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Optimisation of Characteristics Influence the Value of a Supplier Management ERP Application

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ABSTRACT: According to the earlier researches there is no evidence that the information systems (IS) have any tangible benefits. But, it is very clear that IS can identify less costly sources of inputs for firms by making it cheaper and easier to evaluate prospective supplier offers. According to this, adopting IS should denote a value of information. We now develop a model which relates this potential value to various characteristics. The validity of our model is tested using a random sample of 310 medium and large size manufacturing organizations. The results are strongly supportive of the model, and hence provide support for the hypothesis that IS provides tangible benefits and also has a positive impact on performance of the organization.

KEYWORDS: Information Systems, Decision support systems, ERP, Linear regression, organizational characteristics, value of information.

I. INTRODUCTION

Part of the lore of contemporary business is that information systems (IS) are utilized to achieve competitive advantage by lowering costs, speeding the processing of potential input suppliers' offers, enhancing differentiation and changing competitive scope [24], IS applications increase the speed with which corporate functions are performed [13]. Information systems for the manufacturing industry can have a major impact on organizational performance. It has been argued that adopting IS in manufacturing companies can generate substantial reductions in inventory holding costs by minimizing the amount of inventory, reducing raw material costs by enabling the buyer to obtain the best possible conditions, reducing working hours, and lowering response time to market demands [12,18,28,33]. These manufacturing information systems are known as Enterprise Resource Planning (ERP).

Most previous studies attempting to determine the relationship between investment in IS and the performance level of the organization failed to detect a positive relationship. One group of studies compares investment in IS against firm performance, as measured by stock returns [11,14,29]. A second set analyzes industry-level statistics and finds that the marginal dollar of IS investment tends to add less than $1 to the value of output [6]. A third group, using a relatively small sample of firm level information, fails to detect a significant positive relation between IS spending and productivity [15,17,31]. While these groups of results could indicate the absence of a significant relation between IS and firm performance, each group of results is subject to criticism. First, to the extent that financial investors employ rational expectations, anticipated changes in IS investment (or any other type of investment, for that matter) will have no impact on stock returns; only unexpected changes in IS investment should generate noticeable gains. Thus, the lack of a significant relation between IS investment and stock returns is not evidence that IS investment does not enhance firms' productivity. Second, if firms within an industry invest in IS to varying degrees, it is plausible that big investors will do well partly at the expense of small investors. If this is so, one cannot draw any inferences about the impact of IS investment on firm performance from industry-level statistics. Third, even if one focuses on firm-level data, a significant positive relation can be masked if the performance variables are suspect or the sample is not sufficiently large. Brynjolfsson [25] has argued that aspects often attributed to IS "are precisely the aspects of output measurement that are poorly accounted for in productivity statistics...". Failing to correct for this mis-measurement can yield underestimates of the benefits from using IS.

One obvious resolution to these difficulties is to use large samples with firm level data, where evidence of benefits is based on the expert assessment of someone in the firm.[2] Further, such an approach should take organizational characteristics into account, since organizations with different characteristics may gain different benefits from using similar individual IS applications [14,19,26]. Porter et al. argues that "competitive advantage cannot be understood by looking at a lirm as a whole. It stems from many discrete activities a firm performs in designing, producing, marketing, delivering, and supporting its products. Each of these activities can contribute to a firm's relative cost position and create a basis for differentiation". Porter also indicates role of IS in supporting organization's activities: "Information systems technology is particularly pervasive in value chain, since every value activity creates and uses information."
Porter's theory suggests that the impact of the IS should be measured for each activity area by itself, and not for the entire organization as a whole. Barua et al. [20, p. 6] expanded this theory by suggesting that "the primary economic impacts or contributions (to performance) of information technologies (if any) can be measured at lower operational levels in an enterprise, at or near the site where the technology is implemented". That is to say, the contribution of IS to organizational performance should be measured at the lower operational level and not at the aggregated (highest) level of the organization. Barua et al. suggest that "[t]these effects may then be traced through a chain of relationships within the organizational hierarchy to reveal higher order impacts (if any) on enterprise performance". For example, a direct savings in inventory holding costs (the lower operational level) will contribute to total cost reduction (a higher level), and eventually to organizational performance.

