A Hybrid Performance Measure System For E-Business Investments In High-tech Manufacturing: An Empirical Study

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Abstract

For over a decade, empirical studies examining organizational performance of IT investment have been far from conclusive. An issue that has led to the ongoing debate is inadequate methodology applied in measuring IT values. The traditional measures have been focused on financial ones such as return on investment and return on sales. Researchers therefore suggested the need to use more non-financial measures; however, there appeared to be little agreement on precisely which ones to use. Empirical studies also showed the limitations with only a single organization-level measure. A more complete assessment might simultaneously involve the measures from several levels of organizational hierarchy. Besides, benefits from IT investment may be realized over an extended period of time. Therefore, this study proposed an integrative assessment framework based on a three-level structure of organizational hierarchy, such as corporate strategies, manufacturing decisions, and operational activities, with the effect of time lag. The performances of corporate strategies will be examined over a recent three-year time period, manufacturing decisions over a recent two-year time period, and operational activities over a recent one-year time period. Finally, this framework was verified by a survey study of large sample size. The results reported that the effect of time lag on the performance measures of corporate strategies was significant and the relationship between performance measures of corporate strategies and operational activities was significant.

Key words: Productivity paradox, E-business, IT investment, Performance measure.

1. Introduction

In the Internet era, it is about the time to rethink traditional manufacturing processes and relationships with suppliers and customers, and enhancing those with information technology (IT) in order to collaborate with trading partners in real time. The first wave of Internet procurement focused primarily on automation of the internal workflow. The next wave will offer applications that provide decision support as well as reporting and analysis tools. However, for the transformation from the traditional business to e-business in manufacturing, this needs vast investments in IT. Top Managers were often in a difficult position to consider the value justification of e-business (EB) investments.

For over a decade, empirical studies in the IT value literature have also attempted to quantify the benefits realized from IT investments. Although the intent of much of this work has been demonstrated positive relationships between IT investment and economic performance measures (e.g., profits and productivity), the results of these studies, especially those related to the contribution of IT to productivity, have been mixed for finding little or no improvement in productivity despite massive investment in IT development (Paradox of IT values). An issue that has led to the ongoing debate is inadequate methodology applied in researching IT values. The measures often used to evaluate an organization’s performance have historically been financial ones, such as the monetary value of sales and profits or percentage return on monetary investment (White, 1996). These financial measures were regularly classified as internal focus, in contrast to external focus of market share and growth (Lynch and Cross, 1991). In fact, these measures were mostly defined in terms of more concrete business activities within organizations and can be identified as operational measures accordingly.

Perhaps the most serious issue in measuring organizational performance resulting from IT has been that IT payoff is considered in isolation and separate from other organizational practices (Devaraj and Kohli, 2000). Similarly, there were other suggestions that different performance measures be used at different levels of the organizational hierarchy (Lynch and Cross, 1991; Kaplan and Norton, 1992). Although many authors agreed on the need to use more non-financial measures, there appeared to be little, if any, agreement on precisely which measures to use. This study, therefore, recognized an important concept of the strategic potential of IT in use, in particular for the currently major e-business streams of SCM, ERP, and CRM, for implementing a firm’s business strategy to achieve competitive advantage (Mata
et al., 1995; Clemons and Hann, 1999). This concept has not been discussed in the past research of organizational performance measures. Moreover, Wheelwright (1978) suggested that performance measures in manufacturing be tied to the organizational strategy as reflected by its manufacturing decisions. Although different authors have selected different sets of manufacturing decisions, the common ones are, for instance, efficiency, dependability, quality, and flexibility (Maskell, 1991; Anderson et al., 1989; Richardson et al., 1985). Furthermore, because an organization is a complex system, when one factor is changed, meaningful evaluation may need to go beyond immediate, isolated outcomes, to consider long-term system change as well (Chan, 2000). More specific, the values of e-business investments may be realized over an extended period of time, in particular for non-financial measures (Brynjolfsson, 1993).

Therefore, this study proposed a hybrid performance measure system based on three levels of the organizational hierarchy, such as corporate strategies, functional decisions, and operational activities, with time-lag effects for e-business investments in manufacturing industries. Furthermore, because high-tech industries are more likely to have this kind of e-business experience, therefore, the firms from the high-tech industries will be the subjects to empirically examine this framework. Some of the important issues related to the topics were further discussed, for instance, the impact of time lag on the performance measures of corporate strategies and the relationships between the performance measures of corporate strategies and other organizational levels. The findings can serve as decision aid of e-business investments in high-tech industries for senior management and further be extended for the adopting consultation of e-business in other industries, such as service and traditional industries.

