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## GRADUATE SCHOOL, KASETSART UNIVERSITY

Doctor of Engineering (Industrial Engineering)

**DEGREE**

Industrial Engineering | Industrial Engineering

**FIELD** | **DEPARTMENT**

**TITLE:** A Strategy Map Development: Use of Performance Information

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THESIS

# A STRATEGY MAP DEVELOPMENT: USE OF PERFORMANCE INFORMATION

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A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
Doctor of Engineering (Industrial Engineering)
Graduate School, Kasetsart University
2008

Pensuda Jaiwong 2008: A Strategy Map Development: Use of Performance Information. Doctor of Engineering (Industrial Engineering), Major Field: Industrial Engineering, Department of Industrial Engineering. Thesis Advisor: Associate Professor Kongkiti Phusavat, Ph.D. 190 pages.

The research aims to propose an alternative approach for the development of a strategy map. This proposed approach relies primarily on information from performance measurement. This approach has been tested with extensive and comprehensive data from three manufacturing firms collected during January 2005 until June 2006. The Balanced Scorecard (BSC) represents a basis for performance measurement. Included in this research's activities are the verification of the BSC interrelationship, the application of the Muliti – Criteria Performance Measurement Technique (MCPMT), and the categorization of these key performance indicators (KPIs) into different focus areas. These areas represent strategies, objectives, or factors that commonly shared by the three companies. The statistic analysis helps identify possible impacts among focus areas. The time and time-lag effects are also included in this analysis. Then, the strategy map is developed. In order ensure that the proposed alternative is useful and acceptable, its results have been verified and shared with top executives from three participating firms as well as comparisons with other literatures. The three strategy maps have received positive feedback because they provide a comprehensive view that is valuable for performance analysis. Moreover, the time-lag information is perceived to be helpful for planning, communicating to staffs, and monitoring and evaluation. Finally, this research shows that it is possible to use information from performance measurement to formulate a useful strategy map for decisions/ actions from a company's management. As a result, a management process should be strengthened.

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Student's signature Thesis Advisor's signature

# ACKNOWLEDGEMENTS

I would sincerely like to acknowledge the efforts of many people who contributed to the thesis. Without them, the work would never have been undertaken.

Firstly, I am proudly grateful to Associate Professor Dr. Kongkiti Phusavat for his direction, suggestions, support, and encouragement, and also to Professor Dr. Josu Takala from the University of Vaasa for his significant contributions in terms of research methodology. Special thanks to Associate Professor Dr. Peerayuth Charnsethikul, Dr. Pornthep Anussornnitisarn, Associate Professor Dr. Prapaisri Sudasna-na-Ayudthya, Dr. Nirundon Tapachai, and Dr. Peerapong Triyacharoen for their kind help and useful guidance.

I would also like to thank the three industrial experts for their contribution in the focus group interview to provide the ideas and comments for the generalization and the contribution of my work.

Finally, my appreciation is due to my family who always give me heartily support.

Pensuda Jaiwong

October 2008

# TABLE OF CONTENTS

**Page**


TABLE OF CONTENTS i
LIST OF TABLES ii
LIST OF FIGURES v
INTRODUCTION 1
LITERATURE REVIEW 11
MATERIALS AND METHODS 53
Materials 53
Methodology 53
RESULTS AND DISCUSSIONS 61
Results 61
Discussions 119
CONCLUSION AND RECOMMENDATIONS 125
Conclusion 125
Recommendations 126
LITERATURE CITED 129
APPENDICES 145
Appendix A Data collection from three participating companies 146
Appendix B MCPMT demonstration 162
Appendix C Correlation analysis among 10 focus areas 168
Appendix D Profiles of participating manufacturing survey 178
Appendix E Illustration of the survey 180
Appendix F Detailed dimensions or manufacturing strategies 183
Appendix G Correlation analysis among 31 dimensions from survey 185

# LIST OF TABLES


| Table | | Page |
|---|---|---|
| 1 | Critical dimensions of performance | 32 |
| 2 | Sample KPIs from Kaplan and Norton | 34 |
| 3 | Example of focus areas and performance measures | 35 |
| 4 | Measures selected for the balanced scorecard of SDC. | 39 |
| 5 | KPIs at Biddle Air System (BAS) | 40 |
| 6 | The scorecard of REC strategy | 41 |
| 7 | The scorecard of REC principles | 41 |
| 8 | A framework of the balanced scorecard for a manufacturing division | 42 |
| 9 | Performance measures | 45 |
| 10 | The relationship between TQM and organizational performance | 45 |
| 11 | Background of three companies under study | 54 |
| 12 | Common KPIs for data collection | 62 |
| 13 | Overall performance levels of four perspectives for three companies | 64 |
| 14 | The results of correlation analysis of Company #1 | 66 |
| 15 | The relationship between the paired perspectives for Company #1 | 68 |
| 16 | The results of correlation analysis of Company #2 | 70 |
| 17 | The relationship between the paired perspectives for Company #2 | 72 |
| 18 | The results of correlation analysis of Company #3 | 74 |
| 19 | The relationship between the paired perspectives for Company #3 | 76 |
| 20 | Classifying KPIs into 10 focus areas | 81 |
| 21 | The correlation analysis of ten focus areas for Company #1 under no time consideration | 83 |
| 21 | Demonstration of productivity and process efficiency and liquidity areas under time-lag consideration | 84 |
| 23 | The relationship between the paired focus areas for Company # 1 | 84 |
| 24 | The correlation analysis of ten focus areas for Company #2 under no time consideration | 89 |

# LIST OF TABLES (Continued)


| Table | | Page |
|---|---|---|
| 25 | Demonstration of productivity and process efficiency and profitability areas under time-lag consideration | 90 |
| 26 | The relationship between the paired focus areas for Company # 2 | 91 |
| 27 | The correlation analysis of ten focus areas for Company #3 under no time consideration | 95 |
| 28 | Demonstration of Product Innovation and Liquidity Areas Under Time- lag consideration | 96 |
| 29 | The relationship between the paired focus areas for Company # 3 | 97 |
| 30 | The new set of KPIs under adjustment #1 | 102 |
| 31 | The new set of KPIs under adjustment #2 | 103 |
| 32 | Operational strategies of the ten participating SMEs | 113 |
| 33 | The compatible linkage between manufacturing strategy survey and focus area in the proposed strategy map | 114 |
| 34 | Verification of the findings on some of the time effects | 118 |
| 35 | The key different issues between the Kaplan and Norton approach and the proposed approach | 121 |

**Appendix Table**

| | | |
|---|---|---|
| A1 | Data collection from Company # 1 on financial perspective | 147 |
| A2 | Data collection from Company # 1 on the customer perspective | 149 |
| A3 | Data collection from Company # 1 on the internal process perspective | 150 |
| A4 | Data collection from Company # 1 on the innovation and learning perspective | 151 |
| A5 | Data collection from Company # 2 on financial perspective | 152 |
| A6 | Data collection from Company # 2 on the customer perspective | 154 |
| A7 | Data collection from Company # 2 on the internal process perspective | 155 |

# LIST OF TABLES (Continued)


| Appendix Table | | Page |
|---|---|---|
| A8 | Data collection from Company # 2 on the innovation and learning perspective | 156 |
| A9 | Data collection from Company # 3 on financial perspective | 157 |
| A10 | Data collection from Company # 3 on the customer perspective | 159 |
| A11 | Data collection from Company # 3 on the internal process perspective | 160 |
| A12 | Data collection from Company # 3 on the innovation and learning perspective | 161 |
| B1 | Results from Company # 1 on the innovation and learning Perspective | 163 |
| B2 | Preference curve formulation | 165 |
| B3 | Conversion to a common performance scale of 0-100 | 166 |
| B4 | Overall result for the innovation and learning perspective for Company # 1 | 167 |
| C1 | Correlation analysis among 10 focus areas under time-lag consideration for Company #1 | 169 |
| C2 | Correlation analysis among 10 focus areas under time-lag consideration for Company #2 | 172 |
| C3 | Correlation analysis among 10 focus areas under time-lag consideration for Company #3 | 175 |
| D1 | Profiles from ten participating manufacturers | 179 |
| F1 | Detailed dimensions description | 184 |
| G1 | Correlation analysis among 31 dimensions | 186 |

# LIST OF FIGURES


| Figure | | Page |
|---|---|---|
| 1 | Various roles of performance measurement in a management process | 3 |
| 2 | Simplified view on the role of a strategy map in performance analysis | 7 |
| 3 | Research framework | 10 |
| 4 | Forrester's management process model | 12 |
| 5 | Kaydos' s management process model | 13 |
| 6 | Kurstedt's management process model | 14 |
| 7 | Management process model elaborated by Sink | 14 |
| 8 | Malcolm Baldrige Performance Excellence Framework | 16 |
| 9 | ISO 9000:2001 model of a process-based quality management system | 18 |
| 10 | The PMB SIG performance-based management framework | 19 |
| 11 | Three main activity of performance management | 20 |
| 12 | Utilization of performance measurement | 21 |
| 13 | Sink and Tuttle model | 23 |
| 14 | University of California framework | 25 |
| 15 | Family of measures framework | 25 |
| 16 | The performance pyramid | 27 |
| 17 | The performance prism | 28 |
| 18 | The balanced scorecard links performance measure | 29 |
| 19 | The Rexam custom model | 42 |
| 20 | Results for the interrelationship between intellectual capital elements and performance | 44 |
| 21 | The Balanced Scorecard generic strategy map | 47 |
| 22 | The Research Methodology | 59 |
| 23 | Interrelationship among the BSC's four perspectives of Company #1 | 68 |
| 24 | Interrelationship among the BSC's four perspectives of Company #2 | 72 |
| 25 | Interrelationship among the BSC's four perspectives of Company #3 | 76 |
| 26 | The sequential order of the four perspectives in the BSC | 80 |

# LIST OF FIGURES (Continued)


| Figure | | Page |
|---|---|---|
| 27 | Strategy Map for the Company #1 | 88 |
| 28 | Strategy Map for the Company #2 | 94 |
| 29 | Strategy Map for the Company #3 | 100 |
| 30 | Strategy Map under adjustment #1 for the Company #1 | 105 |
| 31 | Strategy Map under adjustment #1 for the Company #2 | 106 |
| 32 | Strategy Map under adjustment #1 for the Company #3 | 107 |
| 33 | Strategy Map under adjustment #2 for the Company #1 | 108 |
| 34 | Strategy Map under adjustment #2 for the Company #2 | 109 |
| 35 | Strategy Map under adjustment #2 for the Company #3 | 110 |
| 36 | Comparison between focus areas and strategic priorities | 113 |

**Appendix Figure**

| | | |
|---|---|---|
| B1 | Preference curve example | 166 |

# A STRATEGY MAPDEVELOPMENT: USE OF PERFORMANCE INFORMATION

## INTRODUCTION

Globalization, competition, and importance of good governance have made measuring performance critical to continuous improvement and business success. This is highlighted by Deming (1986) when he made the following statement. "You cannot manage what you cannot measure." Nevertheless, an extension needs to be made to ensure effective use of performance information for continuous improvement (Sink, 1985; Kaplan and Norton, 1992; and Neely, 2002).

Past practices in performance measurement have been studied and rightfully received many criticisms. For example, there was a failure to convey strategies and priorities effectively within an organization (Maskell, 1991), encouraging short – termism (Johnson and Kaplan, 1987), a lack of balance between financial and non-financial information (Sink, 1985), and a resistance to change (Richardson and Gordon, 1980). Subsequently, many performance measurement concepts began to emerge in order to address these weaknesses. They included Harper's Performance Network (1984), Sink and Tuttle's Performance Criteria (1989), Lynch and Cross's Performance Pyramid (1991), Kaplan and Norton's Balanced Scorecard (1992), and Neely's Performance Prism (1998). Many organizations have used performance measurement as a primary tool for communicating direction, establishing accountability, defining roles, monitoring and evaluating activities, and initiating changes to ensure continuous improvement (Viken, 1995). Additionally, most improvement comes through employee motivation. Feedback on performance is therefore another crucial way of measuring, and the organization that fails to measure in this way is missing a major opportunity (Thor, 1988).

Continuous performance improvement symbolized successful management (Sink and Tuttle, 1989; and Takala *et al*., 2003). It indicated the strength of an

organization's management process (Kurstedt, 1992; and Hoehn, 2003). To maintain high performance and cost- competitiveness, it was important to continuously and explicitly integrate performance measurement with information analysis, and improvement interventions (Rao, 2006). Try and Radnor (2007) pointed out that a strong management process is essential for performance improvement and business competitiveness. This is because a robust management process should be able to drive and fulfill organizational policies, goals, and objectives (Ahmed and Sharma, 2008).

Typically, a management process consists of performance measurement, information analysis, and managerial decisions and actions (Kurstedt, 1992). The importance of this process on business competitiveness and successes can be highlighted by the following illustrations. Requirement 8 of ISO 9001: 2000 stresses a strong foundation of a management process for an effective quality- management system (Traver and Wilcock, 2006). It includes performance measurement, analysis, and improvement. Notably quality-related awards such as the Malcolm Baldrige National Quality Award (MBNQA) and the European Foundation for Quality Management (EFQM) Excellence Model focus on the interrelationships among performance measurement, analysis, and knowledge management (Vokurka, 2004; and Ivanovic and Majstorovic, 2006). This implies that an organization's long-term learning and development depends on the ability to avoid repeated mistakes and to be able to repeat excellent performance. Finally, the Systems Engineering- Capability Maturity Model (CMM) indicates the need to apply quantitative information for performance analysis and continuous improvement (Blanchard, 2004). See Figure 1.

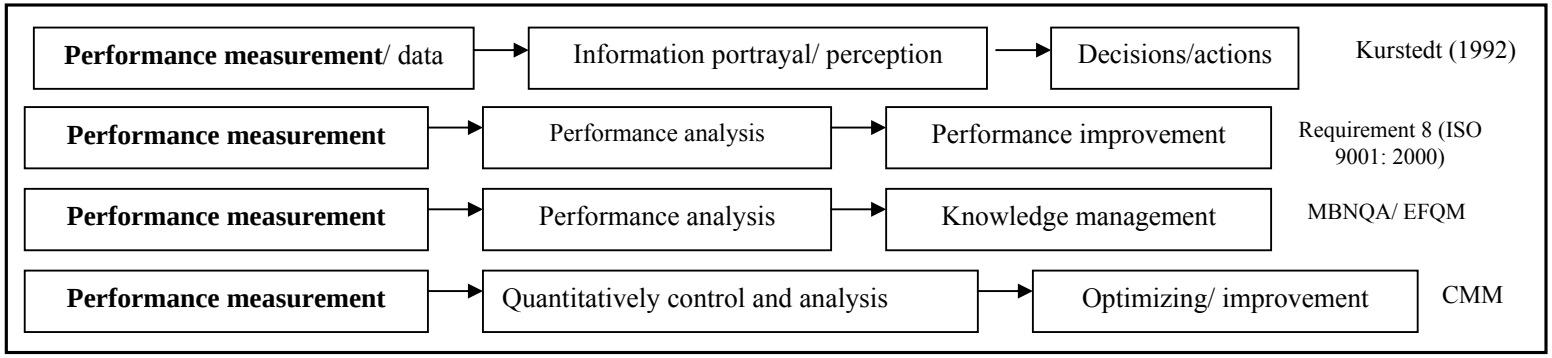



**Figure 1** Various roles of performance measurement in a management process

In attempting to improve management processes, efficient performance measurement and information analysis methods are demanding. This is because the term management process deals primarily with performance measurement and information analysis (Dixon *et al*., 1990). Brignall and Ballantine (1996) emphasized the need for performance measurement as a tool to provide information to stimulate appropriate action and organizational learning at the right level of the organization and stage of the decision making process. Kumar and Liu (2005), Subrahmanya (2005), and Rao (2006) also stressed the importance of having a comprehensive performance measurement and constant information analyses when faced with intense competition. One of the main challenges is to ensure that quality decisions and actions are derived from performance analysis. Performance measurement and analysis represent a process of quantifying past actions in order to give management a more strategic focus by incorporating financial and non-financial, competitor-centered and customer-focused information (Ittner and Larcker, 1998; Parker, 2000; and Neely, 2002). A lack of attention on these interactions could result in a waste of time and resources on data collection and storage, overwhelmed data and deficient reports for management during performance analysis, and poor decision-making quality such as untimely and inaccurate decisions (Hoehn, 2003; and Wong and Lu, 2005). According to Kurstedt (1992), the quality of managerial decisions depended on the quality of information and experience of decision makers. Fairuz *et al*. (2008) indicated information and communication technology would play an important role in creating a robust decision-making process and a learning organization. Finally, the quality of decisions would eventually impact long-term strategic advantages and ensure organizational survival (De Meyer et al., 1989; Hayes and Wheelwright, 1984; Helo and Szekely, 2004; Kazan et al., 2006; Neely, 1998; and Pagell and Krause, 2002).

In recent years the Balanced Scorecard (BSC) has gained popularity in the performance measurement framework (Wongrassamee *et al*., 2003). One of the key contributions to the BSC popularity is that this framework explicitly integrates financial and non-financial measures. In addition to linking measures to vision and

strategy, measures should be linked to each other, following a series of cause-and-effect relationships. The diagrams showing linkages between strategic objectives have been called “strategy map”. To further elaborate the role of a strategy map, it is important to first recognize that performance measurement and analysis are not the same and require different skills for implementation (Neely, 1998). There are various concepts for performance measurement, such as Multi-factor Productivity Measurement Model (MFPMM) by American Productivity and Quality Center, the Value-added Productivity by Michigan Manufacturing Technology Center, Harper’s Network Concept (1984), Sink’s Multi-criteria Performance Measurement Technique (1985), the ratio/ metric concept, etc. On the contrary, for performance analysis, there are many practices such as the regression analysis, statistical trends, benchmarking, etc. A strategy map typically associates with two features: (1) current performance levels or “as is” from performance measurement, and (2) expected performance levels and their interrelationships or “what is” as part of performance analysis (Hoehn, 2003). A strategy map needs to incorporate these as-is and what-is features.

**Problem Background**

Strengthening the enterprise development for SMEs in Thailand requires an extensive practice of performance-based management for their future survival — in reference to the report published by the Department of Industrial Promotion, Ministry of Industry in 2003. This term constitutes three main tasks; i.e., performance measurement, analysis, and improvement. It is known as management process (Sink and Tuttle, 1989; Kurstedt, 1992; and Hoehn, 2003). One of the weaknesses for a typical SME’s management process is the lack of an explicit linkage between performance measurement and analysis (Phusavat, 2007). There must be a complete analysis and feedback loop that ensures that performance measurement is analyzed, and translated into action and behavior which changes the nature of activity and performance. Measurement must improve performance.