Following this approach, together with Porter's theory, we will look for the benefit IS can provide to a manufacturing organization at the lower level of the organization - the benefit provided by an individual IS application to an individual activity centre. The data we utilize in this study was obtained from surveys of senior managers at 310 manufacturing organizations in Israel. These managers were intimately aware of the benefits gained by using IS for different functional areas in their organization. Each respondent was asked to rate the importance of IS, on a scale of 1 to 7. Respondents were also asked a series of questions about the organization's characteristics, including 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 in the firm. In order to better understand the benefit provided by IS to the lower level of the organization, we follow the approach suggested by Mukhopadhyay et al. [19]. They state (p.7) "for example, in a manufacturing environment, investment in material requirement planning (MRP) systems may improve overall capacity utilization (first-order effect), which, in turn, may lead to a higher return on investment (second-order effect)". To accurately predict the first-order effect, however, more must be understood about the particular manufacturing environment. To this end, we seek to identify the relation between perceived IS benefits and various structural characteristics of the firm.

Since we want to link the benefit from using IS applications to the performance of the organization, we use organizational characteristics that were found to have an impact on the organizational performance [3] as the independent variables for our analysis. We found that these characteristics have a significant impact on the benefit the organization gains from using an individual IS application. By considering both the impact of the certain organizational characteristics on the organizational performance, on the one hand, and the impact of the same variables on the benefit the organization derives from using an individual IS application, on the other hand, we can relate the impact of the individual IS application to the organizational performance. These findings support and expand the findings presented by Mukhopadhyay et al. [19] and Mukhopadhyay et al. [20], Following Porter's approach. Barua et al. [20], and Mukhopadhyay et al. [19,20], we examined the impact of an individual IS application that supports an individual activity area on the performance of the organization as a function of the organizational characteristics.

II. CONCEPTUAL FRAMEWORK

The MRP application is an important and the most commonly used CIM/MMIS (manufacturing management information system) application [26]. This application can help to plan the ordering of raw materials as close to the time they are needed as possible. This will reduce inventory holding costs on the one hand, and will increase the overall capacity utilization by assuring the availability of raw materials when needed, on the other hand. Yet there are some cases where this will not work. A process plant that produces products such as chemicals, milk, and cans usually

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produces these products over and over again. The manufacturer usually dedicates each production line to the manufacture of one product. This type of organization makes sure they have raw materials available by keeping minimum levels of raw material in inventory. Hence, for this type of manufacturer, the MRP system would be of little value. Indeed, a recent study Johansen et al. [29, p. 971] suggested that "CIM is not a generic concept, and a common approach does not work in all cases. Understanding the product process, and plant characteristics associated with successful implementations will assist in evaluating and formulating more effective integration and standardization policies, a poor fit with the firm's characteristics and/or its product markets could easily lead to failure".

Mukhopadhyay et al. [19] found that the benefit information systems contribute to the organization is provided by individual applications. Mukhopadhyay et al. [20] found individual IS applications increase the volume and the quality of the output in the mail industry. Based on the Barua et al. [20] study and on Porter's theory, and the two studies presented by Mukhopadhyay et al. [19, 20], it seems that the benefit a manufacturing organization may gain by using IS should be measured at the lower level of the organization (individual activity center) and should be provided by an individual IS application as opposed to the entire IS applications portfolio. In turn, these benefits are likely to depend on the manufacturing organizational characteristics of the activity area, such as the average number of purchase orders per month for the purchasing activity area, supply time to customers for the sales activity area, etc. [14], Indeed, Bartezzaghi and Francesco [18, p. 46] argue that performance 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.

An important part of the MRP application is selecting the optimal supplier(s) of the raw materials the firm uses to produce each of its products. The attributes of a given supplier's offer might include unit price, quality, delay until delivery (i.e., lead time), special conditions (e.g., volume discounts), and so on. Evaluating a given prospective supplier's offer can entail computing the implied cost of an order under a variety of scenarios. Comparing two different offers requires analyzing the offers under several contingencies. It follows that identifying the optimal offer out of a set of many offers will commonly require the application of "sensitivity analysis", whereby the manager considers a variety of possibilities. Clearly, there is a tangible cost associated with considering further information, be it from the further evaluation of existing offers or from the consideration of an additional offer.

Because the manager faces a substantial computational burden in identifying the implied unit cost associated with any supplier, this implied cost cannot be known ex ante. Thus, identifying the optimal offer is a problem of searching for the most attractive opportunity under uncertainty with respect to implied cost. In this context, adopting a decision support IS application has obvious potential value, since it facilitates the evaluation of any potential supplier's package. That is, it allows the firm to evaluate an additional offer at substantially smaller cost. The value of information associated with the IS application can be traced to the expected cost savings due to the additional searches that can be conducted.' That is to say, by using a decision support system a manufacturing organization can identify a less expensive offer for the needed raw materials, and the cost of the search will also be less expensive than looking for the opportunity without using an IS application.