2. Literature Review

2.1. Traditional performance measures and limitations

Traditionally, the internal performance measurement systems used within companies have been primarily based on management accounting systems. This has resulted in most measures focusing on financial data such as return on investment, return on sales, profit per unit production, sales per employee, etc. Of these performance measures productivity in general has been considered the primary indicator of a technology’s contribution. Although IT productivity paradox was originally defined at the economy level and some studies have been carried out at national and industrial levels, most MIS researchers have addressed the productivity question at the firm level. Studies examining these kinds of firm-level performance have often led support to IT productivity paradox.

Many researchers have discussed general limitations of traditional performance measures (Brynjolfsson, 1993; Ghalayini and Noble, 1996). The following present the most commonly cited limitations. First, the most significant limitation of traditional performance measures is that they are based on traditional management accounting systems. Labor was the major cost driver and other costs were de-emphasized by putting them together in one overhead category. However, today labor was no longer a significant portion of the total cost in a company. Second, new technology investment may not have immediate impacts on organizations and sometimes can take several years to show results. Lags of two-to-three years can be found due to users may require learning and adjustment to get proficient in new technology (Brynjolfsson, 1993).

Third, the benefits of aggregated IT investments can be redistributed within or across organizations for a firm level or industry level and as a result, their improvements may not be reflected in financial performance measures as a whole. More specifically, traditional financial reports are inflexible in that they have a predetermined format used across all departments; however, even departments within the same firm have their own characteristics and priorities. Thus, performance measures used in one department may not be relevant for others (Ghalayini and Noble, 1996). Fourth, reducing cost has always been considered an effective weapon to achieve competitive advantage. However, customers’ demands have been changed and low cost is no longer the most important factor for competing in most markets. Skinner (1986) argued that to be competitive you should concentrate on quality, reliable delivery, short lead times, customer service, product innovation, flexible capacity and efficient capital deployment.

2.2. Emerging performance measures for corporate and functional decisions

After reviewing and assessing the research to date, it looks like mismeasurement stands for the core of the productivity paradox. Rapid innovation has made IT-intensive industries particularly susceptible to the problems associated with measuring quality changes and valuing new products.
Increased variety, improved timeliness of delivery and personalized customer service are additional benefits that are poorly represented in productivity statistics. These are all qualities that are particularly likely to be enhanced by IT (Brynjolfsson, 1993).

Barua et al. (1995) examined the effect of IT on intermediate-level variables such as capacity utilization, inventory turnover, relative quality, and new products. They have related these intermediate variables to final performance variables such as market share and ROA. Schein (1996) discussed the limitations of assessing IT impact with only an organization-level approach to analysis, or with any single measure (e.g., ROI). A more complete assessment of technology innovations might involve several levels of analysis, such as the strategic, tactical and operational levels, and several sets of measures. Because an organization is a complex system, when one factor is changed, meaningful assessment may need to go beyond immediate, isolated outcomes, to encompass long-term system changes or strategic impacts as well. Thus, longitudinal studies for IT evaluations may be required.

Therefore, much of the recent discussion in the literature has focused on the performance of strategic alignment with IT investment (Chan et al., 1997, Neumann, 1994). In particular for manufacturing, manufacturing decisions/strategies and performance measures were originally linked together in the article of Skinner (1969), the seminal work in operations strategy (Adam and Swamidass, 1989; Anderson et al., 1989). Skinner laid the groundwork for improvements in performance measures through his criticism that the connection between manufacturing and corporate success is rarely seen as more than the achievement of high efficiency and low costs.

Following the work of Skinner, Wheelwright (1978) went to suggest same concept and further, four manufacturing strategies for performance measures to tie to organizational performance, i.e., efficiency, dependability, quality, and flexibility. Noble (1995) also indicated that better performing competitors should build manufacturing capabilities in a sequential and cumulative manner: starting with quality, followed by dependability, delivery, efficiency, flexibility, and finally, innovation.

2.3. Identification of corporate strategies

The identification of corporate strategies must be able to predict future development, take the lead in business process thinking, and draft plans for emergency, to meet the future and uncertain challenges. These methods to develop strategic opportunities include: a five competitive force model, analysis of the value chain (Porter, 1985), the strategic target/strategic thrust matrix (Wiseman and MacMillan, 1984), critical success factors (Rochart, 1982), the customer resource life cycle (Ives and Learmonth, 1984) and McFarlan’s framework (McFarlan, 1984). However, the adoption of these methods to identify strategic opportunities and further the application of IT to achieve the strategic opportunities have not been reported very clear in the literature, except for the value chain and strategic thrust/strategic target matrix (Bergeron et al., 1991). The first considers the analysis of internal functions and hopefully achieves competitive position through the changes of internal functions, while the second is directed to the analysis of external environment, for which the proper strategies are developed toward certain targets. This matrix constitutes three strategic targets: suppliers, customers, and competitors, and five strategic thrusts or competitive strategies: cost, innovation, growth, strategic alliance, and differentiation.