Since, many workshops and seminars in Thailand have focused on applying the BSC as a means to help realize this recommended practice. Successively, it has

become one of the most popular management concepts among Thai SMEs and large industries, according to the Federation of Thai Industries. According to Kaplan and Norton (2004), a strategy map, for a company, represents managerial anticipation or hypotheses on the interrelationships among strategic objectives or key success factors while creating customers' value. Kaplan and Norton (2004) further elaborate that a strategy map's development is an important task for integrating the BSC into a management process. Moreover, a strategy map should be applied in conjunction with the BSC's four perspectives (i.e., finance, customer, internal business processes, and innovation and learning). Since these four perspectives are interrelated, a strategy map must reflect this view. For example, poor results from the innovation and learning perspective will eventually impact the financial perspective.

The strategy map is important since it can be used as a key management tool for performance analysis (See Figure 2). The analysis of performance measures is support decisions and planning. Managers should invest in effective performance measurement systems that include approaches for analyzing results and sharing information appropriately throughout the organization (Evans, 2007). According to Kaplan and Norton (2004), the strategy map provides the visual framework for integrating the organization's objectives or key success factors in the four perspectives of a Balanced Scorecard. They propose the strategy map builds upon the premise of strategy as hypotheses. The hypotheses underlying the strategy are made explicit through the strategy map's cause-and-effect linkage across the four perspectives. The hypotheses are just assumptions under the experience or forecasting of the executives then they need to collect performance data for testing the hypotheses about interrelationship among strategic objectives. Interestingly, if the managerial anticipations have errors, the strategy map could cause an organization to fail because of getting wrong information for decision making.

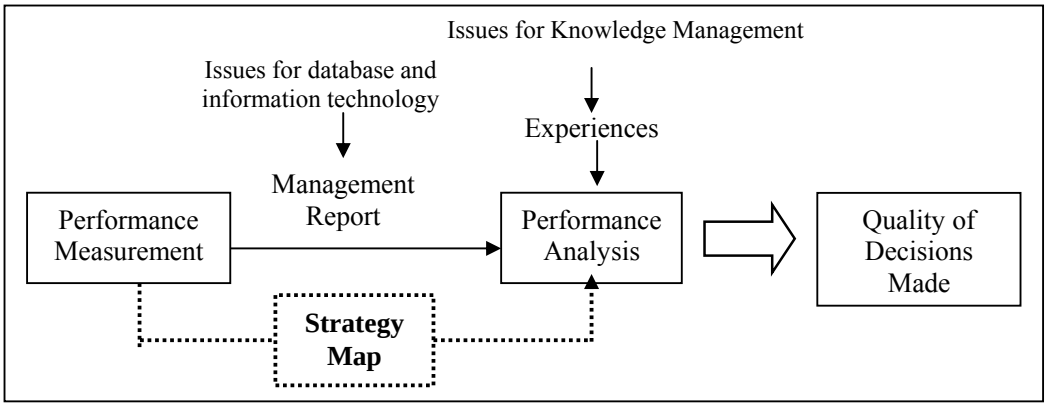



**Figure 2** Simplified view on the role of a strategy map in performance analysis

Even though developing a causal model of the strategy is a central idea in BSC, Davis and Albright (2004) reported that 77 percent of BSC adopters in the USA failed to develop a causal model of their strategy. Similar findings are reported in studies on BSC adoption in India, Finland, Austria, Malaysia and Germany (Anand et al., 2005, Malmi, 2001; Othman, 2006; Speckbacher et al.,2003). The BSC uses in strategy map to present a graphical depiction of the causal model of an organization's strategy (Kaplan and Norton, 1996). However, some researchers argue that no specific method is available to help organizations develop the causal model of their strategy (Malmi, 2001; Speckbacher et al, 2003).

Meyer (2002) argued that BSC has no strong basis in theory as it does not show how to combine the dissimilar measures into an appraisal of performance. According to Atkinson (2006), difficulties in implementing the BSC are due to certain aspects of the method as well as the method itself. However, O'Mara et al (1998), base on their case study research, found that managers had no formal recognition of a link between performance measurement and strategy, so that key performance measures were seldom linked to strategic decisions. Ittner and Larcker (2003) also highlighted the frequent failure of business managers both to link performance measures, on the basis of causal model, to an organization's strategy and to validate the link.

Kaplan and Norton (2004) proposed the strategy map would build upon the premise of strategy as hypotheses. The hypotheses underlying the strategy are made explicit through the strategy map's cause-and-effect linkage across the four perspectives. The clear statement of these connections provides the opportunity for managers to realize how an action classified in one perspective will influence, through chain effects, other dimensions ultimately leading to improved financial results. Kaplan and Norton (1996) note the value of measuring correlations between two or more measures as a means of validating hypothesized cause-and effect relationships and validating strategy. Thus, the concept of feedback loops helps managers to realize the interconnectedness between different performance measures and how change in one area leads to changes in other areas.

Rich (2007) found that managers did not rate the importance of performance measures equally and the decision outcomes were not always related to the factors which managers thought were important at the beginning of the process of designing a strategy map. This aspect is also significant when different managers do not weigh similarly the information employed in strategic decisions even though they face similar problems and have access to similar information (Kunc and Morecroft, 2007). Manville (2007) found that managers did not clearly relate the linkage of the KPIs to the business plan as many had not had access to the plan. Thus, managerial background and actual task environment may have an important effect on managers' attention to differences in the design of causal relationships in the balanced scorecard and use of performance management system.

Due to the difficulty and ambiguity in hypothesizing the strategic objectives namely not clearly relating the linkage of the strategic objectives, this research attempts to develop the method for formulating the strategy map. The performance measurement information reflects the organizational performance. Then, this research will apply the historical information of performance measurement with mathematics and statistical analysis to construct a strategy map. The strategy map from this

research is based on the actual data that reflect the actual relationship under organizational performance.

Therefore, this research is to propose an alternative approach for the development of a strategy map. This proposed alternative is based on using past information from performance measurement instead of managerial anticipation or hypotheses.

## Problem Questions

The research questions include the following:

1. Can past performance information be used to develop a strategy map?
2. Can this proposed alternative of a strategy map development be useful and acceptable?

## Research Objectives

The objective of this research is to propose an approach – developing a strategy map that stems directly from past performance information. This alternative illustrates a clear linkage between performance measurement and analysis.

## Research Framework

This research attempts to propose an alternative approach for the development of a strategy map based on performance information. The performance information is grouped based on the balanced scorecard concept (BSC). In order to develop a strategy map, the statistical method is applied. The strategy map is validated by comparing literature reviews, interviews with top executives, and comparing manufacturing strategic surveys. Finally, the research output is an approach for the development of a strategy map. The research framework is shown in Figure 3.

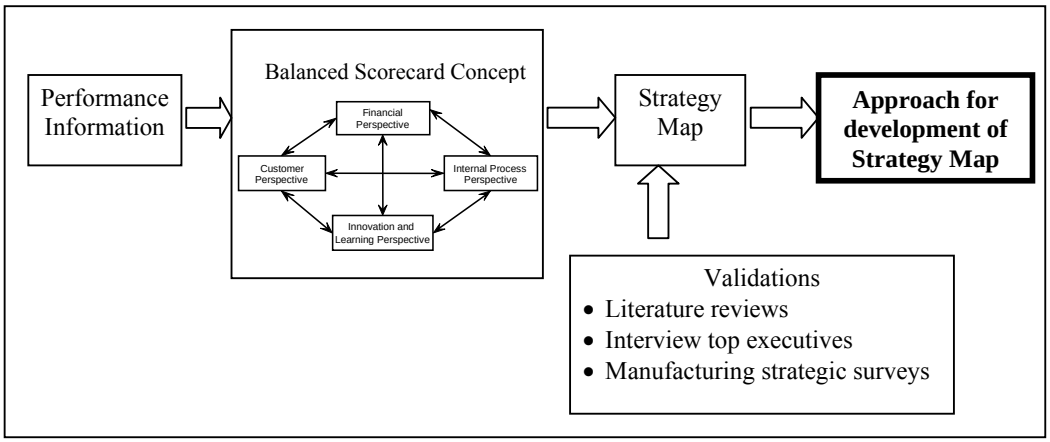



**Figure 3** Research framework

## Research Scopes

This research emphasizes quantitative data and is based on actual data. The research data focuses on information from performance measurement. This research disregards the performance of organizations.

## Benefits

1 The approach is an alternative approach that formulates a strategy map by utilizing performance information.

2 The proposed alternative is expected to strengthen a management process that is essential for business growth and competitiveness.

3 The research provides a roadmap to help companies and firms develop a strategy map for their future use.

# LITERATURE REVIEW

This part provides information on the key subjects for this research. The first part reviews management process. The second part presents a discussion on performance measurement. The third part of this literature review using the balanced scored, the strategy map concept, and how the measures work together. Finally, the last part of the chapter is correlation analysis.

## Management Process

Management is a critical process in an organization. Strengthening an organization's management process has increasingly become more important in recent years (Yeniyurt, 2003; and Andersen *et al*., 2004). According to Hoehn (2003), without a strong management process, it would be difficult to deploy organizational policies and objectives, and to monitor and evaluate performance levels.

According to Simon (1977), managing is decision making. Decision making involves a process that reflects the scientific method and ends in an observable behavior of choosing. A series of related decisions strung together can be used as a tool to do problem solving. The processes for decision making and problem solving make up the management process. Forrester (1961) also suggested that management is the process of converting information into action. The conversion process is decision making. Decision making is in turn controlled by various explicit and implicit policies of behavior. Therefore, it is clear that the management success depends primarily on what information is chosen and how the conversion is executed. This conversion process is illustrated in Forrester's figure as shown in Figure 4. According to the Figure 4, the manager receives information from management tools to make decisions and generate actions from the decisions to affect the work flow, or operation, of his or her responsibility. It shows that information is the key factor for the decision making process or management process.

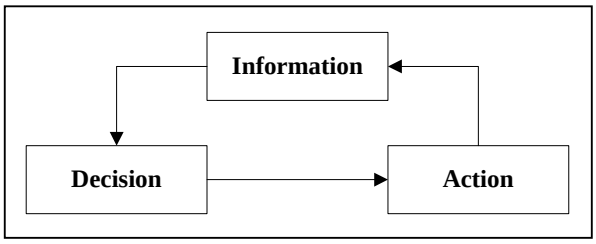



**Figure 4** Forrester's management process model

The management process is a cyclic, recursive set of steps for continuously improving performance. The management process is defined by the following activities: (1) planning, (2) controlling, and (3) decision making (Hansen and Mowen, 2000). The management describes the functions carried out by manager and empowered workers.

Kaydos (1991) represents the management process from an information perspective as showed in Figure 5. There are four steps:

1. The production process creates products or services. The activities in the process generate data.
2. The information system takes the data and converts it into information (i.e., data can be thought of as a collection of points or numbers, while information is the result of converting data into a form that can be used for making a decision).
3. The decision-making system analyzes the information it receives and makes decisions to allocate resources and take actions.
4. The organization executes the decisions by taking actions and using resources allocated to it.

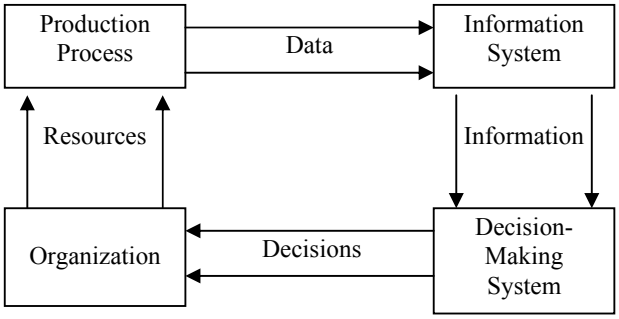



**Figure 5** Kaydos' s management process model

Kurstedt (1992) developed a model that resembles a management process, known as the Management System Model (MSM). The MSM demonstrates a general management process and then depicts the role of performance measurement for the unit of analysis. The Kurstedt's management system consists of three component and three interfaces. The components are "who manages", what is managed", and "what is used to manage". The three interfaces are "decision/action", "measurement/data", and "information portrayal/information perception". Figure 6 demonstrated the Kurstedt's management process. Sink (1990) further elaborates the "what is managed" component or the domain of responsibility for a manager should be divided into five elements. These elements are in the sequential order of "upstream system", "inputs", "value-added process", "outputs", and "downstream system". These interfaces help link the three components together. The first interface of "decision/action" represents improvement interventions made by the manager. The second interface, "measurement/data", is designated as the assessment of effects and impacts from past/current improvement interventions. These results are supposed to lead to the third interface. Feedback data on performance measurement need to be portrayed in the format that can result in quality decisions. Figure 7 demonstrated the management process model that elaborated by Sink (1990).

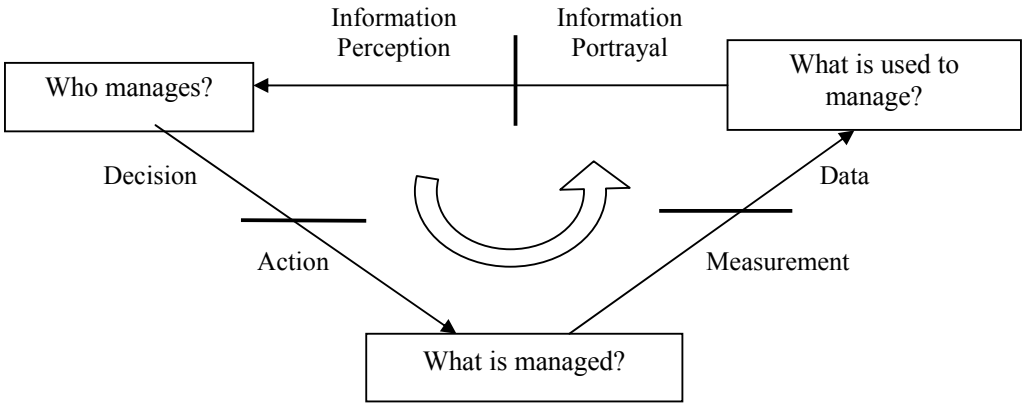



**Figure 6** Kurstedt's management process model

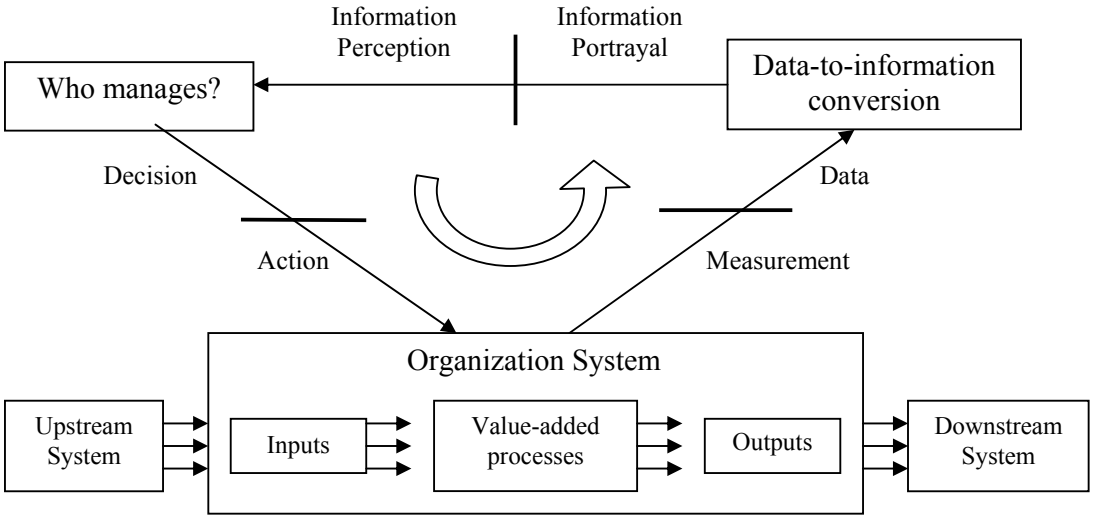



**Figure 7** Management process model elaborated by Sink

The management system model illustrates and confirms many important management principles, including: (1) management is decision making (2) the decision maker converts information into decisions; (3) decisions are valueless unless they become actions; (4) actions cause the operation to change; (5) management must know what to measure before they can get useful data; (6) all management tools convert data into information; (7) when managers portray information, they must consider how the information will be perceived.

From the definitions of management process discussed above, it is clear that performance measurement and information are very necessary in strengthening management process. This is because information constitutes the interface between the manager and the decision tools (Kurstedt, 1992). Daft (1992) and Kaye (1995) also confirmed that good information is essential to the success of an organization since it must understand both its own internal workings and the nature of the environment to which it has to adapt and respond. The importance of performance measurement and information analysis is also described in the scope and activities of management process. Two viewpoints on the scope of management process are discussed. The first viewpoint adapts from the Malcom Baldrige National Quality Award (MBNQA) which provides an integrated model for business excellence and performance. Its Category 4 refers to the management process as measurement, analysis, and knowledge management (Vokurka, 2004). The emphasis is on using knowledge management to ensure learning from past performance, and sharing and communicating the results, lessons learned, and action plans throughout an organization. The second viewpoint applies one of the key requirements from ISO 9001: 2000. This quality management system specifies three activities in its Requirement 8; namely, measurement, analysis, and improvement.

**The Malcom Baldrige National Quality Award (MBNQA)**

The MBNQA was launched by the US Government in 1987 to encourage US firms to use total quality management (TQM) to gain competitive advantage. It offers a set of causal links between performance drivers and an organization's results – it is a good predictor of organizational performance (Evans and Lindsay, 2002). MBNQA has gone beyond quality improvement to a model for overall organizational performance improvement. Although it was initiated with the foundation of quality management, since 1999 it evolved to provide a more holistic view to be an organizational performance excellence framework (Kay et al., 2003) – a strategic management system. See Figure 8.

The Criteria for Performance Excellence Framework are embodied in seven points that are gathered into functional groups:

• Leadership Group emphasizes a leadership focus on strategy and customers: 1) Leadership, 2) Strategic Planning, and 3) Customer and Market Focus.

• System Foundation Group: 4) Measurement, Analysis, and Knowledge Management

• Results Group: 5)Workforce Focus, 6) Process Management, and 7) Results.