It is well known that marginal cost - the extra cost of producing an extra unit of output - is tied to the input prices faced by the firm.[4] Based on its marginal cost and the demand curve the firm perceives that it faces, the firm determines a profit maximizing level of production. Because both costs and the profit maximizing level of output are ultimately tied to the various input prices, so is maximal profit. In particular, a reduction in the price of any raw materials will typically raise maximal profits. Because profits are a declining function of input prices, the firm has an obvious incentive to seek the best raw materials offer it can find. However, since evaluating an offer is costly, the firm has a disincentive to search. The trade-off between lowering the expected price of raw materials, and so raising expected profits from production on one hand, and bearing increased search costs on other hand, frames firm's search problem.
The opportunity cost of searching for alternative sources of raw materials will depend on the difficulty of processing the order; in turn; this is likely to be larger the greater is the potential complexity in suppliers' offers. Such complexity could occur for a variety of reasons. Surely the number of suppliers or the number of orders per period of time is related to the potential complexity, since either of these attributes would raise the number of potential offers to be

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evaluated, and so would increase the number of comparisons that must be made. But it is also true that the range of the required sensitivity analysis is linked to the potential differences in suppliers' offers. While it is easy to see how such differences can exist if there are differences in potential supplier's prices, they can also be linked to the possibility of volume discounts. Such possibilities complicate the problem of identifying the optimal input combination, and the associated profit maximizing output, particularly as different scenarios are contemplated. Differences can also occur if there are differences in lead times, since there may be a trade-off between the possibility of obtaining a shipment of inputs closer to the time they are needed against an earlier arriving shipment that contains a larger quantity of the inputs (which increases the inventory holding cost), but is obtained at a volume discount. Thus, we regard the search cost as a function of such features as the number of suppliers, the number of orders, and heterogeneities in suppliers' offers (including prices, volume discounts, lead times, and so on).

The likely benefit associated with a search for alternative sources of raw materials is linked to the significance of raw materials in the firms' total costs. In turn, this can be measured by inspecting the relative share of raw materials in the cost of the final product. For example, consider an organization that has a very large number of suppliers of raw materials, where differences prevail among the suppliers (differences in prices, lead time, etc.). The purchasing manager has to examine a large quantity of data in order to compare the suppliers and make the best purchase with respect to price, lead time, etc. The manager can reduce purchasing cost by 10-15% by using a computerized decision support system to support such decisions [28]. Given this figure, it may be justifiable to implement a sophisticated purchase order IS application to reduce the cost of raw materials. However, if the share of raw material cost relative to the total production costs is low, then even if the firm makes the best decision concerning suppliers, it will have little impact on the organizational performance in terms of cost reduction. For instance, if the material cost is 5% of the total cost of the product, the savings will amount to 0.75% (15% x 5%) of the cost of the finished product. In this case, a decision support system that helps the purchasing manager to compare and evaluate more suppliers in order to get the best purchase order (the lowest cost) is not particularly valuable.

The firm's size can also affect the value it places on the ability to consider additional potential offers at lower cost. In general, one expects that the larger the firm the smaller are its unit costs. Correspondingly, firms with lower sales levels are more likely to have larger unit costs and hence a greater potential for cost savings. On the other hand, to the extent that firms can exploit network externalities or scale economies, larger firms stand to gain more from employing IS [8], Either way, the implication is that firm size may matter.

Before proceeding to the empirical analysis, we briefly discuss two complications of the analysis. In the process we envision, the firm faces a list of potential suppliers. It may have some past experience with some of these suppliers, either because it has ordered from them or because it has considered offers from them. Nevertheless, market conditions are subject to sufficient flux so that this year's offers cannot be assumed identical to last year's, and so each potential supplier's current offer must be analysed. In practice, these offers are likely to possess a great number of characteristics. They may differ in terms of the price charged, in terms of the possibility of volume discounts, in terms of delivery time, or in terms of quality. Their features may prove particularly advantageous in certain market conditions, but less so in others. Despite this apparent complexity, the firm's optimal strategy is to assign a number to each potential offer, reflecting the anticipated gains from analysing that offer, and to analyse offers in decreasing order of these indices [32], This assignment will generally be based on the various contingencies. It is also tied to the values associated with other offers, so that the general solution involves a fairly complicated dynamic programming problem. Indeed, Weitzman [32] remarks "[t]he actual computation is likely to be a combinatory task of unwieldy proportions unless the number (of offers) is very small". In this interpretation, there is a set-up cost associated with search, which depends on the number of offers being considered. It follows that there is an optimal number of offers to include in the list to be considered, with the usual property that the incremental expected net gain from the last offer placed in the list is non-negative, while including one more offer would generate a negative expected net gain. Plainly, a change that facilitates more rapid and more elaborate computation, such as the adoption of IS, would lower this set-up cost, thereby increasing the optimal number of offers to be considered. In turn, this would lower the reservation price for each offer and raise expected payoff from search [32].