2.4. Integrated performance measurement frameworks

The complexity of managing an organization today requires that managers be able to view performance in several areas simultaneously. Reliance on one instrument may not really reflect organizational performance and could only lead to sub-optimization. In particular for manufacturing activities, the improvement on the linkage between corporate strategies and manufacturing decisions may have an influential role on measuring business performance as a whole (Richardson et al., 1985). Accordingly, past research has proposed a couple of integrated performance measurement frameworks in order to provide an overall view of company’s performance and to guard against sub-optimization.

The strategic measurement analysis and reporting technique (SMART) was developed by Wang Laboratories, Inc. (Lynch and Cross, 1991). It can be represented by a four-level pyramid of objects and measures. At the top is the corporate vision or strategy. At the second is the market and financial performance measures defined for each business unit. At the third level, more concrete objectives or measures, such as customer satisfaction, flexibility and productivity, can be defined for each business operating system. At the fourth level, the department and work centers are evaluated by specific operational criteria such as quality, delivery, process time and cost. As the foundation of the performance
measures pyramid, the lower-level performance measures are the keys to achieve higher-level results and subsequently, ensure successful implementation of the firm strategy. However, the performance measures of financial, productivity, and cost defined at the three different levels of the pyramid are rather confused with the discussions in the literature. Indeed, financial measures such as monetary value of productivity and cost are generally considered as the measures of internal focus rather than external focus in the literature. This is contradictory to SMART definition in that financial measures are defined for measuring the higher-level performances, i.e., business unit.

The balance scorecard allows managers to look at the business from four important perspectives, i.e., customer, innovation and learning, financial, and internal business, and further links their goals and performance measures with them (Kaplan and Norton, 1992). It provides answers to four basic questions: How do customers see us? (Customer perspective); Can we continue to improve and create value? (Innovation and learning perspective); How do we look to shareholder? (Financial perspective); What must we excel at? (Internal business perspective). The balance scorecard attempts to integrate the four important performance perspectives in a simple and easy-to-use management report. The performance measures basically are not founded on the structure of organizational hierarchy and instead, cyclically influence each other, such as the interaction between financial and internal business perspectives and subsequently, the financial and customer perspectives. The same contradictory problem for financial measures as discussed in SMART also occurs in here.

In sum, except for the contradictory definition of financial measures, major common limitations adherent to them include as follows. All of them do not look ahead to predicting, achieving and improving future performance and are only concerned with present performance (Ghalayini and Noble, 1996). In fact, performance measures for higher levels, such as corporate strategy and business unit, may often need to take an extended period of time to show. Next, researchers have argued an important concept for performance measures that lower-level impacts in organizations should, in turn, influence higher-level performances (Mukhopadhyay and Cooper, 1992). This concept also implies that the effect of time lag is an important moderator while assessing higher-level performance measures within the organizational hierarchy. In particular, it would be necessary to include while a hybrid performance measure system simultaneously involves various levels of performance measures within the organizational hierarchy.

3. Theoretical Framework

Although many authors have suggested some integrated performance measurement systems such as SMART and balance scorecard, however, there were some debates discussed above adherent to them. There is a need for a new approach to effectively demonstrate the relationship between IT investment and organizational performance. Therefore, this study proposed a hybrid performance measure system based on a three-level structure of Anthony’s organizational hierarchy, such as corporate strategies, functional decisions, and operational activities, with time-lag effects for e-business investments in manufacturing industries. This framework is depicted as in Figure 2 and primarily discusses the following problems: (1) the effects of time lags on the performance measures of corporate strategies and manufacturing decisions, (2) the relationships between the performance measures of corporate strategies and other two organizational levels.

This study primarily concerned the performance measures from e-business investments in high-tech manufacturing industries and therefore, a survey from a large sample size of firms in these industries was then required. Moreover, this study also intended to understand lag effects of e-business investments and theoretically, longitudinal study should be more adequate for examining the data collected from the sample firms over recent periods of time. However, longitudinal studies in the literature were basically limited to large sample size and more suitable for the situation of case study (Devaraj and Kohli, 2000; Verona and Prandelli, 2002). The reasons for the difficulties may be explained as follows. The first is the difficulty for maintaining the same sample firms continuously joining this study over recent periods of time. The second is the difficulty for confirming the same respondents continuously participating in the data collection process within their firm over recent periods of time. The third is the difficulty for keeping the data reported from the same respondents in a consistent way over recent periods of time.