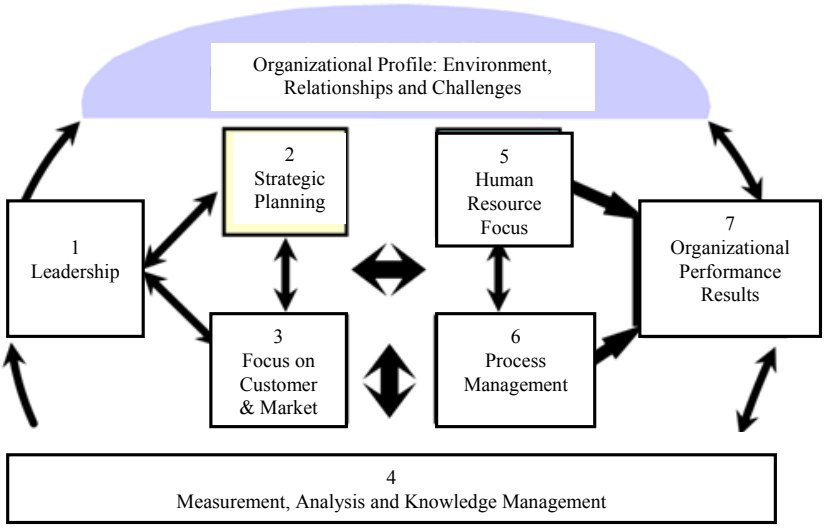



**Figure 8** Malcolm Baldrige Performance Excellence Framework.
**Source**: Evans and Lindsay (2002)

Category 4 in the Malcolm Baldrige criteria for performance excellence – measurement, analysis, and knowledge management – examines an organization's performance measurement system – how it selects, gathers, analyzes, manages, and improves its data information, and knowledge assets. This category is positioned as the foundation for all other categories in the systems framework that underlies the Baldrige philosophy and provides a key feedback structure linking business results to organizational planning activities (Evans and Lindsay, 2002).

**The ISO 9001:2000 standard**

ISO 9001:2000 encourages a process approach to quality management. Figure 9 shows the model of the process-based quality management system approach recommended. This model comprises four key elements:

(1) The “management responsibility” element comprises the requirements for developing and improving the quality system, listening to customers, formulating quality policy and planning, and defining responsibilities, authorities and communication processes to facilitate effective quality management.

(2) The “resource management” element comprises the requirements for managing both human and infrastructural resources in order to implement and improve the quality management system and to address customer satisfaction.

(3) The “product realization” element includes the specific requirements for the product realization processes, which involve identifying customer requirements, reviewing product, requirements, communicating with customers, designing and developing products, purchasing producing (and/or delivering) service, and controlling measurement and monitoring devices.

(4) The “measurement, analysis, and improvement” element features the requirements for monitoring information on customer satisfaction, internal audits, non-conformity detection and improvement actions.

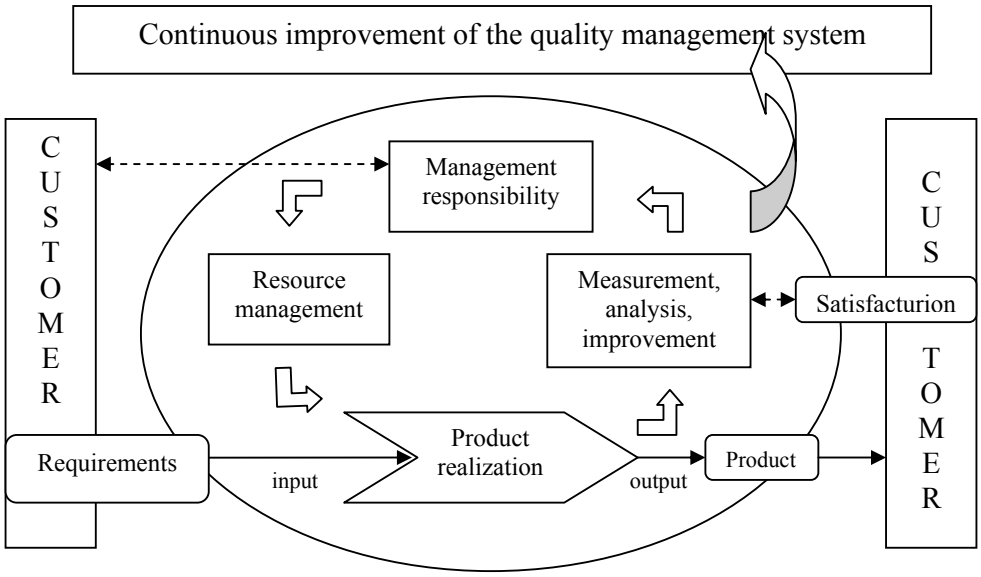



**Figure 9** ISO 9000:2001 model of a process-based quality management system
**Source:** Biazzo and Bernardi (2003)

The chapter on general requirement (clause 4.1) maintains that, to implement a quality management system, an organization has to:

- identify the processes needed for the quality management system;
- determine the sequence and interaction of these process;
- determine criteria and methods required to ensure the effective operation and control of these processes;
- ensure the availability of resources and information necessary to support the operation and operation and monitoring of these processes;
- measure, monitor, and analyze these processes;
- implement actions necessary to achieve planned results and continuous improvement of these processes.

This research mention to requirement 8 (i.e., measurement, analysis, and improvement) because of this state: “If you don’t measure it, you can’t manage it”. Then, tool/approach for analyze is important.

**Performance – Based Management**

Basically, performance – based management follows the Plan-Do-Check-Action (Continuous Improvement) Cycle developed by Walter Shewhart of Bell Labs in the 1930s. Performance – based management is a systematic approach to performance improvement through an ongoing process of establishing strategy performance objective; measuring performance; collecting, analyzing, reviewing, and reporting performance data; and using that data to drive performance improvement. Department of Energy (2001) established the PBM SIG Performance – based management model shown in Figure 10. The six steps to establishing a performance – based management model are:

1. Define organizational mission and strategic performance objectives
2. Establish an integrated performance measurement system
3. Establish accountability for performance
4. Establish a process/system for collecting data to assess performance
5. Establish a process/system analysis for analyzing, reviewing, and reporting performance data
6. Establish a process/system for using performance information to drive improvement

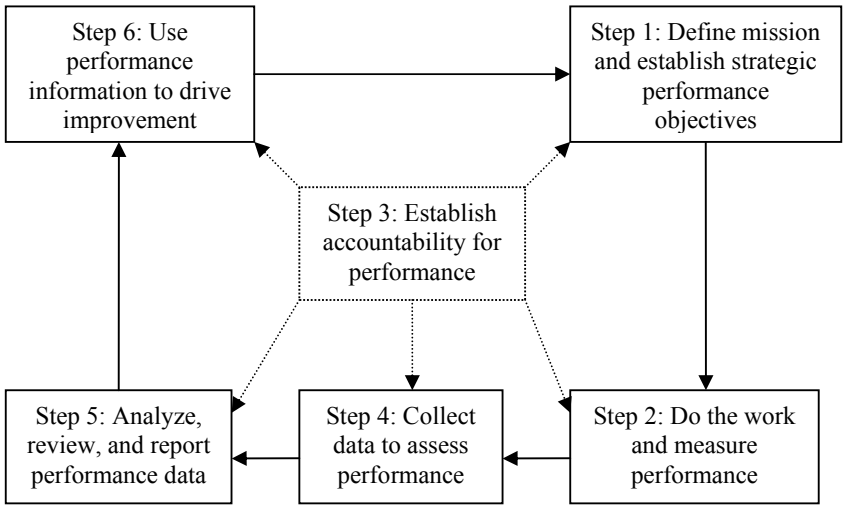



**Figure 10** The PMB SIG performance-based management framework

Department of Energy (2001) founded that many people get confused by the similarities and difference between performance measurement and performance-based management. In simplest terms, performance measurement is the comparison of actual levels of performance to pre-established target levels of performance. To be effective, performance measurement must be linked to the organizational strategic plan. Performance-based management essentially uses performance measurement information to manage and improve performance and to demonstrate what has been accomplished. In other words, performance measurement is a critical component of performance based management.

## Performance measurement

The organizational performance management system has long been regarded as an importance management tool for continuous improvement. There are three major activities in performance management. There are measurement, analysis, and improvement (Figure 11). The system provides feedback to the following three questions. How well and organizational is performing? Is the organization achieving its objectives? How much has the organization improved from a last period? In addition, performance helps create feedback to managers with respect to the effectiveness of improvement interventions (implying corrective and preventive decision). At the same time, the identification of problem, weakness, or areas to be improved can be made scientifically.

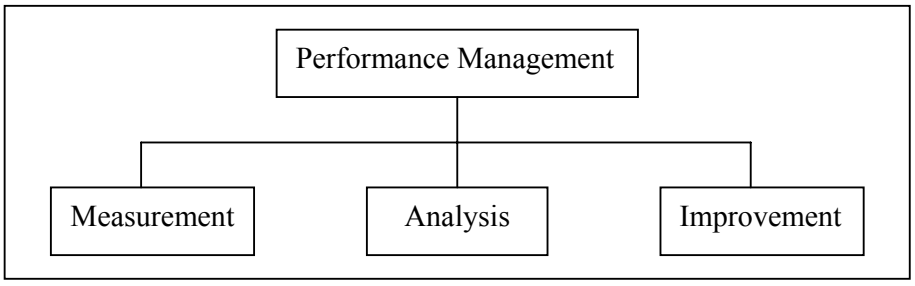



**Figure 11** Three main activity of performance management

**Source:** Suwansaranya and Phusavat (2002)

Phusavat (2000) depicted at least three ways in which the organization can utilize performance measurement. The system can be used by comparing with the past performance level. On the other hand, manager may use information to compare with established standards or with other companies (known as benchmarking). Figure 12 summarizes the overview of the utilization of the organizational performance management system.

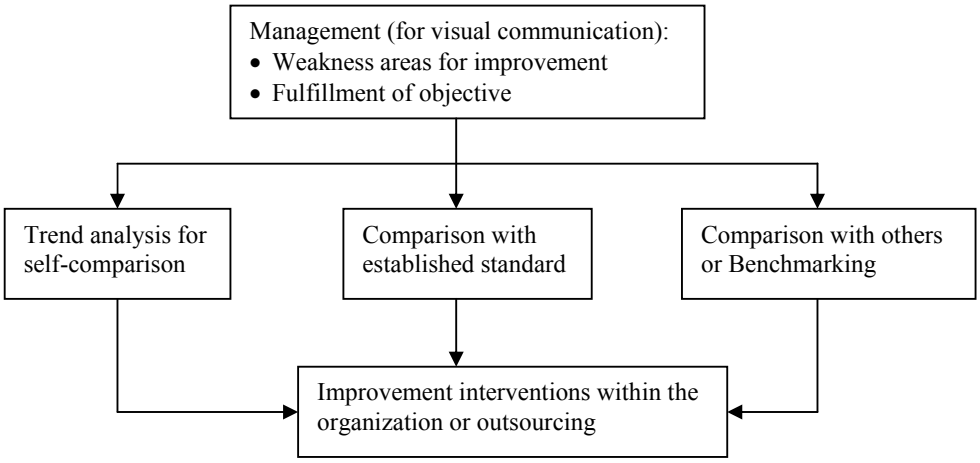



**Figure 12** Utilization of performance measurement
**Source:** Phusavat (2000)

Performance measurement (PM) is the process of quantifying past action (Neely, 1998). PM systems historically developed as a means of monitoring and maintaining organizational control, which is a process of ensuring that an organization pursues strategies that lead to the achievement of overall goals and objectives (Nanni et al., 1990). In attempting to change the focus of an organization, Brignall (1992) suggests that PM is a key agent of change. Even when an organization has attained such a focus, however, PM plays a vital role in maintaining attention on changing customer requirements and competitor actions. PM is a key factor in ensuring the successful implementation of an organization's strategy (Fitzgerald et al., 1993). Business and business unit performance needs to be measured in relation to the objectives identified in the planning process. Attention to PM in the context of modern business has been focused on by the admission that information that had

traditionally been provided to organizations for control and management purposes was no longer adequate for fully effective PM to be achieved.

Dixon *et al*. (1990) suggest that inappropriate PM is a barrier to organizational development since measurement provides the link between strategies and action. Inappropriate measures lead to actions incongruent with strategies, however well formulated and communicated. Appropriate measurement should provide and strengthen this link, and both lead to attainment of strategic goals and impact on the goals and strategies needed to achieve them.

**The performance measurement frameworks**

In response to the dissatisfaction with traditional PM system, there are several frameworks for the executives to develop their performance measures, which the company can apply and adapt for the most suitable for their organization. The example of the performance measurement frameworks are shown as follows:

Sink and Tuttle Framework

A classical approach to a PM system is Sink and Tuttle model (Figure 13), which claims that the performance of an organization is a complex interrelationship between seven criteria (Sink and Tuttle, 1989).Definitions of seven performance criteria are:

(1) Effectiveness, which involves “doing the right thing, at the right time, with the right quality”: in practice, effectiveness is expressed as a ratio of actual output to expected output;

(2) Efficiency, which simply means “doing things right”, and is defined as a ratio of resources expected to be consumed to resources actually consumed;

(3) Quality, where quality is an extremely wide concept: to make the term more tangible, quality is measured at six checkpoints;

(4) Productivity, which the defined as the traditional ratio of output to input;

(5) Quality of work life, which is an essential contribution to a system which performs well;

(6) Innovation, which is a key element in sustaining and improving performance;

(7) Profitability/Budgetability, which represents the ultimate goal for any organization.

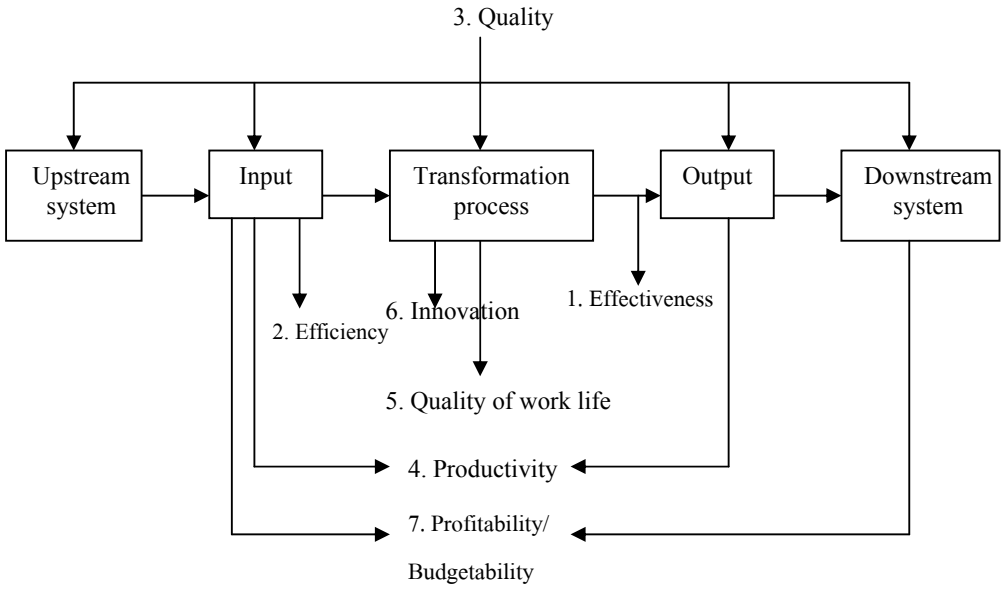



**Figure 13** Sink and Tuttle model

**Source:** Sink and Tuttle (1989)

Although much has changed in industrial since this model was first introduced, these seven performance criteria are still important. However, the model is limited by the fact that it does not consider the customer perspective (Tangen, 2004).

In additional to the work of Sink and Tuttle, the researchers with in the TOPP Project (a research program studying productivity issues in Norwegian manufacturing industry) looked at performance as an integration of three dimensional:

(1) Efficiency;

(2) Effectiveness; and

(3) Adaptability

The first two dimensions in the TOPP performance model are the same as in the Sink and Tuttle framework, while the third expresses the extent to which the company is prepared for future changes.

University of California Framework

University of California Framework is the performance metrics. There are 6 measurement categories (Department of Energy, 2001):

1. Effectiveness: A process characteristic indicating the degree to which the process output conforms to requirement.

2. Efficiency: A process characteristic indicating the degree to which the process produces the required output at minimum resource cost.

3. Quality: Degree to which a product or service meet customer requirements and expectation.

4. Timeliness: Degree to which a unit of work was done correctly and on time. Criteria must be established to define what constitutes timeliness for a given unit of work. The criterion is usually based on customer requirements.

5. Productivity: Reflecting the value added by the process divided by the value of labor and capital consumed.

6. Safety: Degree to which the overall health of the organization and the working environment of its employees.

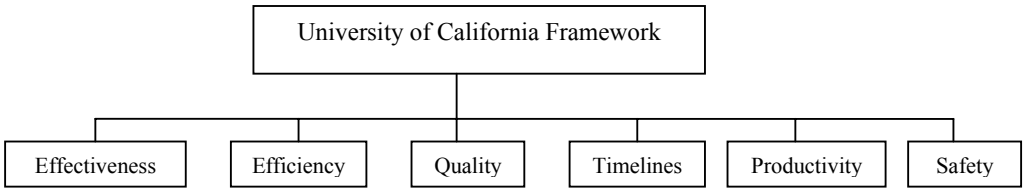



**Figure 14** University of California framework

Family of measures framework

Family of measures framework has five measurement categories (Department of Energy, 2001):

1. Profitability: Relationships between output generated and resources consumed for output generation.

2. Productivity: The value added by the process divided by the value of labor and capital consumed.

3. External Quality: Measures whether a unit of work was done correctly and on time also meets customer requirement and expectations.

4. Internal Quality: A process characteristic indicating the degree to which the process produces the required output at minimum resource cost.

5. Other Quality: Measurement the overall health of the organization and the working environment of its employees. Ability to change over time within processes or operation, and products/services offered in the market.

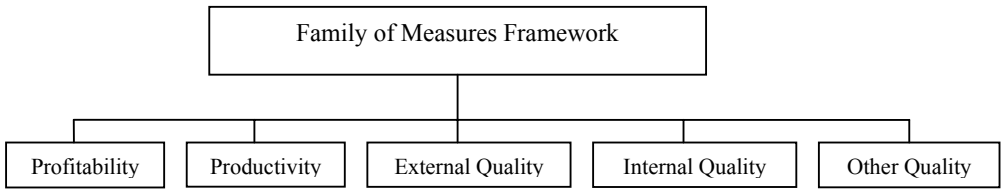



**Figure 15** Family of measures framework

## The Performance Pyramid

An important requirement of a PM system is that there must be a clear link between performance measures at the different hierarchical levels in a company, so that each function and department strives to wards the same goals. One example of how this link can be achieved is the performance pyramid, i.e. the SMART system (Figure 16), propose by Cross and Lynch (1992). The purpose of the performance pyramid is to link an organization's strategy with its operations by translating objectives from the top down (based on customer priorities) and measures from the bottom up. This PM system includes four levels of objectives that address the organization's external effectiveness and its internal efficiency, the development of a company's performance pyramid starts with defining an overall corporate vision at the first level, which is them translated into individual business unit objectives. The second-level business units are set short-term targets of cash flow and profitability and long-term goals of growth and market position (e.g. market, financial). The business operating system bridges the gap between top-level and day-to-day operational measures (e.g. customer satisfaction, flexibility, productivity). Finally, four key performance measures (quality, delivery, cycle time, waste) are used at departments and work centers on a daily basis.