The second complication is that potential suppliers' offers are likely to be correlated if these offers are influenced by some common characteristics. For example, firms supplying paper products to an office will be likely to base their offers on the current and anticipated price of wood pulp; supply shocks in the timber industry would plausibly influence

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these paper suppliers in similar ways. To the extent this is true, considering one potential supplier's offer may convey information about the probable outcome of analyzing a second potential offer. This generates an extra benefit from analyzing an offer, but does not really change our fundamental result, that lowering search cost raises the optimal number of offers to process and reduces the expected cost of production [27].

III. DATA ANALYSIS

The research is based on a sample of 310 manufacturing organizations in Israel. Organizations were randomly selected from each major industrial sector in the Annual Survey of Manufacturing Companies published by the Central Bureau of Statistics in Israel. The companies in the sample varied widely in their characteristics. Table 1 provides information on the minimum, maximum, median, and mean values in our sample for six key characteristics, as well the sample standard deviation. Structured questionnaires were filled out through interviews.
The questionnaire was divided into two sections. The first section included questions about the organization's 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, number of employees). In the second section the respondent was asked to assess the benefit the organization derived by using several specific IS applications. All the organizations that participated in the study used ERP software packages for managing manufacturing organizations. Hence, all of them had the same idea regarding the possibilities and use of each application. Cases that were reported by the interviewer as different than the meaning of the study were pulled out of the sample. Most of the companies that participated had the same use of the purchasing application and only six organizations were pulled out of the sample.

Table 1
Distribution of the respondent organizations' characteristics.

	Min.	Max.	Median	Mean	St. Dev.
Volume of 1990 sales (in million $ US)	1	400	33	41.78	39.52
Number of employees	10	2400	100	200	321
Number of suppliers	1	5000	45	177	526
Relative share of raw materials in the cost of	2%	85%	44%	43.65%	15.31%
Average number of orders per month	1	3.000	47.5	85.7	249
Average lead time of raw materials (in days)	1	160	37.3	38	27.93

A structured interview was conducted with a senior manager in each organization. The person selected was a user of IS, well aware of the benefits gained by using IS for different functional areas in the organization. The majority of the interviewees were the presidents of the organizations (57%). The other was senior managers of the organization (e.g., Production VP, Finance VP). The interviewers explained each question to the interviewees. Usually the interviewee knew the answer. When the interviewee did not, he/she called the person in charge of the topic and got the answer. An ANOVA analysis revealed no significant difference in the respondents' estimates of the benefit derived by using the information systems as a function of their role in the organization.

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 afterward began interviewing independently.

During a pilot test in several organizations we found that we could not determine the real benefit the organization gains by using IS because this information was either unavailable or not released by the interviewee. An alternative is to focus on the perceived value of IS, which has been argued to be "very instrumental in assessing the value of an IS that supports unstructured decisions where the outcomes are somewhat intangible or planned for long range" [1], for these reasons we decided to use the perceived value of the benefit. Each respondent was asked: "How would you rank the benefit derived by your organization from each of the following applications on a scale of: 1 2 3 4 5 6 7, 1 indicating very low benefit, and 7 indicating 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 [1].

Using perceived benefits, as opposed to measured benefits, does have some problems. Because the measure is subjective, there is a concern that responses may not be comparable across firms. That is to say, a dollar impact that one

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manager regards as significant may strike another manager as merely average. There is also the concern that respondents may not respond truthfully, since they have no disincentive to lie. In particular, the results may be biased if the respondent senses the relationship being examined, and subconsciously provides responses that overstate that relation. While these concerns need to be taken seriously, it is important to bear in mind that it is systematic relations between any biases in response and the explanatory variable in the analysis, and not simply the presence of any errors, that would contaminate the results. The fact that subjective, as opposed to objective, measures of benefits are being used really means that our analysis uses a proxy for the dependent variable of interest. The first of the concerns identified above simply points to the presence of measurement errors in the dependent variable, and does not imply any systematic link between those measurement errors and firm size, number of suppliers, or differences amongst suppliers' features. The second concern speaks directly to the possibility that responses could be biased in a way that varies with the explanatory variable, but here again the concern is overstated.