Importantly, research design for the data collected process should be cautiously arranged to overcome the above problems. First, the qualified sample firms for this study should have number of years experience in e-business investments. Second, respondents from the sample firms were requested to recollect their understanding on the performances of e-business investments over recent years and comparatively rated the similarities and differences of these years in a consistent way. The literature has
also suggested that in general, time lags over three years may be sufficient to provide meaningful results for organizational performance measures (Barua et al., 1995; Mukhopadhyay et al., 1997; Brynjolfsson, 1993). More specifically, higher levels of performance results would be expected to take longer years to show than lower levels. Therefore, this study was designed to discriminate the three levels of performance measures by the measures of corporate strategies across a three-year time period, manufacturing decisions across a two-year time period, and operational activities for a regular one-year time period.

In addition, the analytical technique used to identify corporate strategies in organizations was the strategic thrust/strategic target matrix as described earlier. The performance measures for manufacturing decisions/strategies were based on the four evaluation criteria of efficiency, dependability, quality, and flexibility as discussed above. Finally, the traditional financial measures discussed in the literature, such as return on investment, return on sales, sales by total assets, sales by employees, were used for the performance measures of operational activities. Accordingly, the following hypotheses were proposed to verify the two problems discussed in this framework. There are two hypotheses for the first problem in terms of the time-lag effects on the performance measures of corporate strategies and manufacturing decisions. Similarly, two hypotheses for the second problem are presented in terms of the relationships between the performance measures of corporate strategies and other two organizational levels. However, since proper corporate strategies are identified toward three different targets, such as suppliers, customers, and competitors, in the analysis of strategic target/strategic thrust matrix, there are three sub-hypotheses (e.g., H1a, H1b, H1c) for Hypotheses 1, 3, and 4 respectively.

Hypothesis 1: For suppliers (H1a), customers (H1b), and competitors (H1c), the effects of time lags on the performance measures of corporate strategies are not significant.

Hypothesis 2: The effects of time lags on the performance measures of manufacturing decisions are not significant.

Hypothesis 3: For suppliers (H3a), customers (H3b), and competitor (H3c), the relationship between the performance measures of corporate strategies over a three-year time period and manufacturing decisions over a two-year time period are not significant.

Hypothesis 4: For suppliers (H4a), customers (H4b), and competitor (H4c), the relationship between the performance measures of corporate strategies over a three-year time period and operational activities over a regular one-year time period are not significant.

4. Research Design

4.1. Instrumentation

The questionnaire consisted of four major parts. The first part uses nominal scales. The second part uses both nominal and 7-point Likert scales for two sub-parts. The third and fourth parts use 7-point Likert scale. The first part was used to collect basic information about organizational characteristics including industry, annual revenue, number of employees, and respondent characteristics including education, age, experience, and position.

The second part concern with performance measures of corporate strategies was further divided into two sub-parts. The first sub-part used the strategic thrust/strategic target matrix to define corporate strategies such as cost, innovation, growth, alliance, and differentiation toward the targets of suppliers, customers, and competitors respectively. The second sub-part was designed for the performance measures
of the previously defined corporate strategies over one-year, two-year, and three-year time periods respectively. Respondents, therefore, were requested to recollect their experience on the performances over recent one to three years. There would be three data sets for analyzing time-lag effects on the performance achievements of corporate strategies.

The third part concern with performance measures of manufacturing strategies was adapted from Wheelwright (1978) and Noble (1995) as discussed above, including four evaluation criteria, i.e., efficiency, dependability, quality, and flexibility, and these measured using six items, five items, six items, and four items respectively. Similarly, time lags were also considered for the potential performance impacts on manufacturing strategies and therefore, respondents were requested to recollect their experience on the performances over the recent one-to-two years.

The fourth part concern with performance measures of operational activities was mainly relevant to the traditional productivity measures and was adopted from Mahmood and Mann (1993). It contains six items: return on investment, return on sales, growth in revenue, sales by total asset, sales by employee, and market to book value. In general, operational performances were often evaluated on a regular one-year time period.

4.2. Sample organizations and respondents

This study primarily discussed the contributions of e-business investments in organizations from the perspective of strategic alignment. The qualified firms for this study require the emphasis on massive IT investments and have a number of years in the investments. Thus, it was assumed that high-tech, larger manufacturing firms would be more likely to have this experience. A study sample from the high-tech manufacturing industries comprising 932 firms was thus selected from the year of 2002 listing on the high-tech firms published by Taiwan Stock Exchange Corporation. Furthermore, CIOs or IS managers were selected as respondents based on this sample.