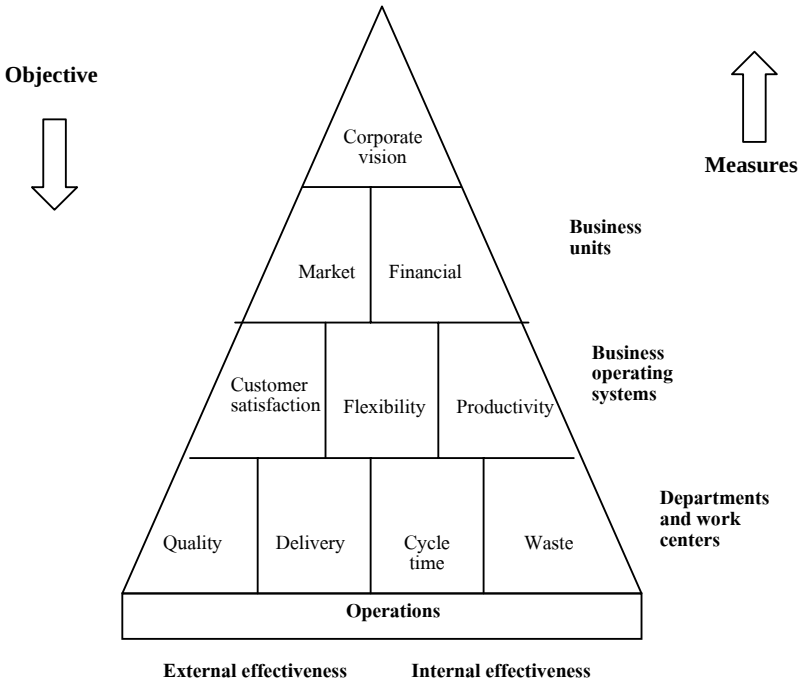



**Figure 16** The performance pyramid

**Source:** Cross and Lynch (1992)

The Performance Prism

One of the more recently developed conceptual frameworks is the performance prism (Figure 17), which suggests that a PM system should be organized around distinct but linked perspectives of performance (Neely *et al*., 2001):

(1) Stakeholder satisfaction. Who are the stakeholders and what do they want and need?

(2) Strategies. What are the strategies we require to ensure the wants and needs of our Stakeholders?

(3) Processes. What are the processes we have to put in place in order to allow our strategies to be delivered?

(4) Capabilities. The combination of people, practices, technology and infrastructure that together enable execution of the organization's business process

(both now and in the future): what are the capabilities we require to operate our processes?

(5) Stakeholder contributions. What do we want and need from Stakeholders to maintain and develop those capabilities?

The performance prism has a much more comprehensive view of different stakeholders (e.g. investors, customers, employees, regulators and suppliers) than other framework (Tangen, 2004). Neely *et al*. (2001) argue that the common belief that performance measures should be strictly derived from strategy is incorrect. It is the wants and needs of stakeholders that must be considered first. Then, the strategies can be formulated.

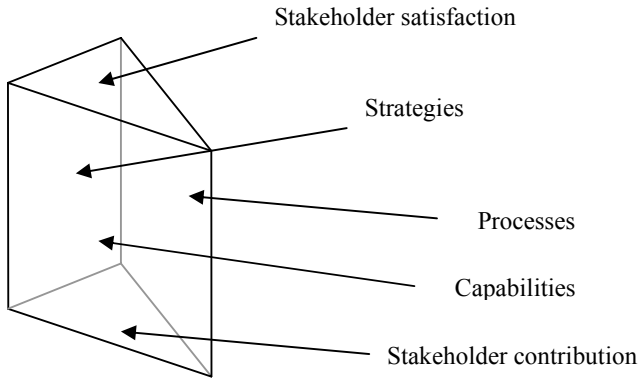



**Figure 17** The performance prism
**Source:** Neely *et al*. (2001)

Balanced Scorecard (BSC)

Probably the most well known PM system is the balanced scorecard system, developed and promoted by Kaplan and Norton (1992). The balanced scorecard proposes that a company should use a balanced set of measures that allows top managers to take a quick but comprehensive view of the business from four important perspectives (Figure 18). In turn, these perspectives provide answers to four fundamental questions:

(1) How do we look to our shareholders (financial perspective)?

(2) How do our customers see us (customer perspective)?

(3) What must we excel at (internal business perspective)?

(4) How can we continue to improve and create value (innovation and learning perspective)?

Evidently, the balanced scorecard includes financial performance measures giving the results of actions already taken. It also complements the financial performance measures with more operational non-financial performance measures, which are considered as drivers of future financial performance. The Balance scorecard framework is relevant this research.

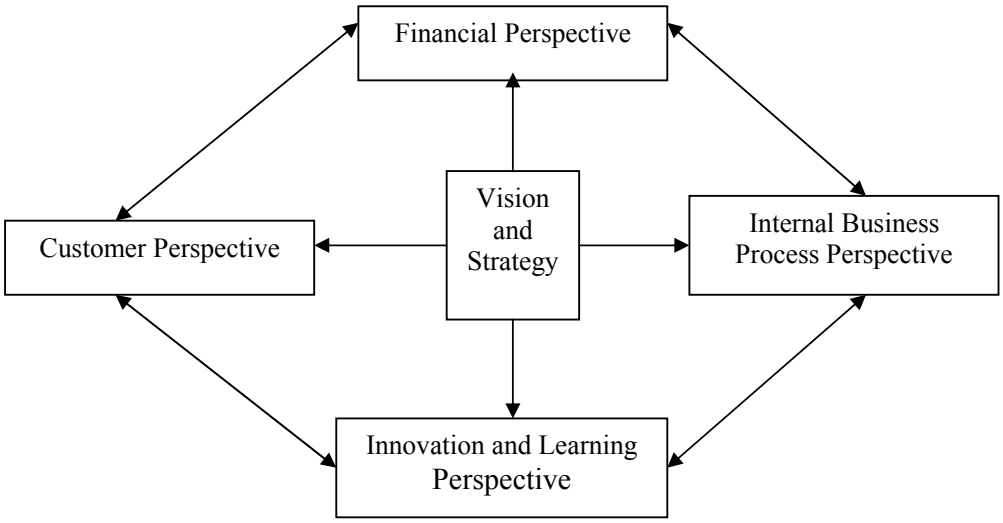



**Figure 18** The balanced scorecard links performance measure

**Source:** Kaplan and Norton (1992)

The process of building a BSC starts with a reinterpretation of the vision, or long-term strategy through the lenses of the four perspectives. This yields key success factors for each perspective, which can be translated into critical measures. In particular, the BSC can help managers carry out four activities:

(1) communication and linking by achieving a strategic alignment of the objectives of the whole organization;

(2) business planning by managing targets, coordinating initiatives and planning the budget;

(3) feedback and learning by updating plans, strategies and the BSC; and

(4) Translating the vision by clarifying the mission and long-term strategy to all constituencies inside the organization.

Renaissance Worldwide's (1998) view is that an effective BSC is more than a limited set of measures gathered into four perspectives. A good BSC should tell the story of the organizational strategy and Renaissance Worldwide describes how the following three criteria help to determine the performance measures which tell the story of the organizational strategy:

(1) Cause-and-effect relationships: every measure selected for the BSC should be part of a chain of cause-and-effect relationships that represent the strategy.

(2) Performance drivers: a good BCS should have a mix of lead and lag indicators. Lag indicators are measures which are common to most organizations while lead indicators as driver of performance tend to be unique as they reflect what is different about the strategy within the organization.

(3) Linked to financial measures: whilst goals are frequently strategic, they must translate into measures that ultimately link to financial indicators within the scorecard.

**The other examples of manufacturing performance measurement**

The key areas of manufacturing success are price, flexibility, quality, delivery, and service dimensions (Kim and Arnold, 1996).

- Price – ability to profit in price competitive markets.

- Flexibility – ability to make rapid changes in design, introduce new products quickly, make rapid volume changes, make rapid product min change, and offer broad product line.
- Quality – ability to offer consistently low defect rates, provide high performance products, and provide reliable/durable products.
- Delivery – ability to provide fast deliveries, and make dependable delivery promises.
- Service – ability to provide effective after-sales service, provide product support effectively, make product easily available, and customize products and services to customer needs.

Chen (1999) founded that quality is perceived the most important among the seven competitive priorities of manufacturing, i.e. quality, dependability, cost, flexibility, innovation, service, and time.

- Quality: represents producing products with high quality performance standards
- Dependability: represents honoring promises, meeting delivery schedules
- Cost: represents producing and distributing products at low cost
- Flexibility: represents responding to or conforming to new situations such as change in product mix, volume, material
- Innovation: represents introducing new products and process constantly
- Service: represents providing pre-sales and after-sales support
- Time: designing, producing, and distributing products faster than competitions

Kathuria (2000) studied under seven performance criteria. There are (1) accuracy, (2) customer satisfaction, (3) efficiency, (4) productivity, (5) timeliness, (6) quality, and (7) quantity. This study founded those performance criteria were consistent with competitive priorities (i.e., cost, quality, delivery, flexibility).

Hudson *et al*. (2001) illustrated the grouping of terms of performance dimension that found within the literature into six general dimensions (Table 1). These six dimensions can be seen to cover all aspects of business: the financial results, the operating performance (through the dimensions of time, quality, and flexibility), the way the company is perceived externally (through its customers), and the cultural aspects of the working environment (through the human resource dimension).

**Table 1** Critical dimensions of performance

| Dimensions | Terms of Performance | |
|---|---|---|
| Quality | - Product performance<br>- Delivery reliability<br>- Waste | - Dependability<br>- Innovation |
| Time | -Lead time<br>-Delivery reliability<br>-Process throughput time<br>-Process time<br>-Productivity | -Cycle time<br>-Delivery speed<br>-Labor efficiency<br>-Resource utilization |
| Flexibility | - Manufacturing effectiveness<br>-Resource utilization<br>-Volume flexibility<br>-New product introduction | -Computer systems<br>-Future growth<br>-Product innovation |
| Finance | -Cash flow<br>-Market share<br>-Overhead cost reduction<br>-Inventory performance<br>-Cost control | -Sales<br>-Profitability<br>-Efficiency<br>-Product cost reduction |
| Customer satisfaction | -Market share<br>-Service<br>-Image<br>-Integration with customers | -Competitiveness<br>-Innovation<br>-Delivery reliability |
| Human resources | -Employee relationships<br>-Employee involvement<br>-Workforce<br>-Employee skills | -Labor efficiency<br>-Quality of work life<br>-Resource utilization<br>-Productivity |

Gomes *et al.* (2006) suggested methodologies and indicators to measure the manufacturing performance in a context pertaining to these concerns:

- Products development and other R&D initiatives
- Manufacturing strategies
- Human resources
- Logistics and planning issues in manufacturing organizations
- Maintenance
- Supply chain activities
- Just in time implementation
- Chang in layouts
- Automation of manufacturing resources
- Conveyor systems in flexible productive environments
- The quality control of products
- Quality circles
- Productive resources

**Key Performance Indicators (KPIs)**

Key Performance Indicators (KPIs) are compilations of data measures used to assess the performance of operations. In order to measure performance of calculate the effects of any given change on the process, one must first determine the appropriate Key Performance Indicators (KPIs) to focus on to measure its impact. Performance indicators can be defined by either the quantitative results of a process, e.g., $/unit, unit/man-hour, or by qualitative measures such as worker behavior on the job, safety, motivation. Table 2 illustrates sample KPIs from Kaplan and Norton (2003)

**Table 2** Sample KPIs from Kaplan and Norton

| BSC Perspectives | Possible Measures |
|---|---|
| Financial | Revenue growth , Costs, Margins, Profitability, Cash flow, Return on investment (ROI), Return on Equity (ROE), EVA (Economic value added) |
| Customer | Customer satisfaction, Customer retention, Market share, Customer referrals, Cross – selling , Price relative to competition, Brand recognition |
| Internal business process | |
| - Operation Management | Quality, Lead time, Inventory, Productivity, Efficiency, Non-value adding activities, Risk minimization, Alternative distribution channels |
| - Customer Management | Customer complaints, Complaint resolution, Products per |
| - Innovation | customer Number of new products, R&D, Patents, New opportunities, |
| - Regulatory & Social | Product and service diversification<br>Employee safety and health, Environment, Regulatory employee acquisition issues, donation |
| Innovation and learning | |
| - Human Capital | Employee turnover, Employee satisfaction, Average workforce age, |
| - Information Capital | Education, Training |
| - Organization Capital | Knowledge sharing, IT infrastructure development, System response rate, Down time<br>Corporate value adoption, Culture development, Teamwork, Leadership efficiency, Organizational alignment |

Many researches have studied on focus areas and performance measures. They are namely, Dixon *et al*., (1990), Ahmed, Montagno and Firenze (1996), White (1996), Neely (1998), Beamon (1999), Ward and Duray, (2000), Gunasekaran *et al*., (2000), Najmi and Kehoe (2000), Evans and Lindsay (2002), Rao (2006), and Phusavat and Photaranon (2006) See Table 3.

**Table 3** Example of focus areas and performance measures

| | Focus Areas | | Performance Measures |
|---|---|---|---|
| 1 | Financial | 1.1 | Annual earning |
| | | 1.2 | profitability |
| | | 1.3 | return on investment |
| | | 1.4 | Inventory turnover |
| | | 1.5 | Production cost |
| | | 1.6 | Operation profits |
| | | 1.7 | Profit-to-sales ration |
| | | 1.8 | Cash flow |
| | | 1.9 | Cost saving |
| | | 1.10 | Revenue growth |
| | | 1.11 | Return on Equity |
| | | 1.12 | Total profit |
| | | 1.13 | Total revenue |
| | | 1.14 | Delivery cost |
| | | 1.15 | Average growth in annual sale |
| | | 1.16 | Average growth in market share |
| | | 1.17 | Percentage growth in return on assets |
| | | 1.18 | Percentage growth in return on sales |
| 2 | Market | 2.1 | Market share |
| | | 2.2 | Sale volume |
| | | 2.3 | Sale growth rate |
| | | 2.4 | Market development |
| 3 | Product | 3.1 | product quality |
| | | 3.2 | productivity |
| | | 3.3 | Range of products and services |
| | | 3.4 | Errors, defects, rework |
| 4 | Process efficiency | 4.1 | Production lead time |
| | | 4.2 | On-time delivery |
| | | 4.3 | Manufacturing cycle time |
| | | 4.4 | operating cost per employee |
| | | 4.5 | sales per employee |
| | | 4.6 | Actual production/planned production |
| | | 4.7 | Capacity utilization |
| 5 | Employee (Human resource management) | 5.1 | improvement in employee skills |
| | | 5.2 | employee flexibility |
| | | 5.3 | Employee turnover |
| | | 5.4 | Employee satisfaction |
| | | 5.5 | Absenteeism |
| | | 5.6 | Employee involvement |
| | | 5.7 | Safety record |
| 6 | Quality/independence of management | 6.1 | Experience/reputation of management |
| | | 6.2 | Shareholder disputes |
| | | 6.3 | Dispersion ownership |
| | | 6.4 | Ethical behavior of management |

**Table 3** (Continued)

| | Focus Areas | | Performance Measures |
|---|---|---|---|
| 7 | Innovation | 7.1 | R&D activities |
| | | 7.2 | R&D expenditure |
| | | 7.3 | new and improved product introduction |
| | | 7.4 | Percent of sales due to new products |
| | | 7.5 | Number of new patents |
| 8 | Regulatory & Social | 8.1 | Political/public affairs |
| | | 8.2 | Donations |
| | | 8.3 | Environment policies implements |
| | | 8.4 | Community involvement |
| 9 | Customer | 9.1 | Customer complaint |
| | | 9.2 | Customer satisfaction |
| | | 9.3 | Retention |
| | | 9.4 | Acquisition |
| | | 9.5 | Warranty claims |
| | | 9.6 | Brand recognition |
| 10 | Competitive environment | 10.1 | Potential for new competitors |
| | | 10.2 | Geographic diversification |
| | | 10.3 | Customer diversification |
| | | 10.4 | Product diversification |

Performance measures are often used increase competitive and profitability of manufacturing companies through the support and encouragement of productivity improvements. Appropriate performance measures can ensure that managers adopt a long-term perspective and allocate the company's resource to the most effective improvement activities. Tangen (2003) suggests that:

- The measures must be derived form strategic objectives to ensure that operations, employee behavior is consistent with corporate goals.
- The measures must provide timely, relevant and accurate feedback, from both a long-term and short-term perspective.
- Measurement should be undertaken in ways that are easily understood by those whose performance is being evaluated
- Measurement should be accomplished by a limited number of performance measures that consist of both financial and non-financial measures.

## Using the Balanced Scorecard

Papalexandris *et al*. (2004) present the experience from the implementation of a specific BSC model at a large software development company (SDC) in Greece. There are seven distinct sequential project phases.

### Phase I (Project preparation)

Phase I was the project preparation comprising:

(a) Project visioning, scoping and planning;
(b) Assessment of the change imperative, and;
(c) Selection of the project team.

### Phase II (clarification of the vision and identification of the strategy)

Phase II involved the clarification of the company's vision, the assessment of the external and internal environment and the synthesis of the detailed strategy and evolved as follows:

(a) Structured questionnaires were compiled and distributed to interviewees;
(b) One-hour workshops and interviews were performed;
(c) Results were analyzed and summaries were compiled;
(d) A SWOT analysis was established;
(e) Strategy details were devised and classified into strategic themes, which provided the means for segmenting the strategy into areas of focus;
(f) Conclusions were reported and approved by management committee.

### Phase III (identification and prioritization of strategic objectives)

Phase III was the most critical implementation phase. It addressed the identification and prioritization of strategic objectives, targeting:

(a) The ranking of strategic objectives inherent in each strategic theme;
(b) The allotment of objectives into BSC perspectives.

**Phase IV (selection of the measures)**

Phase IV involved the selection of the measures for monitoring strategic objectives and the measure owner responsible for one or more of them. Table 4 shows a final selection of 20 measures, four perspectives.

**Phase V (target setting and scheduling)**

Phase V include target setting and determining measurement frequency. Milestones were also set for each target according to the most appropriate measurement period. Financial measures were taken every six months to one year; all other measures, which were not affected by seasonality and other factors that would make the results misleading, were examined at shorter interval.

**Phase VI (development of strategic initiatives)**

Phase VI involved the development of strategic initiatives that would contribute in attaining the targets set in Phase V, and the designation of a budget for these initiatives.

**Phase VII (formulation of the implementation plan)**

Phase VII addressed the formulation of the implementation plan including the communication and breakdown of measures to all organizational levels, and the selection of the IT necessary to monitor the KPIs.