The fear that respondents could deduce the desired relation from the questions asked is unconvincing, since each questionnaire contained a large number of questions.[5] The dependent variable in our analysis is the perceived value to the organization from using IS for the Suppliers and Purchase Order application. This application manages all the details regarding the organization's suppliers and each raw material purchase order. Specifically this application governs the procurement of raw materials. The information provided by this application helps the organization in planning the purchase of raw materials according to the production plan and the anticipated needs for raw materials. This application also provides the purchasing managers with information regarding previous purchase orders. Such information enables the purchasing managers to conduct a more detailed sensitivity analysis, including a comparison of the benefit derived by quantity discount versus the added holding costs of the inventory for a longer time. It also allows the firm to better negotiate with its suppliers. By using this information the organization can obtain the best prices for raw materials and receive supplies close to the date they are needed.

These potential benefits should be larger the greater the potential for IS to lower search costs or the greater the potential gain from lowering unit costs. The potential reductions in search costs are greater the larger the initial search cost, which should be correlated with the complexity of prospective suppliers' offers. Ceteris paribus, we would expect a greater potential for firms to gain from adopting IS (1) the larger the number of potential suppliers they deal with; (2) the larger the number of orders they make in a typical month; (3) if there are differences between potential suppliers' offers, either in terms of price, lead time, or quality; or (4) if some of the potential suppliers offer price discounts based on quantity. The potential gain from lowering unit costs will be greater the larger the initial share of raw materials in the firm's overall costs. It will also be greater the larger the firm's potential to expand production following a reduction in unit cost. Economic theory predicts that smaller firms (which tend to be higher cost firms) will generally realize a larger increase in equilibrium output and profits for a given reduction in unit costs. Thus, we would expect the potential gain from adopting IS to be positively correlated with the share of raw materials in the firm's costs, and negatively correlated with the firm's size.

Based on the above description, we used the following variables in our empirical analysis:

(1) the relative share of cost of raw material in the overall cost of the final product;
(2) a variable reflecting differences among the suppliers' lead times;
(3) a variable reflecting differences between suppliers' prices;
(4) a variable reflecting differences between the quality of suppliers' products;
(5) a variable reflecting possibility of obtaining raw material price discounts as a function of ordered quantity;
(6) the average lead time of all the raw materials the organization uses (in days);
(7) the number of suppliers the firm maintains contact with;
(8) the average number of purchase orders per month;
(9) a variable reflecting the firm's size (annual sales, in US $).

Most of these variables are self-explanatory. The variables reflecting differences between potential suppliers and the firm's size require further discussion. Suppliers can differ in terms of supply lead time, price, and quality. When there are differences among the suppliers regarding these attributes, more-combinations have to be checked, and a greater amount of information is needed to choose the best supplier for a specific purchase order. We capture these effects by using dummy variables. The respondents were asked questions like: "Are there differences in lead time among the suppliers? YES/NO." The dummy variable reflecting differences among the suppliers' lead time takes the value 1 if the respondent indicated there were differences and 0 otherwise. The dummy variable reflecting differences among the

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suppliers' prices takes the value 1 if there are differences in the suppliers' prices, and 0 otherwise. The dummy variable reflecting differences among the suppliers' qualities takes the value I if there are differences in the quality of products from the firm's suppliers, and 0 otherwise. Finally, the dummy variable reflecting the possibility of obtaining raw material price discounts as a function of ordered quantity takes the value 1 if some of the firm's suppliers offer quantity discounts, and 0 otherwise.