In order to improve survey return, telephone calls or letters were used to follow up after 3 weeks. 154 firms replied, with 14 incomplete responses deleted, resulting in a total sample of 140 firms for a 15% response rate. The seemingly low response rate raised the concern about non-response bias. A test for non-response bias was conducted using two responding subsamples: early and late respondents. They were correlated on their annual revenue and working experience. There was not significantly systematic non-response bias in the responding sample.

4.3. Scales validation

Confirmatory factor analysis (CFA) was used to analyze scales validation. This procedure describes as below. First, a measurement model should be assessed for goodness of fit. The literature suggested that, for a good model fit, chi-square/degrees of freedom (χ²/df) should be less than 3, adjusted goodness-of-fit index (AGFI) should be larger then 0.8, goodness-of-fit index (GFI), normed fit index (NFI), and non-normed fit index (NNFI) should be greater than 0.9, and root mean square error (RMSE) should be less than 0.10 (Henry and Stone, 1994; Scott, 1994). Secondly, convergent validity can be assessed by three criteria. Factor loading (λ) for an item is at least 0.7 and/or significant for t-value, construct reliability is a minimum of 0.8, and average variance extracted (AVE) for a construct is larger than 0.5 (Fornell and Larcker, 1981). Finally, discriminant validity can be assessed by the measure that AVE for a construct should be larger than the squared correlation between the construct and other constructs.

For the part of questionnaire with the performance measures of corporate strategies, since it was defined by a well-documented technique in the literature, the scale reliability and validity should be certainly considered as acceptable. For the parts of questionnaire with the performance measures of manufacturing strategies and operational activities, the indices for the measurement model indicated a poor fit. GFI (0.85) and AGFI (0.77) were below the acceptable levels. The results from the model also indicated that two items of efficiency, dependability, and quality, as well as one item of flexibility had item factor loadings lower than 0.7. The literature suggested that model fit could be improved by re-specifying the model without these items (Segars and Grover, 1993). The re-evaluation results showed a good fit with χ²/df (0.96), AGFI (0.88), GFI (0.92), NFI (0.96), NNFI (0.98), and RMSE (0.02). The results of convergent and discriminant validities for the four constructs of the performance measures of manufacturing strategies and the one construct of the performance measures of operational activities are presented in Table 1. They all indicate a relatively high degree of reliability and validity.
5. Analysis And Findings

5.1. Lag effects on the performances of corporate and functional strategies

First, time-lag effects on the performance measures of corporate strategies from e-business investments were examined respectively in terms of the three strategic targets of suppliers, customers, and competitors. The proposed relationship structure indicates time-period lag and choice of corporate strategy as two independent variables, and performance measure of corporate strategy as one dependent variable. Moreover, time-period lag with three levels of time periods (one year, two years, and three years) and choice of corporate strategy with five levels of alternative choices (cost, innovation, growth, alliance, and differentiation) are of non-metric attributes, and performance measure of corporate strategy is of metric attribute. Therefore, two-way ANONA was used to analyze their relationship.

For the target of suppliers, the testing results are shown in Table 2. The effects of time lags from e-business investments are significant on the performance measures of corporate strategies. Therefore, Hypothesis 1a is rejected at 0.01 level. In addition, the choices of corporate strategies do not have significant impacts on the performance measures of corporate strategies. For the target of customers, time lags significantly affect the achievements of corporate strategies from e-business investments as indicated in Table 3. Therefore, Hypothesis 1b is rejected at 0.01 level. Besides, the choices of corporate strategies also have significant effects on the performance measures of corporate strategies. For the target of competitors, the results show that both time lags and the choices of corporate strategies significantly affect the performance measures of corporate strategies as indicated in Table 4. Therefore, Hypothesis 1c is rejected at 0.05 level.

In sum of these findings, it can be concluded that time lag is the major determining factor of the performance achievements of corporate strategies regardless of the role of the choices of corporate strategies toward the three strategic targets. Moreover, an analysis of mean differences among the three

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Construct</th>
<th>Factor loading</th>
<th>Construct reliability</th>
<th>AVE</th>
<th>Eff. loading</th>
<th>Dep. loading</th>
<th>Qua. loading</th>
<th>Flex. loading</th>
<th>Prod. loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing strategy</td>
<td>Efficiency</td>
<td>0.85-0.88</td>
<td>0.95</td>
<td>0.82</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Dependability</td>
<td>0.90-0.92</td>
<td>0.96</td>
<td>0.88</td>
<td>0.16</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quality</td>
<td>0.84-0.89</td>
<td>0.95</td>
<td>0.81</td>
<td>0.10</td>
<td>0.15</td>
<td>0.00</td>
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</tr>
<tr>
<td></td>
<td>Flexibility</td>
<td>0.87-0.89</td>
<td>0.94</td>
<td>0.80</td>
<td>0.16</td>
<td>0.20</td>
<td>0.10</td>
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<tr>
<td>Opera. activity</td>
<td>Productivity</td>
<td>0.81-0.88</td>
<td>0.95</td>
<td>0.78</td>
<td>0.24</td>
<td>0.33</td>
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Table 1 Scales reliability and validity

