	42.6%
R^2 adjusted	34.5%	39.8%
Constant	3.3445	1.8954
	10.48 ***	6.80 ***
	0.000	**0.000**
Country: 0 = Israel; 1 = U.S.	0.4247	0.9725
	*2.27 ****	*5.79 ****
	0.024	**0.000**
Relative share of raw materials in the cost of the product	0.006717	0.049865
	1.43	*12.02 ****
	0.155	**0.000**
Number of suppliers	–0.0000671	0.0004241
	–0.35	*2.55 ****
	0.729	**0.011**
Average number of purchase orders per month	0.0006845	0.0003411
	*2.07 ****	*1.25*
	0.039	**0.211**
Lead time for a purchase order	0.007021	0.011637
	*2.48 ****	*4.65 ****
	0.014	**0.000**
Suppliers' difference in lead time 0 = no difference; 1 = difference	0.0477	0.3678
	0.29	*2.58 ****
	0.771	**0.010**
Suppliers' price differences 0 = no difference; 1 = difference	0.2396	0.1859
	1.27	*1.12*
	0.205	**0.266**
Quantity discount 0 = no discount 1 = discount	0.0324	0.2838
	0.17	*1.70*
	0.865	**0.089**
Accumulated quantity discount 0 = no discount 1 = discount	0.2229	0.2802
	1.37	*1.98****
	0.171	**0.049**
Number of customers	–0.0002229	0.0000189
	–0.45	*0.41*
	0.656	**0.683**
Number of sales transactions per month	–0.001528	0.0000297
	–1.84	*1.49*
	0.067	**0.138**
Percentage of production for customers' orders	0.023811	0.001728
	*1.42 ****	*.94*
	0.000	0.348
Lead time for customer order	0.0018121	0.000996
	1.34	*0.89*
	0.182	**0.372**

(Continued)

Table 3. Continued

	Customers' application	Suppliers' application
Average number of levels in the bill of materials	0.06034 *3.65 **** **0.000**	0.03063 *2.14 **** **0.033**
Days raw materials stay at the company	0.003263 *2.04 **** **0.043**	0.003320 *2.36 **** **0.019**
Number of production lines	0.00797 *0.79* **0.432**	0.000711 *0.08* **0.933**
Average number of days to complete a work order	0.004549 *2.58 **** **0.010**	0.000771 *0.64* **0.522**
*N**	**379**	**376**

* Observation with missing values were omitted.
*** *t* statistic is significant at the 5% level.
For each independent variable, within each cell we present the coefficient, *t value,* and ***p* value.**

ders, the more benefits the organization stands to gain from using this application. Also, as the number of purchase orders per month increases, more information is needed to coordinate the supply of raw materials with customer orders.

Other characteristics significantly related to customer order management are "average number of levels in the bill of materials" (t =3.65, p = 0.000), "days raw materials stay at the company" (t =2.04, p = 0.043), and the "average number of days to complete a work order" (t =2.58, p = 0.010). The more levels there are in the bill of materials, the more complicated are the product and its subsequent production, and more information is needed. The differential impacts of the other two characteristics on this application require further study.

Suppliers

Next we examine which operational characteristics were significantly related to the benefit derived from using the "suppliers and purchasing application" in each sample. The "relative share of raw materials in the cost of the final product" contributes significantly to the benefit derived from using this application (t = 12.02, p = 0.000). Since this application may help an organization reduce the cost of raw materials by about 15 percent, the higher the value of this variable, the higher the potential savings for the organization. Six other operational characteristics are significantly related to this application. They are "number of suppliers" (t = 2.55, p = 0.011), "lead-time for a purchase order" (t = 4.65, p = 0.000), "suppliers' differences in lead-time" (t = 2.58, p = 0.010), "accumulated quantity discount (t = 1.98, p = 0.049), "average number of levels in the bill of materials" (t = 3.65, p = 0.000), and "days raw

Table 4. The Regression Results for the Benefit the Organization Gains from Using the Entire IS Applications Portfolio

Significance of the regression	0.010
R^2	8.3%
R^2 adjusted	4.2%
Constant	4.1784 14.24 *** **0.000**
Country	0.1537 *0.90* **0.367**
Relative share of raw materials in the cost of the product	0.003474 *0.81* **0.418**
Number of suppliers	0.0003587 *2.45* *** **0.015**
Average number of purchase orders per month	0.0003382 *1.22* **0.223**
Lead time for a purchase order	0.004318 *1.66* **0.098**
Suppliers' difference in lead time 0/1	0.0958 *0.64* **0.525**
Suppliers' price differences 0/1	0.2840 *1.64* **0.101**
Quantity discount 0/1	0.3440 *1.95* **0.052**
Accumulated quantity discount 0/1	0.0681 *0.45* **0.650**
Number of customers	0.00000442 *0.34* **0.734**
Number of sales transactions per month	0.0000835 *1.19* **0.234**

(Continued)

materials stay in the firm" ($t = 2.36, p = 0.019$). We offer these explanations. The more suppliers there are, the more information is necessary to manage all of them. If several vendors supply the same raw material and there are lead-time differences among the vendors, more information is needed when planning a purchase order. The same reasoning holds for the existence of a quantity discount. The more levels that exist in the bill of materials, the more information is needed to purchase materials and to plan their timely receipt. Manufacturing organizations can reduce the inventory holding

Table 4. Continued

Percentage of production for customers orders	0.003461 *1.79* **0.074**
Lead time for customer order	0.001561 *1.35* **0.179**
Average number of levels in the bill of materials	0.00740 *1.49* **0.624**
Days raw materials stay at the company	0.001383 *0.90* **0.367**
Number of production lines	0.003734 *0.45* **0.654**
Average number of days to complete a work order	0.002540 *2.09* *** **0.037**
*N**	393

* Observation with missing values were omitted.