There are several potential variables that might reflect firm size, including the number of employees per establishment, the number of employees per firm, value added per establishment, sales per establishment, and the firm's total sales [10]. At first blush, these variables would appear to provide a roughly equivalent picture of firm size. It has been observed, however, that IS lends to induce firms to substitute skilled labour for unskilled labour, with the net effect on employment being indeterminate [7]. Thus, we prefer not to use a measure that is tied to the number of employees. Our model suggests firm size will matter to the extent that smaller firms have a greater potential for cost savings; so that one expects smaller firms to perceive larger benefits. On the other hand, it has been argued that IS may enhance potential networking externalities, which would tend to favour larger firms. Under either scenario, firms with smaller sales differ in a predictable way from firms with larger sales. But having larger sales does not imply a larger value added, since a small firm with a large margin might easily have a greater value added than a big firm with a small margin. Thus, we prefer not to use a measure that is related to value added. For these reasons, we adopt the firm's annual sales, in US dollars, as our measure of firm size.

IV. RESULT ANALYSIS

We now turn to the task of statistically identifying the relation between perceived benefits for firm I (Y_i) and relevant organizational characteristics. In this analysis, we hypothesize that perceived benefits can be explained by the following variables:

X_{1i} = the relative share of raw materials in firm i's overall cost,
X_{2i} = 1 if and only if there are differences in lead time among firm i's suppliers,
X_{3i} = 1 if and only if there are price differences among firm ;'s suppliers,
X_{4i} = 1 if and only if there are quality differences among firm i's suppliers,
X_{5i} = 1 if and only if some of firm i's suppliers offer price discounts as a function of ordered quantity.
X_{6i} = the average lead time of raw materials for firm i,
X_{7i} = the number of suppliers firm i deals with,
X_{8i} = the average number of purchase orders firm i makes per month,
X_{9i} = firm i's sales, in US $.

Specifically, we consider the following regression equation:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i} + \eta_i,$$

where n_i, is a disturbance term. For now, we assume that the disturbance term satisfies the assumptions in the Gauss – Markov theorem, namely that it is identically and independently distributed across agents, and that this distribution is symmetric about a mean of zero. We discuss the implication of relaxing the assumed homoscedasticity below. We analyzed this regression using ordinary least squares (OLS).[6]

The formal hypotheses we wish to test, and the associated alternative hypotheses are:

H_o: $\beta_k = 0$ (regress or k does not matter);

H_a: $\beta_k > 0$ for $k = 1, \ldots, 8$, or $\beta_9 < 0$.

The alternative hypotheses are based on the discussion from section 2.
These hypotheses can be tested by comparing the J-statistic for $f5_k$ against the critical point on a Student's ^distribution. Because each alternative hypothesis is one-sided, the null hypothesis of no impact in favour of the alternative hypothesis suggested by our model in each case.

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Table 2
OLS regression results.

Independent variable	Point estimate	f-statistic
Intercept	0.0377	0.09
Relative share of cost of raw materials in	0.05129	10.70a
Lead time differences among the suppliers	0.4615	2.80[3]
Price differences among the suppliers	0.7163	3.21[a]
Quality differences among the suppliers	0.2756	1.64[b]
Price as a function of ordered quantity	0.7597	3.94[a]
Average lead time of raw materials	0.01528	5.6 l[a]
Number of suppliers	0.00028	2.06[b]
Number of orders per month	0.00117	3.71[a]
Sales	-0.00440	—2.17[b]
R – squared = 48.3%		
Adjusted R – squared = 46.5%		

The coefficient on sales deserves particular discussion. Since this coefficient has a negative sign, the implication is that smaller firms perceive larger benefits than larger firms from applying IS to the management of suppliers' orders. This could occur because small firms have larger unit costs than big firms, and so have a larger potential to reduce their raw materials costs. An alternative explanation, suggested by Brynjolfsson [25], is that IS reduces the transactions costs firms must bear when they choose to increase their dealings with outside sources. Ceteris paribus, this will favour firms with smaller internal production, and be less favourable for firms that have large levels of internal production, i.e., firms that are heavily vertically integrated. To the extent that vertical integration has generated a competitive advantage in recent times, one might expect larger firms to have a larger degree of vertical integration. In such an event, smaller firms might perceive a larger potential benefit from using IS to manage the supplier order application. A hypothesis that our results are not supportive of, is that IS favors larger firms.

While these results unequivocally indicate each variable has a statistically important effect on perceived benefits, ihis does not imply the effect is economically significant. To assess economic importance we must consider the elasticity of perceived benefits with respect to each independent variable. To construct each of these elasticities, we first calculate the average values for perceived benefits, K_a, and each of the independent

variables, Xka, k = 1 , ….. 9. The elasticity of perceived benefits with respect to the kth independent variable is:

$$e^* = \beta_k X_{ka}/Y_a.$$

Observe that e* may be interpreted as the percentage change in perceived benefits due to a one percent change in the kth independent variable.[9]Estimates of these elasticity's are given in table 3.