**Table 4** Measures selected for the balanced scorecard of SDC

| BSC Perspectives | Strategic objectives | Performance measures |
|---|---|---|
| Financial | - Add value to the group | - EVA (Economic value added) |
| | - Reduce cost | - Total cost per employee per division |
| | - Increase Earning | - EBIT (Earnings before interest and tax) |
| | - Increase revenue from new technologies | - Revenue from new technologies / total revenue |
| Customer | - Increase customer satisfaction | - Customer satisfaction index |
| | - Add and retain value customers | - Revenue per customer |
| | - Diversify customer portfolio | - Customer loyalty index |
| | - Increase market share | - % projects in new technologies |
| | | - % market share |
| Internal business process | - Manage attrition | - Employee turnover (%) |
| | - Increase productivity/employee utilization | - Chargeability per employee (%) |
| | - Improve quality: | |
| | (a) Keep milestones | - (a) Deviation from milestones |
| | (b) Reduce number of error reaching the client | - (b) Number of critical and major errors reaching to customer |
| | (c) Minimize response time to error | - (c) Response time to error/ maximum allowed response time |
| | - Reduce time to market for projects in new technologies | - Time – to – market |
| Innovation and learning | - Improve employee satisfaction | - Employee satisfaction index |
| | - Improve training efficiency | - Training efficiency index |
| | - Improve knowledge management | - Knowledge management access and contribution |
| | - Train in leading edge technologies | - % training in leading edge technologies |
| | - Cross train/ perform job enlargement | - % Man – hours in cross training |

The results of the implementation include the strategy maps and the KPIS, which were properly established and thoroughly evaluated. The crux of the balanced scorecard is the linking together of the measures of the four areas in a causal chain which passed thought all four perspectives.

The BSC can be implemented successful with the small and medium size enterprises, SME (Fernandes *et al*., 2005). Biddle air system (BAS) is an established SME and operates with less than 250 employees. The resulting list of KPIs was then

allocated to each of the four perspectives and is demonstrated in Table 5. The implementation exercise at BAS resulted in the following benefits:

- The implementation of BSC enhanced BAS's ability to respond rapidly to the ever-changing refrigeration and air-conditioning market within which it operates.
- It enhanced the stability and operability of the company.
- The inventory could be kept at a very low level.
- The average stock turnover of products in the warehouse had been lowered.
- The information flow in the supply chain has been speeded significantly.

**Table 5** KPIs at Biddle Air System (BAS)

| BSC Perspectives | Critical factors | KPIs |
|---|---|---|
| Financial | - Growth | - Revenue growth |
| | - Profitability | - Return on equity |
| | - Cost leadership | - Unit cost |
| | - Add value to company | - EVA (Economic value added) |
| | - Increase earning | - EBIT |
| Customer | - New products | - % of sale from new products |
| | - Responsible supply | - On – time delivery |
| | - Preferred supplier | - Share of key accounts |
| | - Customer partnership | - No. of cooperative efforts |
| Internal business process | - Product excellence | - Cycle time |
| | - Increased design productivity | - Efficiency |
| | - Product launch | - Actual launch vs. delay |
| | - Employee turnover | - Reduction in W/F |
| Innovation and learning | - Product learning | - Time to new process maturity |
| | - Product focus | - % of product representing 80% sales |
| | - Time to market | - Compare to competitions |

Butler *et al*. (1997) report on a study undertaken for Rexam Customer Europe to determine, develop and implement balanced scorecard for top level use. The proposed measures based on two-part balanced scorecard tailored suit the particular requirement of the company; split up into 2 major sections: Strategy and Principles.

- Strategy (Part A): Linking measures to key objective and targets from strategy.
- Principles (Part B): Linking measures to the way that Rexam 'does its business' as outlined.

Tables 6 and 7 show the scorecards of strategy and Principles, respectively. Those scorecards of strategy are shown in diagrammatic form in Figure 19.

However, they acknowledge that each of the four specified categories require 'translation' into the special operating conditions and needs of individual companies.

**Table 6** The scorecard of REC strategy

| Perspectives | Objective | Measures |
|---|---|---|
| Shareholder's (or Financial) | - Return on net assets improvement | - Gross margin (%)<br>- Overhead, % of sales (%)<br>- Working capital (%) |
| Extraordinary growth | - Sales growth / broader base of customers | - % Sales growth yr/yr (%)<br>- % Sales from new projects (%)<br>- % Sales from top '4' customers<br>- Factored sales of new projects sanctioned (€)<br>- Market share in markets where REC No. 1 or No.2 (%) |
| Continuous improvement (process improvement) | - Profit improvement | - Capacity utilization (%)<br>- Waste (%)<br>- Production cost yr/yr improvement (%)<br>- Gross margin for new project development (%)<br>- Customer return (%) |
| | - Cycle time reduction | - Average turnaround sample requests (days)<br>- Projects sanctioned/commercialized (over period) (%)<br>- R&D time on new projects (%)<br>- % project productive (%)<br>- No. projects changed after commercialized (No.)<br>- On time delivery |

**Table 7** The scorecard of REC principles

| Principles | Measures |
|---|---|
| Customer | - Customer satisfaction index (index)<br>- % Partner (%) |
| People | - Employee satisfaction index (index)<br>- Training hours/employee (hr) |
| Innovation | - % Sales from new products (%)<br>- No. of "spirit of innovation" awards (No.) |
| Process | - No. of "spirit of Co-operation" awards (No.)<br>- No. of commendations (No.) |

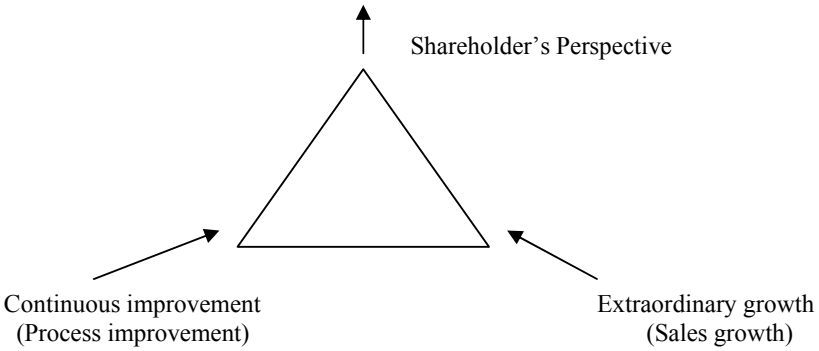



**Figure 19** The Rexam custom model

**The relationship between perspectives**

Sim and Koh (2001), using information collected from 83 electronics companies located within the USA., correlation and regression results from the study provide support for the balanced scorecard; customer, internal business process, and innovation and learning perspectives are positive (+) related to market share and sales but negative (-) related to manufacturing costs. Specifically, findings suggest that BSC can be used as a tool for monitoring the long-term value creation process. Table 8 is a scorecard used in her study.

**Table 8** A framework of the balanced scorecard for a manufacturing division

| BSC Perspectives | Strategic objectives | Performance measures |
|---|---|---|
| Financial | Reward shareholder by cutting costs and improving sales | • Manufacturing costs<br>• Sales<br>• Market share |
| Customer | Delight the Customers | • Customer performance<br>(1) customer perceived product durability and reliability<br>(2) customer perceived overall product performance<br>(3) customer complaints<br>• Delivery performance |

**Table 8** (Continued)

| BSC Perspectives | Strategic objectives | Performance measures |
|---|---|---|
| Internal business process | To improve manufacturing efficiency | • Quality performance<br>(1) cost of scrap<br>(2) units reworked<br>(3) units of defect<br>(4) warranty cost<br>(5) sales returned<br>• Performance in manufacturing lead time |
| Innovation and learning | Be innovative and continually improve our manufacturing skills | • Employee training<br>(1) management devotion to quality improvement<br>(2) quality related training provided to employee<br>(3) percent of employee who have quality as a major responsibility<br>• Innovative techniques<br>(1) quality function deployment technique<br>(2) Taguchi methods<br>(3) continuous process improvement technique<br>• New product development time |

Wang and Chang (2005) investigate the impact of intellectual capital elements on business performance, as well as the relationship among intellectual elements from a cause-effect perspective. They use the partial least squares approach. Results (Figure 20) show that intellectual capital elements directly affect business performance, which the exception of human capital. Human capital affects innovation capital and process capital. Innovation capital affects process capital, which in turn influences customer capital. Finally, customer capital contributed to performance. The cause-effect relationship between leading elements and lagged elements provides implications for the management of firms in the IT industry.

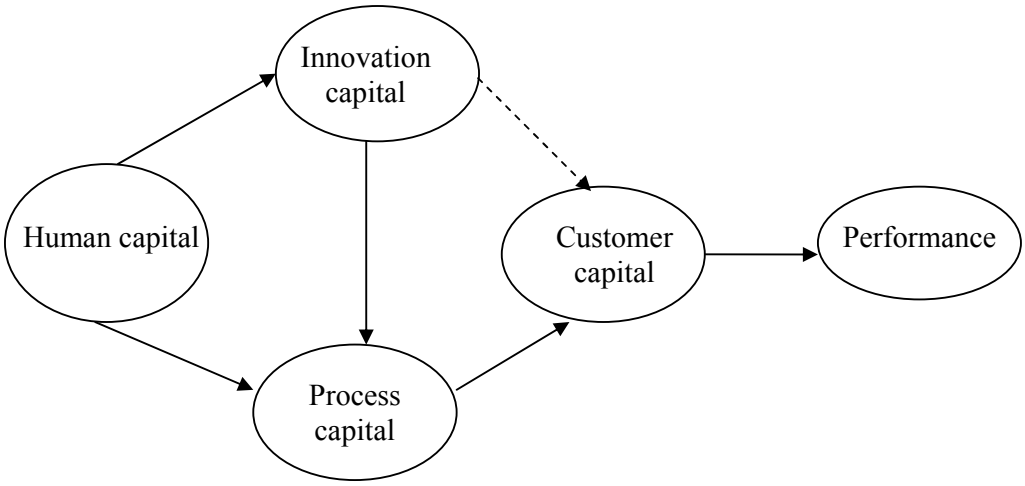



**Figure 20** Results for the interrelationship between intellectual capital elements and performance

Hasan and Kerr (2003) investigate the relation between total quality management practices and organizational performance in service organizations. The total quality management is nine dimensions in service organization. The four organizational performance used in this framework are shown in Table 9. Quality dimensions are independent variable, and performance measures are dependent variable. Using a questionnaire survey, several multiple regression models were developed which indicate that the dimensions "role of top management" and "customer satisfaction" are among important in term of their effect on organizational performance (Table 10).

**Table 9** Performance measures

| Organizational performance | Measure |
|---|---|
| Productivity and quality | - Productivity<br>- Efficiency<br>- Cost of quality<br>- Error of defects |
| Scheduling and delivery | - Lead time<br>- Timeliness of delivery<br>- Vender relation |
| Financial result | - Return on asset<br>- Return on sales<br>- Return on total quality<br>- Market share |
| Customer satisfaction performance | - Customer satisfaction<br>- Employee satisfaction<br>- Employee turnover |

**Table 10** The relationship between TQM and organizational performance

| Organizational performance measures | Dimensions of quality management |
|---|---|
| - Employee satisfaction | - Top management<br>- Quality cost<br>- Service design |
| - Efficiency | - Employee involvement<br>- Customer satisfaction |
| - Customer satisfaction | - Employee involvement<br>- Customer satisfaction |
| - Employee turnover and<br>- Error or defects | - Top management<br>- Customer satisfaction |
| - Productivity | - Employee involvement<br>- Customer satisfaction |
| - Return on total quality | - Employee involvement |
| - Cost of quality | - Top management<br>- Quality cost |

## The Strategy Map Concept

The concept of a strategy map was introduced by Kaplan and Norton (2001, 2004). A strategy map is like a road map, which describes only the main characteristics of the strategy of the strategy on the way to a better future. A strategy map includes a linked series of objectives located in the different perspectives and incorporates a set of cause-and-effect relations among the objectives. The definition of the objectives and linkages may be based on research, experience or hypotheses.

The strategy consists of a series of linked hypotheses. A strategy map specifies these cause-and-effect relationships, which makes them explicit and testable. The key then, to implementing strategy is to have everyone in the organization clearly understand the underlying hypotheses, to test the hypotheses continually, and to use those results to adapt as required (Kaplan and Norton, 2003).

The balanced scorecard provides a language that executive teams can used to discuss the direction and priorities of their enterprises. They can view their strategic measures, not as performance indicators in four independent perspectives, but as a series of cause-and effect linkages among objectives in the four balanced scorecard perspectives.

The strategy map is best built by starting at the top working downwards. The manager should state by revisiting the mission statements and core value of the company – why the company exists and what is believes in. from that a strategic vision can be developed and the strategy is then defining the logic for how to arrive at that destination. The four dimensions of the strategy map is the same as the earlier identified critical success factors identified in earlier versions of the balanced scorecard framework. They follow the same linear cause-and –effect relationship as proposed in 1996. By starting with the financial perspective, the strategy map is laid down from what we want to achieve to what changes and capabilities we need to acquire as an organization.

The strategy map is created using a framework that plots the dimensions (or perspectives) of the balanced scorecard. Across the top are the generic financial strategies of the organization, namely; build franchise, increase customer value, increase cost structure, and improve asset utilization. The main idea of the mapping process is to plot the organization's financial objectives in the financial area (also referred to as the "outcome" area), then use the map as a cause-and-effect architecture to show how the strategy in each dimension is to be carried out to achieve the desired outcomes. The map is created in a downward flow, each dimension completed in the context of how it helps execute the dimension above it. Note the seemingly reverse logic of the arrows, which flow upward: this is to indicate that the boxes below explain how the box above it will be achieved (for example, "If we expand relations with existing customers (“customer retention”), then we can increase customer value"). The map should be read as a series of IF-THEN statement. The arrows articulate the cause-and-effect relationships among the objectives.

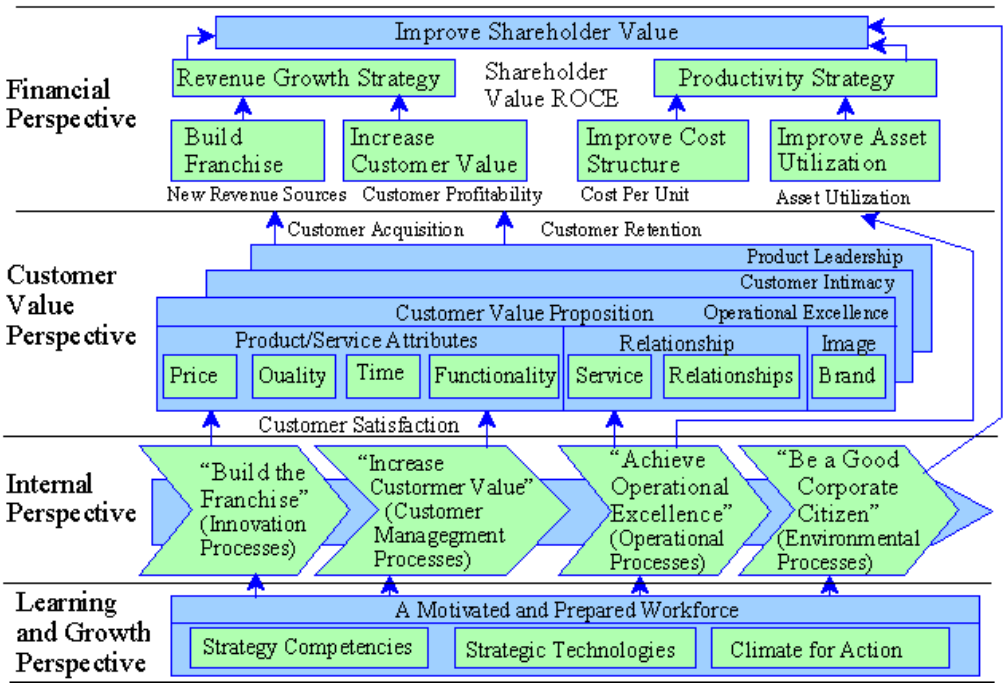



**Figure 21** The Balanced Scorecard generic strategy map

Figure 21 shows what a completed generic strategy map might look like. The systematic process of building the map, piece by piece, brings clarity and logic to the strategy formulation process. This not only enhances the strategy, it also makes it easier to communicate through the appealing visual format that results. In practice, a few differences are often noted:

- for a specific organization, a strategy map will be much more specific to that organization's strategy;
- the cause-and-effect arrows are often omitted to reduce clutter; and
- the names of the dimensions can vary depending on the company and nature of the organization (e.g. "customer" may be called "stakeholder" in a not-for-profit situation).

Scholey (2005) guide a general step-by-step process for delivering on a strategy mapping initiative (i.e. the "how" element). A framework that has proven useful for several organizations is a six-step process that results in not only a completed strategy map, but also a well-understood, describable strategy that can be communicated throughout the organization:

- choose the overriding objective;
- select appropriate value proposition;
- determine general financial strategies to follow;
- determine customer-focused strategies;
- decide how internal processes will support execution of strategies chosen;
- implement the skills/capabilities and employee programs that are required to achieve strategy.

Kettunen and Kantola (2005) discussed that the balanced scorecard may well be an insufficient tool to communicate and implement the strategy due to the unreliable measures and troublesome calculation. The hypotheses underlying the strategy are made explicit through the strategy map’s cause-and-effect linkage across the four perspectives. Ittner and Larcker (2003) also highlighted the frequent failure

of business managers both to link performance measures, on the basis of causal model, to an organization's strategy and to validate the link. Manville (2007) found that the operational manager did not clearly relate the linkage of the KPIs to the business plan as many had not has access to the plan until quite recently as the business plan is used mainly as an executive document. Thus, managerial background and actual task environment may have an important effect on managers' attention to differences in the design of causal relationships in the balanced scorecard and use of performance management system.

Davis and Albright (2004) reported that 77 percent of BSC adopters in USA failed to develop a causal model of their strategy. Similar findings are reported in studies on BSC adoption in India, Finland, Austria, Malaysia and Germany (Anand *et al*., 2005, Malmi, 2001; Othman, 2006; Speckbacher *et al*.,2003). Meyer (2002) argued that BSC has no strong basis in theory as it does not show how to combine the dissimilar measures into an appraisal of performance. According to Atkinson (2006), it appears that the difficulties in the BSC are due to the difficulties in implementing certain aspects of the method as well as in the limitations of the method itself. However, some researchers argue that no specific method is available to help organizations develop the causal model of their strategy (Malmi, 2001; Speckbacher *et al*., 2003).