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<tr>
<th>Source</th>
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<th>DF</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
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<tr>
<td>Time lag</td>
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<td>2</td>
<td>3.55</td>
<td>4.74</td>
<td>0.009**</td>
</tr>
<tr>
<td>Corporate strategy</td>
<td>0.72</td>
<td>4</td>
<td>0.18</td>
<td>0.25</td>
<td>0.910</td>
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<tr>
<td>Error</td>
<td>308.82</td>
<td>405</td>
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<tr>
<td>Total</td>
<td>506.12</td>
<td>419</td>
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Table 2 ANOVA results with time lag and corporate strategy toward suppliers

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
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<tr>
<td>Time lag</td>
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<td>2</td>
<td>3.78</td>
<td>5.48</td>
<td>0.004**</td>
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<tr>
<td>Corporate strategy</td>
<td>12.66</td>
<td>4</td>
<td>3.16</td>
<td>4.59</td>
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<tr>
<td>Error</td>
<td>284.99</td>
<td>405</td>
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<td>Total</td>
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Table 3 ANOVA results with time lag and corporate strategy toward customers

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
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<tbody>
<tr>
<td>Time lag</td>
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<td>2</td>
<td>2.32</td>
<td>3.32</td>
<td>0.037*</td>
</tr>
<tr>
<td>Corporate strategy</td>
<td>8.27</td>
<td>4</td>
<td>2.07</td>
<td>2.95</td>
<td>0.020*</td>
</tr>
<tr>
<td>Error</td>
<td>288.93</td>
<td>405</td>
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<td>Total</td>
<td>478.65</td>
<td>419</td>
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Table 4 ANOVA results with time lag and corporate strategy toward competitors

**: P-value < 0.01
*: P-value < 0.05
years of performance measures with Least Significant Difference pairwise comparison method is reported in Table 5. There is only a significant difference for the pair comparison between the third year and the first year for all the three strategic targets. This implies that if there were some lags required to realize the performance of IT investments, we would expect to see more benefits over longer time periods.

<table>
<thead>
<tr>
<th>Strategic target</th>
<th>1-year lag</th>
<th>2-year lag</th>
<th>3-year lag</th>
<th>Group mean difference</th>
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<tr>
<td>Suppliers</td>
<td>Mean</td>
<td>Std.</td>
<td>Mean</td>
<td>Std.</td>
</tr>
<tr>
<td></td>
<td>4.42</td>
<td>.091</td>
<td>4.69</td>
<td>.088</td>
</tr>
<tr>
<td>Customers</td>
<td>4.54</td>
<td>.078</td>
<td>4.79</td>
<td>.073</td>
</tr>
<tr>
<td>Competitors</td>
<td>4.51</td>
<td>.074</td>
<td>4.74</td>
<td>.077</td>
</tr>
</tbody>
</table>

**: P-value < 0.01, *: P-value < 0.05

Next, the effects of time lags on the performances of manufacturing strategies were verified in terms of the relationship structure indicating the performances of four manufacturing strategies as four dependent variables (efficiency, dependability, quality, and flexibility) and time-period tag as one independent variable with two levels of time periods (one year and two years). As dependent variables are of metric attributes and independent variable is of non-metric attribute, MANOVA is the suitable technique to analyze their relationship. The testing results indicate that Wilks’ λ value is 0.41, equivalent F statistic for the Wilks’ λ value is 30.23, and as a result, the probability is less than 0.01. Therefore, Hypothesis 2 is rejected and indicates that time lags have significant impacts on the performance achievements of manufacturing strategies. In particular, univariate F statistics were further examined to understand the performances of four manufacturing strategies varying across the two years of time periods. The testing results are presented in Table 6. Except for efficiency, the rest of the three strategies are all significant for lag effect. This may be explained by that although efficiency criteria was defined as one of manufacturing decisions in the literature, it was practically considered as more likely an immediate measure of IT payoff rather than strategic measure and as a result, time lag would not expect to play an influential role.