Table 3
Implied Elasticities for suppliers and purchase order application.

Independent variable	Point estimate	Elasticity
Relative share of cost of raw materials in	0.05129	0.4706
Lead time differences among the suppliers	0.4615	0.0588
Price differences among the suppliers	0.7163	0.1243
Quality differences among the suppliers	0.2756	0.0792
Price as a function of ordered quantity	0.7597	0.1282
Average lead time of raw materials	0.01528	0.1290
Number of suppliers	0.00028	0.0104
Number of orders per month	0.00117	0.0302
Sales	-0.00440	-0.0386

We note that the independent variable with the largest elasticity is the relative share of raw materials in the overall cost of the final product. This is comforting, since one expects that potential benefits from using an IS application to manage supplier orders would be positively and strongly related to the potential cost savings, which in turn is linked to

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raw materials' relative share in costs. It is interesting that the three variables with the next largest impact are "average lead time", "price as a function of ordered quantity", and "price differences among suppliers". This is completely consistent with the trade off we described at the outset, where the firm may have to compare "just in time" delivery of a shipment of raw materials that just meets its current needs against a larger shipment that brings a quantity discount, but forces the firm to bear additional inventory holding costs. The comparison of such possibilities is precisely the sort of "what if" sensitivity analysis that we argue can be facilitated by applying IS. Such comparisons are all the more complex when the firm's potential suppliers offer different prices as well.

One potential criticism of the regression analysis presented above is that it does not allow for idiosyncratic differences across firms in different industries. In particular, it is conceivable that firms in industries that manufacture electronic components will assess different benefits to IS as compared to firms in food processing industries. This could occur because there are intrinsic differences in the benefits from IS in different industries. Alternatively, firms in a given industry may hold similar subjective views towards the potential for IS to lower their costs, and these attitudes could differ from firms in some other industry, whether there are any true differences or not. Idiosyncratic industry effects can show up as systematic differences in perceived benefits, i.e., they may cause the value of the intercept β_0 in the regression equation above to differ across industries. Industry specific dummy variables would capture such idiosyncratic differences. Alternatively, the variance of the disturbance term $_i$, could be tied to the industry in which firm *i* participates. While OLS still produces unbiased coefficient estimates in such a setting, the associated estimates of the covariance structure are biased. In this case, a weighted least squares approach that allows the variance of the disturbance term to differ across industries would be appropriate.

As a robustness check of our results, we ran a second regression that allowed for both these types of industry specific effects. In this regression, we replaced the common intercept term with dummy variables for each industry. We also allowed for different variances in different industries, and used the information on these different variances to perform weighted least squares. Our survey asked the respondent to identify the industry the firm participated in from the following list: wood, metal, food, textile, rubber, chemistry, paper, electronic, or "other". This allows us to define dummy variables for each of these ten categories. For example, the dummy variable for wood is coded as "1" for every firm that indicated it was in wood and "0" for all other firms. The results of this regression are reported in table 4.

There are several features we wish to point out here. First, the industry specific effects do vary across industries, although the statistical significance of this variation is borderline.[10] Second, the goodness of fit measures is roughly similar to the ones reported above. While there is an increase in *R*-squared, this is to be expected because of the inclusion of extra regress or s. Finally, most of the coefficients on the other variables are quite similar to their analogs in the original regression, as reported in table 2, although the estimated coefficient on quality differences is no longer significant. We conclude that the results we reported above remain significant when industry specific effects are allowed for. These findings are consistent with findings presented by Ragowsky and Adams. They compared the impact of organizational characteristics on the benefit the organization gains from using IS applications with the impact of the sector (wood, metal, etc.) the organization belongs to on this benefit. They found that specific organizational characteristics have strong impacts on the benefits that organizations gain from using IS applications and that sectorial classification was less important in that respect.

On the whole, our empirical results are corroborative of our discussion in section 2. In addition, they demonstrate a link between organizational characteristics and the value of an IS application for manufacturing organizations.

Table 4
Weighted least squares regression results, industry dummies included.