## How the Measures Work Together

Because all balanced scorecards will possess a variety of disparate measures using different units, it is necessary to provide an easy way to integrate these. This is normally done by using a simple (say, 0-10) scale for each factor– and using a conversion process to convert actual measures to these normalized scores (Sanger, 1998). The setting of the normalized score conversion points is very important. It does however make the results much more easily viewed by those with little detailed knowledge of the actual situation. For example, an average floor-to-floor time for a manufacturing cycle of four days is only good or bad when compared to some target – whether an internally imposed target, or a benchmark from competitors. When the

actual is compared to the target and converted to a score of 8 out of 10, the performance can easily be assessed.

Sink (1985) proposed the Multi-Criteria Performance Measurement Technique (MCPMT). MCPMT is designed to allow the user to evaluate the various productivity measures and decide which are the most important. It also allows the user to aggregate dissimilar productivity measures. Kurstedt (1992) also use this technique to group the measures into several indicators. For example, he grouped the performance measures into input, transformation, and output combinations by multiplying them together.

MCPMT Procedure:

1. Typically, each criterion is quantifiable or measurable. A performance scale needs to be developed for each criterion. These performance scales can range over any interval; however, 0 to 1.0, 0 to 10, or 0 to 100 are the usual. Note that the major purpose of a performance scale is to have a non-dimensional scale for unlike criteria.

2. Convert the data from each criterion into performance scale. Using there preference curve help complete assignment of a score for all results. There are three points (the maximum, minimum, and average) that help form a preference curve for each criterion. Note that actual performance as measured against the scales represented on the x-axis is transformed into a performance score (0 to 1.0, 0 to 10, or 0 to 100) on the y-axis.

3. Assign the weight for each criterion. Weighting factors will reflect the relative contribution from each performance criterion in the organizational system's overall performance.

4. Then, these performance score are multiplied by the criteria weighting factors to obtain the weighted scores.

5. The final step is to add together all the weighted scores.

This research uses MCPMT to aggregate multiple measures into the overall performance level because this technique has clearly procedure.

## Correlation Analysis

The last part of the chapter describes how to use the correlation analysis to verify the relationship between focus areas. According to Triola (2002), Correlation analysis is a measure of the strength and the direction of the linear relationship between two variables, describing the direction and degree to which one variable is linearly related to another. In other words, the linear correlation coefficient measures how closely the points in a scatter diagram are spread around the regression line. The correlation coefficient calculated for the population data is denoted by $\rho$ (Greek letter rho) and the one calculated for sample data is denoted by $r$. The linear correlation coefficient is sometimes referred to as the Pearson product moment correlation coefficient. The linear correlation coefficient formula is:

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2}\sqrt{n(\sum y^2) - (\sum y)^2}}$$

Where,

$n$ represents the number of pairs of data present.

$\sum$ denotes the addition of the items indicated.

$\sum x$ denotes the sum of the all $x$-values.

$\sum x^2$ indicates that each $x$-value should be squared and then those squares added.

$(\sum x)^2$ indicates that x-value should be added and the total then squared.

$\sum xy$ indicates that each $x$-value should first be multiplied by its corresponding $y$-value. After obtaining all such products, find their sum.

$r$ represents the linear correlation coefficient for a sample.

$\rho$ represents the linear correlation coefficient for a population.

**Interpretation**

The Pearson correlation coefficient can take values from -1 to +1. A value of +1 shows that the variables are perfectly linear related by an increasing relationship, a value of -1 shows that the variables are perfectly linear related by an decreasing relationship, and a value of 0 shows that the variables are not linear related by each other. There is considered a strong correlation if the correlation coefficient is greater than 0.8 and a weak correlation if the correlation coefficient is less than 0.5.

**Statistical test**

Student t-test was used to determine if the value of Pearson correlation coefficient is statistically significant from zero, at a significance level of 0.05.

The null hypothesis vs. the alternative hypothesis was:

$H_0$: $\rho = 0$ (there is no linear correlation between the variables)

$H_1$: $\rho \neq 0$ (there is linear correlation between the variables)

For significance level equals to 0.05, a p-value less than 0.05 means that there is an evidence to reject the null hypothesis in favor of the alternative hypothesis. In other words there is a statistically significant linear relationship between the variables.

Nowadays, many statistical software packages are developed and used extensively. The examples of these software packages are Minitab, SPSS, and etc. These programs can be used as efficient tools for statistical analysis such as establishing simple and multiple regression models, checking the significance and adequacy of the relationships, plotting statistical graphs, solving statistical problems, and so on.

# MATERIALS AND METHODS

## Materials

The materials for this research can be categorized into two groups as follows:

1. Hardware

A personal computer, CPU Pentium III, Ram 128 MB, is used to process the raw data, analyze the data, and evaluate the statistical results.

2. Software

Microsoft Excel is used to create indexes, process raw data, and create tables for this research document.

Minitab 14 is used to analyze statistical data, and evaluate the model.

Microsoft Word is used to create this research document.

## Methodology

This section focuses on the methodology of this research. The study has been conducted in nine steps as follows: (See Figure 22).

Step 1: Investigation of the current key performance indicators (KPIs) from the case selection. The case selection is to select three medium-sized manufacturing companies which represent one of the major industrial sectors in Thailand.

It is important to initially determine key parameters used to select companies for this study. There are three parameters: (1) market position, (2) market share, and (3) companies' previous achievement. Based on information collected, participating companies are in general well respected with past and present business successes. See Table 11.

These three participating companies can be described as a medium in size, and operate in a competitive environment. The first company produces construction and chemical materials with approximately 150 employees. The second company sells plastics and paper packages with the employment of over 200 staffs. The third company's primary output is drinking water. There are approximately 200 employees. For all three SMEs under study, their top executives are also the owners.

**Table 11** Background of three companies under study

| **Description** | **Results in 2005** | | |
|---|---|---|---|
| | Company # 1 | Company # 2 | Company # 3 |
| 1. Market Position (more than 10 companies in each of the company's corresponding industry) | 2 | 1 | 3 |
| 2. Market Share (approximation) | 25% | 70% | 25% |
| 3. Major Rewards and Recognitions (during the study's period) | (1) Best Product Quality Award from the Thai Concrete Association | (1) Best Product Design Awards from the Ministry of Industry<br>(2) Small and Medium Enterprise (SME) Awards for Outstanding Management | (1) Best Factory Management Award from the Ministry of Industry<br>(2) Small and Medium Enterprise (SME) Awards for Outstanding Management |

Step 2: Classification of the common KPIs from the three participating companies based on the balanced scorecard concept (BSC) in order to provide the information for analyzing the balanced scorecard model. The BSC has four perspectives:

(1) Finance perspective: emphasizing shareholder satisfaction, key goals and measures here generally involve (gross and/or net) profitability, return on capital employed, sales growth, market share etc.

(2) Customer perspective: focusing on "real" customer satisfaction, key goals and indicators typically stress common customer concerns such as delivery time, quality, service and cost etc.

(3) Internal business process perspective: key goals and measures should highlight critical skills and competencies, process and technologies that will deliver current and future organizational (customer/financial) success.

(4) Innovation and learning perspective: underpinning the other three perspectives, key long-term goals and indicators in this regard typically relate to improving flexibility and investing for future development and new opportunities.

Step 3: Collection of the data from three companies. Top managers from three companies have assisted in the data collection effort that has taken place between January 2005 and June 2006. Monthly frequency is used for the study.

Step 4: Verification of the interrelationship between scorecards. This step is important, as suggested by Kaplan and Norton (2004), prior to the development of a strategy map. In order to develop a strategy map (due to its sequential order), it is important that the balanced relationships among the four perspectives need to be clarified. Under the analysis, each scorecard consists of many indicators. Therefore, each scorecard will integrate set of KPIs to the overall result in order to verify the interrelationships among scorecards.

This step involved two techniques. The first one is the Multi-Criteria Performance Measurement Technique (MCPMT). See Sink (1985), and Sink and Tuttle (1989) for more details. This technique is useful when attempting to measure performance at the functional and organizational levels. It is primarily used for identifying the overall performance level by converting performance results into non-dimensional scale information. The performance scale of 0 to 100 was selected for this study. There were two critical tasks when using the MCPMT in this research. The first one was for converting the results from each KPI into the common 0-100 scale. The second task was for deriving an overall result for each performance perspective by assigning an equal weight for KPIs. The overall result was computed by multiplying the result from each KPI with the assigned weight.

The next technique is correlation analysis. This technique is used to examine the possibility of existing interrelationships. Typically, when establishing these interrelationships between two terms (e.g., finance and customer perspectives, or customer and internal-business perspectives), there are two conditions to be examined in this study. They are:

(1) no time consideration.
(2) time-lag consideration for one, two, three, and four month-periods.

Step 5: Development of the focus areas and classification of these KPIs into their corresponding focus areas. To develop a strategy map, these KPIs were grouped into different focus areas. These areas represented the company's key strategic objectives for the next decade. The focus areas represent key strategies, objectives, or factors that are commonly shared by the three companies under study. Its verification primarily concentrates on comparing literature.

Step 6: Quantification of the time-lag impact between focus areas. In order to quantify time-lag effects among the focus areas, the MCPMT and correlation analysis were again applied. Due to classify KPIs into focus areas, multiple KPIs under each focus area applied MCPMT to convert performance results into the overall performance level for each focus area. This research uses MCPMT to aggregate multiple measures into the overall performance level because this technique has clearly procedure. After that correlation analysis was applied to quantify the time-lag effects.

To increase the strategy map's effectiveness, Hoehn (2003) and Prybutok and Cutshall (2004) earlier indicated the need for better integration of the time- lag impacts. See Sink and Tuttle (1989), Chen (1999), Takala *et al*. (2003), and Helo (2005) for more details on the time factor and its relationships with responsiveness. To highlight the importance of the time factor, Li (2000), cited the lack of time consideration as one of many weaknesses embedded in a management process. Then,

this step attempts to find the time-lag impact between focus areas. The amount of time-lag impact assists to increase the strategy map's effectiveness.

Step 7: Building of a strategy map for each participating company. In order to understand the approach for the development of a strategy map, this study tries to adjust the set of KPIs because some KPIs can reflect more than one focus area. The adjustment of KPIs is approved by participating executives. After adjusting the set of KPIs, the process will repeat the process in step 4 again. The methodology for explicit linking performance measurement with a development of a strategy map is concluded.

Step 8: Validation of the strategy map. This step analyzes whether strategy map are useful and acceptable. There are three criteria including:

(1) Comparing manufacturing strategic surveys.
(2) Interviews with executives from the three participating companies.
(3) Compatibility with literature reviews.

Manufacturing strategies indicating the past viewpoint on the level of interest, attention, and time were given by top executives in order to advance manufacturing operations. The manufacturing strategic surveys are based on top managers' opinions. There are 10 manufacturers who participated in this survey. All participating firms were locally owned with more than 25 years of business experience. They were generally considered as high performers in their businesses. See Appendix D for these profiles. The survey, developed by Takala (2002), was chosen and modified to fit with manufacturers in Thailand. See Appendix E. There are six competitive priorities; i.e., cost, customer-focus, delivery, flexibility, know-how, and quality. These priorities are further separated into 31 manufacturing strategies. See Appendix F for more details. The analysis on the survey applies the Analytic Hierarchical Process (AHP). The AHP aimed to integrate the results (in this case, the opinions from the top executives) with pair-wise comparisons (Rangone, 1996; Takala, 2002; and Takala *et al.*, 2003). Then, the following task was to examine the relationships

among these 31 dimensions by correlation analysis. The results from the manufacturing strategic surveys are compared with the proposed strategy map.

For this study, the participating companies need to successful and belong to the Federation of Thai Industries (FTI). Due to the comprehensiveness of the results, coupled with the likelihood for lengthy follow-up interviews, only three companies voluntarily participated in this study. The top manager of each company was briefed on the concept of the performance measurement approach. Then the open-ended questionnaires were mainly used during discussion. The interview questions mainly focus into the proposed strategy map applicability and usefulness.

Step 9: Conclusions, there are two activities including 1) proposing the approach for linking performance measurement with a development of a strategy map, and 2) comparing a proposed approach with the Kaplan & Norton approach.

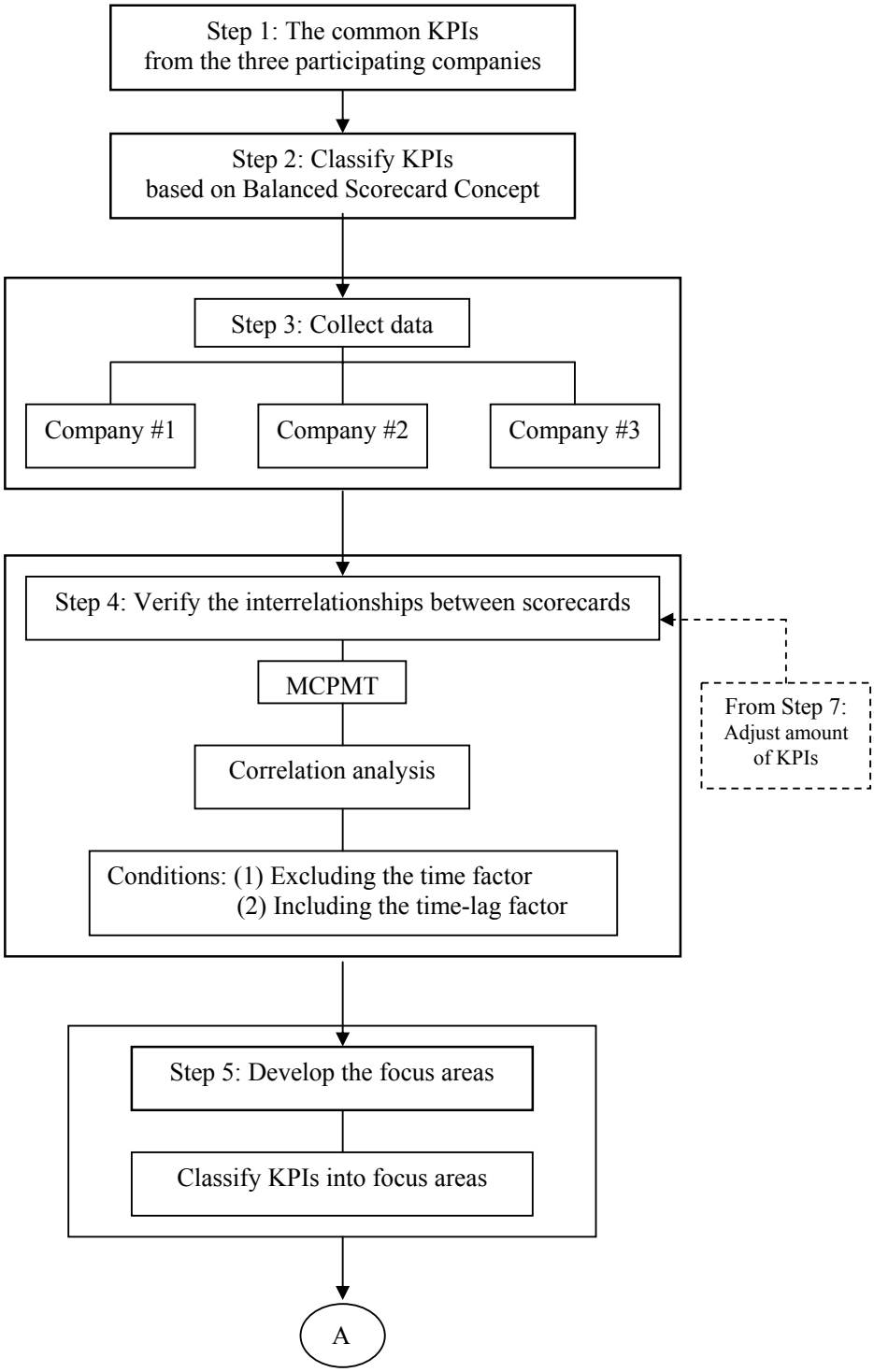



**Figure 22** The research methodology

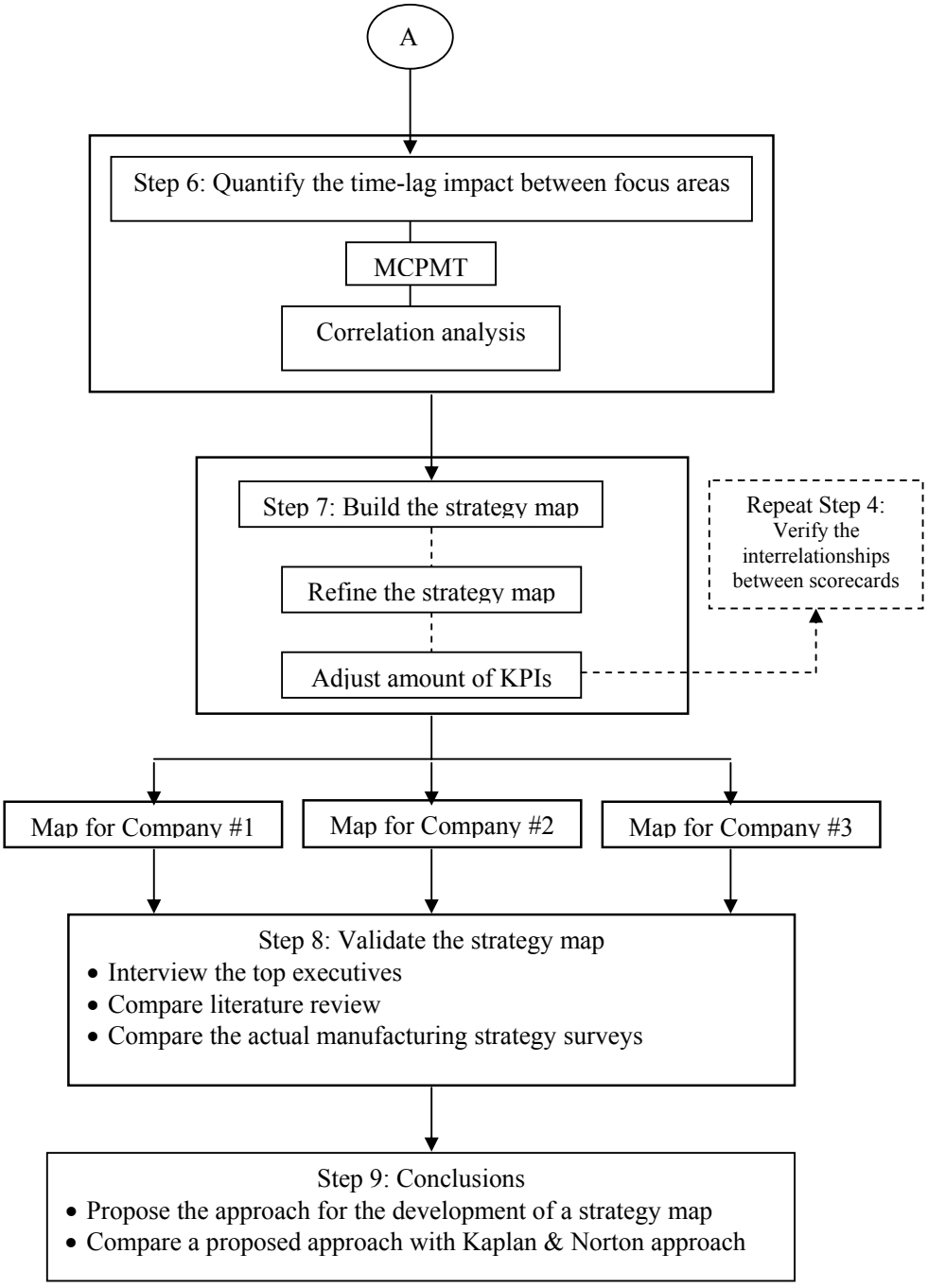



**Figure 22** (Continued)

# RESULTS AND DISCUSSIONS

## Results

This section presents the results of the study. The results can be divided into two parts. The first part concerns the development of the strategy map by based on performance information. The second part is the validation of the proposed strategy map in order to confirm the alternative approach of a strategy map development.