<table>
<thead>
<tr>
<th>Manufacturing strategy</th>
<th>1-year lag</th>
<th>2-year lag</th>
<th>F</th>
<th>P-value</th>
<th>Group mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>4.26</td>
<td>.052</td>
<td>4.35</td>
<td>.042</td>
<td>1.14</td>
</tr>
<tr>
<td>Dependability</td>
<td>4.56</td>
<td>.061</td>
<td>4.94</td>
<td>.065</td>
<td>17.86</td>
</tr>
<tr>
<td>Quality</td>
<td>4.41</td>
<td>.054</td>
<td>4.61</td>
<td>.051</td>
<td>6.05</td>
</tr>
<tr>
<td>Flexibility</td>
<td>4.45</td>
<td>.055</td>
<td>4.63</td>
<td>.045</td>
<td>4.30</td>
</tr>
</tbody>
</table>

**: P-value < 0.01, *: P-value < 0.05

5.2. Relationships between performances of corporate strategies and other levels

As discussed in previous subsection, the relationships between performance measures of corporate strategies and other two organizational levels (manufacturing strategies and operational activities) were also verified respectively towards the target of suppliers, customers, and competitors. First, Hypothesis 3 was tested for the relationship between performances of corporate strategies over a three-year time period and manufacturing strategies over a two-year time period. Their relationship structure can be described in terms of performances of four manufacturing strategies as four independent variables and five corporate strategies as five dependent variables. Furthermore, both independent and dependent variables are of metric attributes. Canonical correlation approach was used to analyze their relationship. For the target of suppliers, there exist four canonical functions for this relationship structure and one of them reaches significance as indicated in Table 7. By the same token, canonical correlation analyses for customers and competitors’ targets are also significant. Therefore, Hypotheses 3a, 3b, and 3c are all rejected.

This implies that while time lags are properly considered in the IT payoffs of the functional and corporate strategies (in the case, two years versus three years), the influential relationship between them is significant. Moreover, the relative effects of the performances of four manufacturing strategies on the performances of corporate strategies as a whole can be examined in terms of canonical cross-loadings of the predictor canonical variate as indicated in Table 8. In that, a variable is considered as importance while canonical cross-loading is greater than 3. The results indicate that the performances of four manufacturing strategies are all the important determinants of the performances of corporate strategies. The implication for practice is that senior management in high-tech industries should dedicate to simultaneously improve the
performances of all the four manufacturing strategies rather than part of them in order to optimally achieve the performances of corporate strategies.

Table 7 Canonical correlation analyses between corporate and manufacturing strategies for the three strategic targets

<table>
<thead>
<tr>
<th>Can. function</th>
<th>Can. correlation</th>
<th>Wilks' λ</th>
<th>Chi-Sq</th>
<th>DF</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier</td>
<td>0.630</td>
<td>0.574</td>
<td>74.50</td>
<td>20</td>
<td>0.00**</td>
</tr>
<tr>
<td>Customer</td>
<td>0.681</td>
<td>0.491</td>
<td>95.37</td>
<td>20</td>
<td>0.00**</td>
</tr>
<tr>
<td>Competitor</td>
<td>0.645</td>
<td>0.543</td>
<td>81.79</td>
<td>20</td>
<td>0.00**</td>
</tr>
</tbody>
</table>

**: P-value < 0.01

Table 8 Canonical cross-loadings of the four manufacturing strategies for the three strategic targets

<table>
<thead>
<tr>
<th>Manufacturing strategy</th>
<th>Efficiency</th>
<th>Dependability</th>
<th>Quality</th>
<th>Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier</td>
<td>0.600*</td>
<td>0.555*</td>
<td>0.580*</td>
<td>0.611*</td>
</tr>
<tr>
<td>Customer</td>
<td>0.644*</td>
<td>0.640*</td>
<td>0.664*</td>
<td>0.660*</td>
</tr>
<tr>
<td>Competitor</td>
<td>0.562*</td>
<td>0.539*</td>
<td>0.593*</td>
<td>0.644*</td>
</tr>
</tbody>
</table>

*: Coefficient > 0.3

Next, Hypothesis 4 was tested for the relationship between performance measures of corporate strategies over a three-year time period and operational activities over a regular one-year time period. Their relationship structure can be described in terms of performances of operational activities as one independent variable and five corporate strategies as five dependent variables. That is, items for measuring the performances of operational activities are mainly defined to assess operational productivity and further converged to one construct. Both independent and dependent variables are of metric attributes. Canonical correlation technique was used to analyze their relationship. There exists a significant canonical function for this relationship structure respectively for the targets of suppliers, customers, and competitors as indicated in Table 9. Therefore, Hypotheses 4a, 4b, and 4c are all rejected.