*** *t* statistics is significant at the 5% level.

For each independent variable, within each cell we present the coefficient, *t* value (in italics), and *p* value (in bold).

costs (financing, storing, insurance, etc.) by about 25 to 30 percent using computerized information systems [31]. Therefore, the more days the raw materials inventory remains in the organization, the higher the potential cost savings. When quantity discounts apply, more options must be evaluated when planning a purchase order.

Furthermore, we found that country, measured as a dichotomous variable (0,1), was related to the benefit derived from using the customer management and supplier applications. Specifically, the expected benefit from using both applications is greater for the Israeli sample than for the U.S. sample. These differences may occur because of general differences between the countries [20], the potential differences between businesses in the United States and those in Israel with respect to the way they do business, the time periods in which the samples were obtained, or some other factor. Despite these actual and potential differences, we obtained meaningful regression results across the two countries.

Overall IS Applications Portfolio

Table 4 presents regression results relating the operational characteristics to the benefit from the overall IS portfolio. There appears to be no meaningful relationship between the portfolio of IS applications and the organizational operating characteristics we studied. Although the regression is significant ($F = 2.01$, $p = 0.01$), the adjusted R^2 is only 4.2 percent. With 393 observations, we were able to detect only a weak link between operational characteristics and the benefits from the overall IS portfolio. Since we used a broad set of operational characteristics that are likely to affect many IS applications beyond customers and suppliers (inventory control, production scheduling, shop floor control, and others), this result supports our second research proposition.

The benefits that IS provides the organization accrue largely by adding value to primary activities at lower levels within the organization and depend on the organization's operating characteristics. These operating characteristics can be used to plan the implementation of an individual application but not to predict the benefit to be obtained from the overall IS application portfolio. Our results do not suggest that there is no benefit to be obtained from the overall IS portfolio, just that the organization's operating characteristics do not help much in explaining that benefit. As Marschak [25] suggests, organizations and researchers should look for the potential benefits from IS through the lens of each organization's particular operating environment. Our findings indicate that this search for benefits should occur at the level of the individual application. We recognize that our findings are not detailed enough to enable an organization actually to evaluate each IS application; at best our regression equations explain less than half the variation in the data. More research is needed on this topic. For example, one might investigate other organizational characteristics not studied here or assess the impact of organizational characteristics on IS applications using a structural equation model. These and other extensions of our study can provide organizations with better insights into their IS investment decisions.

Conclusion

WE LOOKED AT 310 MANUFACTURING ORGANIZATIONS IN ISRAEL and 197 such firms in the United States. We found significant relationships between the organization's operating characteristics and the benefit the organization derives from using individual IS applications, but we found only a weak relationship between the same organizational characteristics and the benefit the organization derives from using the entire IS applications portfolio. Our findings are consistent with the suggestions presented by Barua, Kriebel, and Mukhopadhyay [5].

Despite differences between the two countries in the expected level of benefit from using each of two specific IS applications, a meaningful relationship was found between operational characteristics and the benefit from each application when we looked at the combined sample. The fact that the approach is supported by two independent samples strengthens the approach and creates many opportunities for both practitioners and academic researchers. Obviously, each organization may gain different benefits from using each specific IS application as a function of the organization's operating characteristics. In addition, IS planning must consider the lower levels of the organization, close to the activities on the shop floor, as was suggested by Porter [28] and by Barua et al. [5].

For academic researchers, this study can potentially open a new stream of research. While organizational characteristics are clearly related to the benefit the organization may derive by using individual IS applications, the characteristics reviewed in this study fall short of providing a complete explanation of the benefits organizations can potentially obtain. We suggest that future research efforts focus on other factors that influence these benefits. By identifying these parameters, organizations will be able to plan the investment and implementation of information systems in a way that will lead to better utilization of the information systems.

Notes

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1. Optimally, the data on the firm's benefit from using IS would come from some objective sources, and indeed there are studies that base their findings on objective performance measures such as organization profit, return on investment, and the like (e.g., [10, 12]). These measures were collected from published financial reports, which required a focus on companies whose financial reports are in the public domain. Consequently, the samples consisted of firms that were very big, generally *Fortune* 500 firms. Since we wish to obtain information from companies of varying size, and since smaller companies are generally privately held, many of the firms in our sample do not have financial reports in the public domain. Thus, we trade the possibility of obtaining objective information on performance for the additional breadth in our sample associated with using companies that are not public domain.

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