**Part I: The development of the strategy map**

The initial work involved the investigation of the current key performance indicators (KPIs) from the three participating companies. The current KPIs of the three companies were mainly in the ration format and were quantitative in nature. The KPIs for this study were selected by the common KPIs from the three companies. Since these three firms commonly shared key features in their operations such as size, nature of competition, and industrial growth, it was agreed that the three companies could use the same KPIs. A total of 47 common KPIs were selected and classified in to four perspectives – 19, 9, 12, and 7 KPIs for financial, customer, internal business process, and innovation and learning perspectives respectively. Table 12 shows the common KPIs for three participating companies classified into the BSC's four perspectives. It should be pointed out that the financial and internal-process perspectives have received most of their attention.

These three participating companies can be described as a medium in size, and operate in a competitive environment. The first company produces construction and chemical materials with approximately 150 employees. The second company sells plastics and paper packages with the employment of over 200 staffs. The third company's primary output is drinking water. There are approximately 200 employees. For all three SMEs under study, their top executives are also the owners.

The next step involves data collection. Top managers from three companies have assisted in the data collection effort (during January 2005 to June 2006). The monthly frequency is used for the study. The details of data collection from three companies are illustrated in Appendix A.

**Table 12** Common KPIs for data collection

| Finance | Customer | Internal Business | Innovation and Learning |
|---|---|---|---|
| F1. Current rate (baht/baht) | C1. New customers per Total customers (%) | IP1. On - time delivery (%) | IL1. R&D expense per Total expenses (%) |
| F2. Interest expense to sales ratio (baht/baht) | C2. Customer lost (%) | IP2. Average lead time (day) | IL2. Competence development expenses per Employee (baht/employee) |
| F3. Revenues per Total assets (%) | C3. Satisfied - customer index (%) | IP3. Lead time, from order to delivery (day) | IL3. Satisfied - employee index (%) |
| F4. Revenues per Employee (baht/employee) | C4. Customer - loyalty index (%) | IP4. Lead time, production (day) | IL4. Marketing expense per Customer (baht/customer) |
| F5. Profits per Employee (baht/employee) | C5. Number of customer complaints (record) | IP5. Average time for decision-making (day) | IL5. Information coverage ratio (%) |
| F6. Market value (baht) | C6. Brand-image index (%) | IP6. Inventory turnover (baht/baht) | IL6. Investment in new product support and training per Total employee (baht/employee) |
| F7. Return on capital employed (%) | C7. Average Customer Size (bath/customer) | IP7. Maintenance cost per Revenue (%) | IL7. Staff turnover (%) |
| F8. Profit margin (%) | C8. Customer payment on – time (%) | IP8. Supplier on-time delivery (%) | |
| F9. Cash flow (baht) | C9. Average direct communications to customers (time/customer) | IP9. MTBF (hour) | |
| F10. Return on investment (%) | | IP10. MTTR (hour) | |
| F11. EBITDAR (baht) | | IP11. Percentage of new product development projects completed on time (%) | |

**Table 11** (Continued)

| Finance | Customer | Internal Business | Innovation and Learning |
|---|---|---|---|
| F12. Revenues from new product per Total revenue (%) | | IP12. Total supply chain delivery performance to end customer (%) | |
| F13. Revenues per Cost of goods sold (baht) | | | |
| F14. Revenues per Marketing expense (baht) | | | |
| F15. Revenues per Raw material cost (baht) | | | |
| F16. Revenues per Energy cost (baht) | | | |
| F17. Market share (%) | | | |
| F18. Profit per Customer (baht/customer) | | | |
| F19. Revenue per Service expense (baht/baht) | | | |

In order to verify the interrelationships between scorecards, the Multi – Criteria Performance Measurement Technique (MCPMT) is applied. This technique is based on the concept of the multi–attribute decision. Its emphasis is on converting data into non–dimensional–scale information, representing an overall level of performance. Its key components involve the performance scale and the preference curve. See Appendix B for more detail on the MCPMT. Table 13 demonstrates the overall performance levels of the four perspectives from the three participating companies.

**Table 13** Overall performance levels of four perspectives for three companies

| Period | Company #1 | | | | Company #2 | | | | Company #3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **F** | **C** | **IP** | **IL** | **F** | **C** | **IP** | **IL** | **F** | **C** | **IP** | **IL** |
| 1 | 14.49 | 44.13 | 13.85 | 44.11 | 27.57 | 48.24 | 16.35 | 17.02 | 33.03 | 56.19 | 25.19 | 34.25 |
| 2 | 26.03 | 31.29 | 24.63 | 37.19 | 29.79 | 58.58 | 24.60 | 17.44 | 42.93 | 61.82 | 40.18 | 32.10 |
| 3 | 52.67 | 46.05 | 32.41 | 41.92 | 32.76 | 36.53 | 18.96 | 17.65 | 45.33 | 43.74 | 36.95 | 42.15 |
| 4 | 45.01 | 57.49 | 42.76 | 50.40 | 39.95 | 59.67 | 34.47 | 25.56 | 50.77 | 45.30 | 64.58 | 50.46 |
| 5 | 53.96 | 61.07 | 49.55 | 27.01 | 44.91 | 72.04 | 42.14 | 25.05 | 47.89 | 65.29 | 43.23 | 39.18 |
| 6 | 59.84 | 48.66 | 61.58 | 48.29 | 45.82 | 59.89 | 64.17 | 23.95 | 47.91 | 56.21 | 69.76 | 47.40 |
| 7 | 60.21 | 74.45 | 65.29 | 57.48 | 36.40 | 52.86 | 67.35 | 82.30 | 46.39 | 81.98 | 74.75 | 42.45 |
| 8 | 60.20 | 68.33 | 71.44 | 54.92 | 43.27 | 56.74 | 69.50 | 70.53 | 46.60 | 73.33 | 79.62 | 50.34 |
| 9 | 52.89 | 60.92 | 76.18 | 54.24 | 31.26 | 55.46 | 69.31 | 82.84 | 25.95 | 69.74 | 69.84 | 50.23 |
| 10 | 53.98 | 70.18 | 71.92 | 44.97 | 41.84 | 45.72 | 63.81 | 79.00 | 30.69 | 61.29 | 67.08 | 49.52 |
| 11 | 48.43 | 68.32 | 78.62 | 32.74 | 38.05 | 63.93 | 65.06 | 69.59 | 36.30 | 68.65 | 71.89 | 51.74 |
| 12 | 31.42 | 66.01 | 75.88 | 34.66 | 39.57 | 68.13 | 77.00 | 69.04 | 26.50 | 62.13 | 77.78 | 51.27 |
| 13 | 68.52 | 44.09 | 67.74 | 58.14 | 56.94 | 51.97 | 77.79 | 90.22 | 66.48 | 46.18 | 75.56 | 53.73 |
| 14 | 73.71 | 44.73 | 65.52 | 71.82 | 68.10 | 55.25 | 78.19 | 74.69 | 66.65 | 43.31 | 75.01 | 57.25 |
| 15 | 64.11 | 49.99 | 73.31 | 70.09 | 54.08 | 57.28 | 80.17 | 89.94 | 55.69 | 41.31 | 69.95 | 58.24 |
| 16 | 73.07 | 58.52 | 71.63 | 76.43 | 67.58 | 48.93 | 73.12 | 93.03 | 60.97 | 42.41 | 67.61 | 58.40 |
| 17 | 65.54 | 59.47 | 70.85 | 68.22 | 67.99 | 64.23 | 73.68 | 75.39 | 64.51 | 48.32 | 76.50 | 59.61 |
| 18 | 44.98 | 61.61 | 71.40 | 64.98 | 74.35 | 64.28 | 88.08 | 82.36 | 64.89 | 52.53 | 78.33 | 59.04 |

**Note:** "F", "C", "IP", and "IL" were denoted to overall finance performance, overall customer performance, overall internal business performance, and overall innovation and learning performance respectively.

After aggregating multiple measures into an overall performance, the correlation analysis was also applied to determine the possibility of existing interrelationship. Typically, when establishing these interrelationships between two terms (e.g., finance and customer perspectives, or customer and internal-business perspectives), there are two conditions to be examined in this study. There are: (1) no time consideration, and (2) time-lag consideration for one, two, three, and four month-periods. Due to the 18-month data, it was agreed that the maximum time lag of four periods would be sufficient. The correlation analysis is to test the relationship between the paired perspectives, based on the significance level of 0.05. The relationship can be statistically described as follows:

$H_0$: there is no correlation between the scorecards.

$H_1$: there is correlation between the scorecards.

From the statistical results, the P-value is less than the significance level (0.05), so there is evidence to reject the null hypothesis in favor of the alternative hypothesis. In other words there is a statistically significant linear relationship between the scorecards.

For company #1, the result from the correlation analysis can be described as follows: (See Table 14, 15 and Figure 23)

- There are somewhat interrelationships between the financial and customer perspectives. However, it appears that these impacts were not considered to be mutual or two-way. Namely, the financial perspective impacted on the customer perspective. In contrast, the customer perspective looks as if it did not have any impact on the financial perspective.
- The customer and internal business process perspectives were interrelated in the form of two-way impacts.
- The financial and internal business process perspectives are interrelated.
- In the same way, the financial and innovation and learning perspective are closely related in a reciprocal way.

**Table 14** The results of correlation analysis of Company #1

| Relationship between | F | C | IP | IL | F(t-1) | C(t-1) | IP(t-1) | IL(t-1) | F(t-2) | C(t-2) |
|---|---|---|---|---|---|---|---|---|---|---|
| F | - | 0.192 | 0.618 | 0.631 | - | -0.056 | 0.433 | 0.399 | - | -0.089 |
| | | (0.446) | (0.006) | (0.005) | | (0.830) | (0.082) | (0.112) | | (0.744) |
| C | 0.192 | - | 0.628 | -0.042 | 0.505 | - | 0.55 | 0.195 | 0.454 | - |
| | (0.446) | | (0.005) | (0.868) | (0.039) | | (0.022) | (0.453) | (0.078) | |
| IP | 0.618 | 0.618 | - | 0.385 | 0.731 | 0.667 | - | 0.37 | 0.781 | 0.593 |
| | (0.006) | (0.006) | | (0.115) | (0.001) | (0.003) | | (0.144) | (0.000) | (0.016) |
| IL | 0.631 | -0.042 | 0.385 | - | 0.642 | -0.192 | 0.416 | - | 0.337 | -0.095 |
| | (0.005) | (0.868) | (0.115) | | (0.005) | (0.461) | (0.096) | | (0.202) | (0.725) |

**Table 14** (Continued)

| Relationship between | IP(t-2) | IL(t-2) | F(t-3) | C(t-3) | IP(t-3) | IL(t-3) | F(t-4) | C(t-4) | IP(t-4) | IL(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|
| F | 0.213 | -0.008 | - | 0.088 | 0.16 | -0.252 | - | 0.021 | 0.131 | -0.386 |
| | (0.428) | (0.976) | | (0.756) | (0.568) | (0.365) | | (0.943) | (0.656) | (0.173) |
| C | 0.156 | 0.12 | 0.164 | - | -0.125 | 0.322 | 0.218 | - | -0.278 | 0.202 |
| | (0.564) | (0.657) | (0.559) | | (0.657) | (0.242) | (0.454) | | (0.336) | (0.489) |
| IP | - | 0.41 | 0.76 | 0.541 | - | 0.318 | 0.7 | 0.573 | - | 0.136 |
| | | (0.115) | (0.001) | (0.037) | | (0.247) | (0.005) | (0.032) | | (0.642) |
| IL | 0.389 | - | 0.29 | 0.076 | 0.384 | - | 0.232 | 0.103 | 0.505 | - |
| | (0.136) | | (0.295) | (0.789) | (0.158) | | (0.424) | (0.726) | (0.066) | |

**Note:** - F denoted overall finance-perspective performance. $F_{(t-1)}$, $F_{(t-2)}$, $F_{(t-3)}$, and $F_{(t-4)}$ denoted overall finance-perspective performance under time-lag consideration for one, two, three, and four month-periods respectively.

- C denoted overall customer-perspective performance. $C_{(t-1)}$, $C_{(t-2)}$, $C_{(t-3)}$, and $C_{(t-4)}$ denoted overall customer-perspective performance under time-lag consideration for one, two, three, and four month-periods respectively.
- IP denoted overall internal-business-perspective performance. $IP_{(t-1)}$, $IP_{(t-2)}$, $IP_{(t-3)}$, and $IP_{(t-4)}$ denoted overall internal-business - perspective performance under time-lag consideration for one, two, three, and four month-periods respectively.
- IL denoted overall innovation/ learning- perspective performance. $IL_{(t-1)}$, $IL_{(t-2)}$, $IL_{(t-3)}$, and $IL_{(t-4)}$ denoted overall innovation/ learning -perspective performance under time-lag consideration for one, two, three, and four month-periods respectively.
- Upper results show the Pearson correlation value while the lower values illustrate the P-value.

**Table 15** The relationship between the paired perspectives for Company #1

| Relationship between | | Without time factor | With time-lag factor (t-n) | | | |
|---|---|---|---|---|---|---|
| | | | n=1 | n=2 | n=3 | n=4 |
| F | C | - | - | - | - | - |
| C | F | - | √ | - | - | - |
| F | IP | √ | - | - | - | - |
| IP | F | √ | √ | √ | √ | √ |
| F | IL | √ | - | - | - | - |
| IL | F | √ | √ | - | - | - |
| C | IP | √ | √ | - | - | - |
| IP | C | √ | √ | √ | √ | √ |
| C | IL | - | - | - | - | - |
| IL | C | - | - | - | - | - |
| IP | IL | - | - | - | - | - |
| IL | IP | - | - | - | - | - |

**Note:** "√" = The relationship is significant at the 0.05 level

"–" = The relationship is not significant at the 0.05 level

F = overall finance-perspective performance

C = overall customer-perspective performance

IP = overall internal-business-perspective performance

IL = overall innovation/ learning- perspective performance

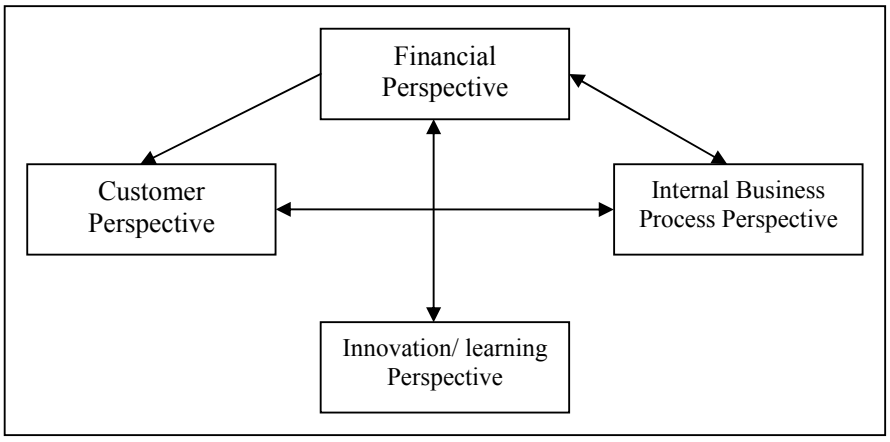



**Figure 23** Interrelationship among the BSC's four perspectives of Company #1

For company #2, the result from the correlation analysis can be described as follows: (See Table 16, 17 and Figure 24)

- The financial and internal business process perspectives are interrelated in the form of two-way impacts (i.e.; the financial perspective impacted the internal business process perspective while the internal business process perspective appeared to influence the financial perspective).
- The financial and innovation/ learning perspectives are also interrelated in the form of two-way impacts.
- The internal business process and innovation/ learning perspectives are also interconnected in the form of two-way impacts.
- Interestingly, the customer perspective appeared not to have any significant relationship with the other three remaining perspectives.

**Table 16** The results of correlation analysis of Company #2

| Relationship between | F | C | IP | IL | F(t-1) | C(t-1) | IP(t-1) | IL(t-1) | F(t-2) | C(t-2) |
|---|---|---|---|---|---|---|---|---|---|---|
| F | - | 0.215 | 0.682 | 0.556 | - | 0.168 | 0.601 | 0.602 | - | 0.112 |
| | | (0.392) | (0.002) | (0.017) | | (0.519) | (0.011) | (0.011) | | (0.679) |
| C | 0.215 | - | 0.322 | 0.027 | 0.273 | - | -0.007 | 0.048 | 0.068 | - |
| | (0.392) | | (0.192) | (0.914) | (0.289) | | (0.978) | (0.855) | (0.801) | |
| IP | 0.682 | 0.322 | - | 0.882 | 0.698 | 0.366 | - | 0.783 | 0.675 | 0.287 |
| | (0.002) | (0.192) | | (0.000) | (0.002) | (0.149) | | (0.000) | (0.004) | (0.281) |
| IL | 0.556 | 0.027 | 0.882 | - | 0.561 | 0.157 | 0.958 | - | 0.628 | 0.347 |
| | (0.017) | (0.914) | (0.000) | | (0.019) | (0.547) | (0.000) | | (0.009) | (0.188) |

**Table 16** (Continued)

| Relationship between | IP(t-2) | IL(t-2) | F(t-3) | C(t-3) | IP(t-3) | IL(t-3) | F(t-4) | C(t-4) | IP(t-4) | IL(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|
| F | 0.563 | 0.500 | - | 0.004 | 0.506 | 0.610 | - | -0.042 | 0.601 | 0.642 |
| | (0.023) | (0.049) | | (0.989) | (0.054) | (0.016) | | (0.887) | (0.023) | (0.013) |
| C | 0.072 | 0.169 | -0.119 | - | -0.171 | -0.175 | 0.095 | - | -0.126 | 0.133 |
| | (0.790) | (0.530) | (0.673) | | (0.543) | (0.532) | (0.746) | | (0.667) | (0.650) |
| IP | - | 0.743 | 0.542 | 0.250 | - | 0.676 | 0.600 | 0.187 | - | 0.651 |
| | | (0.001) | (0.037) | (0.368) | | (0.006) | (0.023) | (0.523) | | (0.012) |
| IL | 0.888 | - | 0.587 | 0.406 | 0.830 | - | 0.409 | 0.228 | 0.636 | - |
| | (0.000) | | (0.021) | (0.133) | (0.000) | | (0.147) | (0.434) | (0.015) | |

**Note:** - F denoted overall finance-perspective performance. $F_{(t-1)}$, $F_{(t-2)}$, $F_{(t-3)}$, and $F_{(t-4)}$ denoted overall finance-perspective performance under time-lag consideration for one, two, three, and four month-periods respectively.