Table 9 Canonical correlation analyses between corporate strategies and operational activities for the three strategic targets

<table>
<thead>
<tr>
<th>Can. function</th>
<th>Can. correlation</th>
<th>Wilks' λ</th>
<th>Chi-Sq</th>
<th>DF</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier</td>
<td>0.561</td>
<td>0.658</td>
<td>51.20</td>
<td>5</td>
<td>0.00**</td>
</tr>
<tr>
<td>Customer</td>
<td>0.541</td>
<td>0.707</td>
<td>47.01</td>
<td>5</td>
<td>0.00**</td>
</tr>
<tr>
<td>Competitor</td>
<td>0.604</td>
<td>0.636</td>
<td>61.38</td>
<td>5</td>
<td>0.00**</td>
</tr>
</tbody>
</table>

**: P-value < 0.01

The IT performances of operational activities over a regular one-year time period and corporate strategies over a three-year time period indicate significantly explainable relationship. Furthermore, canonical cross-loadings of the predictor canonical variate, i.e., the performances of operational activities, for the targets of suppliers, customers, and competitors were all greater than 0.5 and therefore, the achievements of operational activities were the important determinants of the final performances of corporate strategies. The results indicate that while lag effect is properly considered in the IT payoff of corporate strategies, operational productivity plays the intermediate role in accomplishing the goal of corporate strategies. This implies an important fact that if IT values were assessed in terms of the operational productivity associated with the performances of other organizational levels over certain extended time periods, the contribution of IT to productivity would be apparent on facilitating the performances of corporate strategies.

In contrast, IT productivity paradox has historically been reported for financial measures and isolated outcomes from other organizational practices without considering the impact of time lag. In fact, the results of IT operational productivity measures over an extension of one-year time period in this study indicated rather ambiguous clues in terms of the term “IT productivity paradox”. Individually, there were approximately 40% of surveyed firms with operational productivity measures less than average performance measure and on the contrary, 60% of surveyed firms with positive productivity improvement. The isolated aspect from other organizational measures on examining IT contribution showed similar findings as literature’s discussion. However, as the results were put together and examined as a whole, overall operational productivity is significantly greater than average operational productivity. This may be explained from the domain of empirical study in that high-tech industries are in a situation of short product life cycle and frequent product innovation and therefore, the feedbacks of e-business investments should be greatly concerned on the physical realization in a short time period.
6. Suggestions And Conclusions

Many valuable findings from the empirical study had uncovered the veils of “IT productivity paradox”. These findings not only identified the causes of productivity paradox but also provided some helpful suggestions for properly measuring the performances of business organizations. The reasons under which productivity paradox occurs can be discussed from two aspects of time lag and mismeasurement. First, time lags have demonstrated the significantly influential power on the performances of organizational measures, in particular, higher organizational levels required for longer time periods to realize the benefits. The implication to practitioners is that specific time lags vary based on the measures of organizational levels and the nature of industry and as a result, adequate time lags for measuring the performances of different organizational levels can be effectively defined in order to correctly examine the contribution of IT to productivity.

Second, a well-defined, hybrid performance measurement framework that included the performances measures of several organizational levels (both financial and non-financial measures) rather than the isolated measures (financial measures) would eliminate the limitations of traditional measurements. This approach would provide more interrelated information about organizational performances. These empirical evidences indicated that correlations between the performances of corporate strategies and manufacturing decisions as well as operational activities are significant. The implication for practitioners is that the values of IT are realized basically through a chain of relationship within the organizational hierarchy, i.e., lower-level impacts should, in turn, affect higher-level performance measures. As a result, an integration of the performance measures within the organizational hierarchy in terms of the levels of operational activities, manufacturing decisions, and corporate strategies has the capability to avoid sub-optimization in certain organizational level and effectively align the efforts of operational activities and manufacturing decisions with the goal of corporate strategy.

Subsequent research could be founded on this work. First, this research framework can be generally extended to the domains of service and traditional industries to understand the specific differences and similarities of organizational performance measures. In that, the second-order performance measures (manufacturing strategies) for high-tech industries should be properly modified to adapt to the different industries. Second, a comparative study can be conducted from the aspects of manufacturing managers rather than IS managers since this research is mainly for high-tech manufacturing. Third, this research is mainly for exploring the impact of e-business investments as a whole in organizations. This research can be focused on understanding the performance measures of the specific e-business investments such as customer relationship management or supply chain management. This would provide helpful insight to the specific decision of IT investments for senior management.

Finally, although this study has produced some interesting results, it may still have some limitations. The first limitation is the generalizability of the findings reported to other industries and other countries. Second, this study basically requires respondents to recollect the performance of e-business investment over recent years. The potential problem could occur for respondents clearly and correctly answering the questionnaires. Third, IS managers or CIOs from larger high-tech firms are primarily chosen to be the participants in this survey. However, some of the questionnaires might have been completed by subordinates or surrogates. As a result, the data might have some biases from above two limitations.

References