Independent variable	Coeff.	St. Dev.	t – statistic
Intercept	2.4681	0.5165	4.78[a]
Relative share of raw materials in overall cost of the final product	0.0538	0.0049	I0.95[a]
Lead time differences among the suppliers	0.4129	0.1701	2.43[a]

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Price differences among the suppliers	0.6086	0.2243	2.71[a]
Quality differences among the suppliers	0.1755	0.1720	1.02
Price as a function of ordered quantity	0.6972	0.1945	3.49[a]
Average lead time of raw materials	0.0121	0.0029	4.12[a]
Number of suppliers	0.00026	0.00014	1.87[b]
Number of orders per month	0.00116	0.00032	3.66[a]
Sales	-0.0038	0.0020	— 1.85[b]
Wood	0.1405	0.6455	0.2178
Metal	-0.2061	0.5070	-0.407
Food	-0.8075	0.5271	-1.53
Textile	-0.4237	0.5372	-0.789
Rubber	0.1261	0.5306	0.238
Chemistry	-0.4035	0.5374	-0.751
Paper	-0.3274	0.5656	-0.579
Electronic	0.0310	0.5179	0.060
Construction	-0.5399	-0.6156	-0.877
$R-$ squared $= 50.1\%$ Adjusted $R-$ squared $= 46.6\%$			

a Estimate significant at 1% level (one-sided test).
b Estimate significant at 5% level (one-sided test).

V. DISCUSSION AND CONCLUSION

In this paper we have posed and tested a model describing the potential for IS to benefit manufacturing firms by allowing them to analyze a greater number of offers from raw materials suppliers. Interpreting this as a reduction in the cost of making an additional search for a lower cost supplier, we characterize the value of information induced by adopting IS. Our model predicts that the benefits from IS adoption should be positively correlated with the number of potential suppliers, the average number of orders in a typical month; the presence of differences between potential suppliers' offers, either in terms of price, lead time, or quality; the presence of price discounts based on quantity and the share of raw materials in overall costs, and negatively correlated with the firm's size. Using a sample of 310 manufacturing firms, we were able to empirically confirm each of these predictions.

The benefit a manufacturing organization may gain from an IS application is a crucial factor when considering any investment in IS. Most previous studies sought a relationship between the entire IS application portfolio of the organization and the performance of the entire organization. These studies generally fail to detect a positive relationship between the investment in IS and the performance of the organization. We expanded the findings presented by Barua et al. [20] and the two studies presented by Mukhopadhyay et al. [19] and Mukhopadhyay et al. [20]. While the last two studies focused on the impact of individual IS applications on the output and the quality of the process, we focused on the benefit an organization may gain by using an individual IS application, namely applying IS to lower the cost of searching for a cheaper source of raw materials, and the organizational characteristics that impact this benefit. The analyses performed in this study found a relationship behind the benefit a manufacturing organization may gain from using a specific application, as a function of organizational characteristics such as the presence of significant differences among the unit's suppliers, the relative importance of raw materials, the number of suppliers the firm uses, the number of orders it makes, and firm size.

We found that these characteristics have a significant impact on the benefit the organization gains from using an individual IS application. As mentioned in section 2, by using a decision support system, a manufacturing organization can identify a less expensive offer for the needed raw materials. This, of course, will reduce the overall costs of the organization and will contribute to the organizational performance. Yet, the contribution will be more or less significant based on the organizational characteristics (e.g., the value of raw materials out of the total costs of the product). Hence, the decision of what applications to implement should be based on the organizational characteristics.
Obviously there are many more individual IS applications that can be used by manufacturing organizations to support the organization's performance either by lowering costs or by increasing sales. The purpose of this study is to present

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and examine a new approach to relate the benefit derived from using IS to the performance of the organization and not to analyze all the possible applications. Our findings indicate that the contribution of IS to the manufacturing organization's performance depends on various organizational characteristics. By using the approach presented in this study, other studies can develop similar models in order to relate other individual IS application to the performance of manufacturing organizations. For example, as we described above, the MRP application can be useful for inventory levels reduction, but not every organization may need it. Some organizations (e.g., process manufacturing plant) will not gain much benefit from using it, and other organizations (e.g., automotive suppliers) may have to pay a penalty if relying on the MRP recommendations. The customers' management application may be more beneficial the more complicated the product is and the more it is adjusted to the customer's specification.

By using the approach presented in this paper, IS managers can better identify the best way to invest in organizational information systems. The business value of IS should be identified for each activity area by itself, and determined for each application rather than an entire portfolio of applications. In addition, the business value of a particular application depends upon how the functionality of the application relates to the organizational characteristics that are related to the particular activity area that is supported by the individual application. These findings suggest that decisions on IS investment should be made at the application level.

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