- C denoted overall customer-perspective performance. $C_{(t-1)}$, $C_{(t-2)}$, $C_{(t-3)}$, and $C_{(t-4)}$ denoted overall customer-perspective performance under time-lag consideration for one, two, three, and four month-periods respectively.
- IP denoted overall internal-business-perspective performance. $IP_{(t-1)}$, $IP_{(t-2)}$, $IP_{(t-3)}$, and $IP_{(t-4)}$ denoted overall internal-business - perspective performance under time-lag consideration for one, two, three, and four month-periods respectively.
- IL denoted overall innovation/ learning- perspective performance. $IL_{(t-1)}$, $IL_{(t-2)}$, $IL_{(t-3)}$, and $IL_{(t-4)}$ denoted overall innovation/ learning -perspective performance under time-lag consideration for one, two, three, and four month-periods respectively.
- Upper results show the Pearson correlation value while the lower values illustrate the P-value.

**Table 17** The relationship between the paired perspectives for Company #2

| Relationship between | | Without time factor | With time-lag factor (t-n) | | | |
|---|---|---|---|---|---|---|
| | | | n=1 | n=2 | n=3 | n=4 |
| F | C | - | - | - | - | - |
| C | F | - | - | - | - | - |
| F | IP | √ | √ | √ | - | √ |
| IP | F | √ | √ | √ | √ | √ |
| F | IL | √ | √ | √ | √ | √ |
| IL | F | √ | √ | √ | √ | - |
| C | IP | - | - | - | - | - |
| IP | C | - | - | - | - | - |
| C | IL | - | - | - | - | - |
| IL | C | - | - | - | - | - |
| IP | IL | √ | √ | √ | √ | √ |
| IL | IP | √ | √ | √ | √ | √ |

**Note:** "√" = The relationship is significant at the 0.05 level

"–" = The relationship is not significant at the 0.05 level

F = overall finance-perspective performance

C = overall customer-perspective performance

IP = overall internal-business-perspective performance

IL = overall innovation/ learning- perspective performance

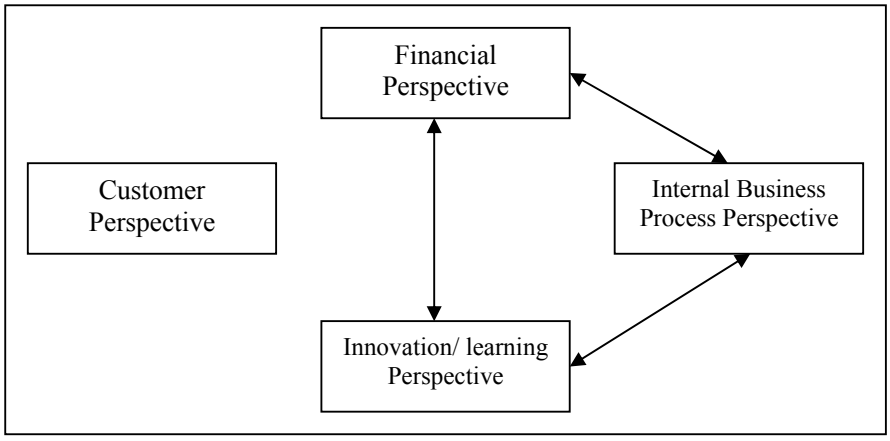



**Figure 24** Interrelationship among the BSC's four perspectives of Company #2

For company #3, the result from the correlation analysis can be described as follows: (See Table 18, 19 and Figure 25)

- The financial and innovation/ learning perspectives appear to be interrelated in a mutual way.
- The financial and customer perspectives are also interrelated in a mutual way.
- The internal business process and innovation/ learning perspectives are also interconnected in the form of two-way impacts

**Table 18** The results of correlation analysis of Company #3

| Relationship between | F | C | IP | IL | F(t-1) | C(t-1) | IP(t-1) | IL(t-1) | F(t-2) | C(t-2) |
|---|---|---|---|---|---|---|---|---|---|---|
| F | - | -0.594 | 0.299 | 0.520 | - | -0.658 | 0.117 | 0.365 | - | -0.584 |
| | | (0.009) | (0.229) | (0.027) | | (0.004) | (0.655) | (0.149) | | (0.018) |
| C | -0.594 | - | 0.081 | -0.429 | -0.367 | - | 0.130 | -0.204 | -0.175 | - |
| | (0.009) | | (0.748) | (0.076) | (0.148) | | (0.618) | (0.433) | (0.517) | |
| IP | 0.299 | 0.081 | - | 0.804 | 0.205 | 0.142 | - | 0.614 | 0.133 | 0.134 |
| | (0.229) | (0.748) | | (0.000) | (0.429) | (0.586) | | (0.009) | (0.624) | (0.621) |
| IL | 0.520 | -0.429 | 0.804 | - | 0.485 | -0.269 | 0.647 | - | 0.351 | -0.225 |
| | (0.027) | (0.076) | (0.000) | | (0.048) | (0.296) | (0.005) | | (0.182) | (0.402) |

**Table 18** (Continued)

| Relationship between | IP(t-2) | IL(t-2) | F(t-3) | C(t-3) | IP(t-3) | IL(t-3) | F(t-4) | C(t-4) | IP(t-4) | IL(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|
| F | 0.067 | 0.404 | - | -0.482 | 0.020 | 0.349 | - | -0.329 | 0.220 | 0.449 |
| | (0.806) | (0.121) | | (0.069) | (0.944) | (0.203) | | (0.251) | (0.450) | (0.107) |
| C | -0.081 | -0.250 | 0.130 | - | -0.116 | -0.264 | 0.293 | - | -0.523 | -0.480 |
| | (0.765) | (0.351) | (0.644) | | (0.681) | (0.341) | (0.310) | | (0.055) | (0.082) |
| IP | - | 0.574 | 0.055 | -0.109 | - | 0.656 | 0.397 | -0.093 | - | 0.607 |
| | | (0.020) | (0.845) | (0.698) | | (0.008) | 0.160 | (0.753) | | (0.021) |
| IL | 0.742 | - | 0.168 | -0.150 | 0.550 | - | 0.167 | 0.076 | 0.830 | - |
| | (0.001) | | (0.548) | (0.594) | (0.034) | | (0.569) | (0.796) | (0.000) | |

**Note:** - F denoted overall finance-perspective performance. $F_{(t-1)}$, $F_{(t-2)}$, $F_{(t-3)}$, and $F_{(t-4)}$ denoted overall finance-perspective performance under time-lag consideration for one, two, three, and four month-periods respectively.

- C denoted overall customer-perspective performance. $C_{(t-1)}$, $C_{(t-2)}$, $C_{(t-3)}$, and $C_{(t-4)}$ denoted overall customer-perspective performance under time-lag consideration for one, two, three, and four month-periods respectively.
- IP denoted overall internal-business-perspective performance. $IP_{(t-1)}$, $IP_{(t-2)}$, $IP_{(t-3)}$, and $IP_{(t-4)}$ denoted overall internal-business - perspective performance under time-lag consideration for one, two, three, and four month-periods respectively.
- IL denoted overall innovation/ learning- perspective performance. $IL_{(t-1)}$, $IL_{(t-2)}$, $IL_{(t-3)}$, and $IL_{(t-4)}$ denoted overall innovation/ learning -perspective performance under time-lag consideration for one, two, three, and four month-periods respectively.
- Upper results show the Pearson correlation value while the lower values illustrate the P-value.

**Table 19** The relationship between the paired perspectives for Company #3

| Relationship between | | Without time factor | With time-lag factor (t-n) | | | |
|---|---|---|---|---|---|---|
| | | | n=1 | n=2 | n=3 | n=4 |
| F | C | √ | √ | √ | - | - |
| C | F | √ | - | - | - | - |
| F | IP | - | - | - | - | - |
| IP | F | - | - | - | - | - |
| F | IL | √ | - | - | - | - |
| IL | F | √ | √ | - | - | - |
| C | IP | - | - | - | - | - |
| IP | C | - | - | - | - | - |
| C | IL | - | - | - | - | - |
| IL | C | - | - | - | - | - |
| IP | IL | √ | √ | √ | √ | √ |
| IL | IP | √ | √ | √ | √ | √ |

**Note:** "√" = The relationship is significant at the 0.05 level,

"–" = The relationship is not significant at the 0.05 level,

F = overall finance-perspective performance,

C = overall customer-perspective performance,

IP = overall internal-business-perspective performance,

IL = overall innovation/ learning- perspective performance.

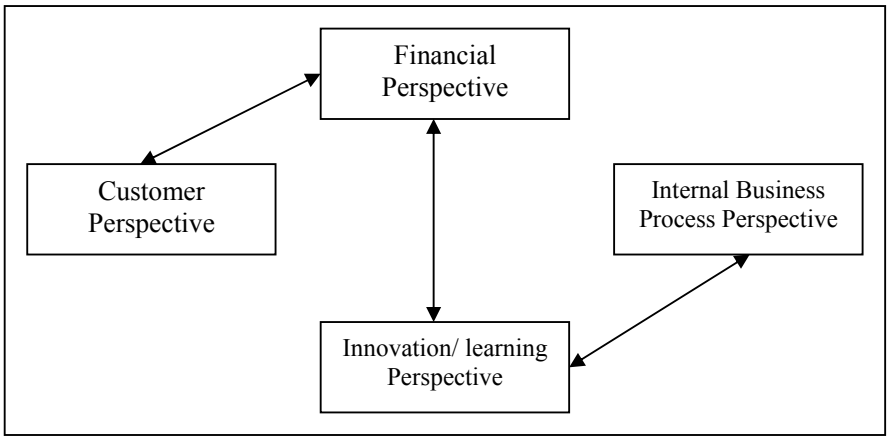



**Figure 25** Interrelationship among the BSC's four perspectives of Company #3

From the verification of interrelationships between scorecards, the results confirm the relationships between scorecards although it does not appear in every pair of scorecards. The lacks of relationship between some pairs of perspectives are likely caused by the following attributes: (1) the short data-collection period, (2) the suitability of KPIs used to reflect these perspectives, and the weight assigned to each KPIs when applying the MCPMT.

The next task was to develop the focus areas and to classify KPIs into the different focus areas. The focus areas represented the company's key strategic objectives for the next decade. Samuel and Perter (1990) suggested that enough objectives should be set so that all areas important to the operation of the firm are covered. They advised that eight key areas in which organizational objectives should normally be set are:

1. Marker standing: the position of an organization – where is stands – relative to its competitors. One of the organization's objectives should indicate the position an organization is striving to achieve relative to its competitors.
2. Innovation: any change made to improve methods of conducting organizational business. Organizational objectives should indicate targets at which the organization is aiming in the area of innovation.
3. Productivity: the level of goods or services produced by an organization relative to the resources used in the production process. Organizations that used fewer resources to produce a specified level of products are said to be more productive than organizations that require more resources to produce at the same level.
4. Resources level: the relative amounts of various resources held by an organization, such as inventory, equipment, and cash. Most organizations should set objectives indicating the relative amounts of each of these assets that should be held.
5. Profitability: the ability of an organization to earn revenue beyond the expenses necessary to generate the revenue. Organizations commonly have objectives indicating the level of profitability they seek.

6. Manager performance and development: the quality of managerial performance and the rate at which managers develop personally. Because both of these areas are critical to the long-term success of an organization, emphasizing them by establishing and striving to reach related organizational objectives is very important.

7. Worker performance and attitude: the quality of non-management performance and such employees' feeling about their work. These areas are also crucial to long-term organizational success. The important of these considerations should be stressed through the establishment of organization objectives.

8. Social responsibility: the obligation of business to help improve the welfare of society while it strives to reach organizational objectives. Only a few short years ago, setting organizational objectives in this area would have been somewhat controversial. Today, however, setting such objectives in organizations is commonplace and is considered very important.

Hudson *et al.* (2001) concluded the critical dimensions of performance that are found within the literature into six general dimensions (i.e., quality, time, flexibility, finance, customer satisfaction, and human resources). He recommended that six dimensions can be seen to cover all aspects of business: financial results, operating performance (through the dimensions of time, quality, and flexibility), way the company is perceived externally (through its customers), and cultural aspects of the working environment (through the human resource dimension).

Then, this research attempts to set the focus areas to cover all aspects of business. There are ten focus areas in this research: (1) liquidity, (2) profitability, (3) corporate competency, (4) service quality, (5) customer relation, (6) productivity and process efficiency, (7) partnership, (8) operational and technical quality, (9) product innovation, and (10) quality of work life. After discussion, the 10 focus areas were agreed with the participating companies. Their descriptions are defined as follows. See Table 20 for the classification results.

1. Liquidity: It is ability to sustain operations financially on the continuous basis. Sales and receipts begin to come in as fast as they are going out. The company can finally pay all bills on time. Liquidity is normally achieved as continuing strong sales and short-term profitability give the company temporary cushions of cash. Staffing increases as more jobs are created and payrolls can be met. Investment is not dwindling away. (Reddish, 1990).

2. Profitability: It is the ability to generate revenue and profit under the effective and efficient use of resources. See Sink (1985).

3. Corporate Competency: It is the embedded ability of a company to overcome competition and changes in its business environment. See Melton *et al*. (2006).

4. Service Quality: It is the ability to respond to and possibly exceed the expectation of a company's customers. See Kumar and Liu (2005). The rationale for this area is the belief that the customer satisfaction is the most important requirement for long-term organizational success and that it requires the entire organization to be focused on the customer's need.

5. Customer Relation: It reflects that attempt by a company to communicate and understand its customers for future growth. See Wong and Lu (2005). A relationship between customer and a company is an important part because building relationship with a customer is a good way to retain that customer for the long term.

6. Productivity and Process Efficiency: It is the relationship between a company's outputs and inputs with the ability to utilize resources and time in the manner in which a company can achieve its policies and objectives. See Sink (1985).

7. Partnership: It is the ability to work with suppliers for operational excellence. See Sandhu and Helo (2006). The partners improve the efficiency of both operations, work together to take costs out the logistic system, mutually boost profitability and improve service to eng customer (Tate, 1996).

8. Operational and Technical Quality: It is the ability to achieve operational excellence and produce quality products. See Kumar and Liu (2005). The operational excellence and produce quality products are also thought to provide the

additional benefit of cost reduction as wastes is eliminated. Expert also suggested that design quality improves, revenue and market share increase (Deming, 1986).

9. Product Innovation: It is the ability of a company to change according to time by being able to anticipate future needs or want from its customers. See Sink and Tuttle (1989), and Blanchard (2004).

10. Quality of Work Life: It reflects the feelings of workers, staffs, and employees on many factors within a company such as autonomy, flexibility, culture, supervisor relations, and etc. See Sink and Tuttle (1989). Employee involvement is recognized as an important enabler of host of quality management initiatives. Employee involvement is effect on employee satisfaction and/or performance, and organizational performance (Sumukadas, 2006).

Prior to the development of a strategy map, a review session was held to determine the sequential order of the four perspectives in the BSC. It was agreed that the financial perspective be placed at the top. This was due to an overall aspiration of top managers (also the company's owners) for financial security. The customer point of view was expected to directly impact financial performance. It was further agreed that the innovation and learning perspective represented the company's foundation that would eventually influence the internal-processes perspective. See Figure 25.

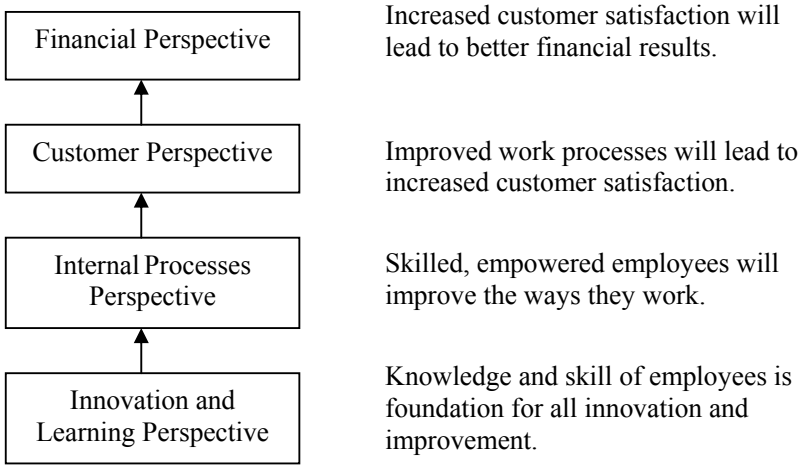



**Figure 26** The sequential order of the four perspectives in the BSC

**Table 20** Classifying KPIs into 10 focus areas

| Perspective | Focus Areas | KPIs |
|---|---|---|
| Financial | (I) Liquidity: LQ | F1: Current rate |
| | | F7: Return on capital employed |
| | | F9: Cash flow |
| | | F10: Return on investment |
| | (II) Profitability: PF | F2: Interest expense to sales ratio |
| | | F3: Revenues per Total assets |
| | | F4: Revenues per Employee |
| | | F5: Profits per Employee |
| | | F6: Market value |
| | | F8: Profit margin |
| | | F11: EBITDAR |
| | | F12: Revenues from new product per Total revenue |
| | | F13: Revenues per Cost of goods sold |
| | | F14: Revenues per Marketing expense |
| | | F15: Revenues per Raw material cost |
| | | F16: Revenues per Energy cost |
| | (III) Corporate Competency: CC | F17: Market share |
| | | F18: Profit per Customer |
| | | F19: Revenue per Service expense |
| Customer | (IV) Service Quality: SQ | C3: Satisfied - customer index |
| | | C4: Customer - loyalty index |
| | | C5: Number of customer complaints |
| | | C7: Average customer size |
| | | C8: Customer payment on - time |
| | (V) Customer relation: CR | C9: Average direct communications to customers |
| | | C1: New customers per Total customers |
| | | C2: Customer lost |
| | | C6: Brand - image index |
| Internal Business Process | (VI) Productivity and Process Efficiency: PP | IP2: Average lead time |
| | | IP3: Lead time, from order to delivery |
| | | IP4: Lead time, production |
| | | IP6: Inventory turnover |
| | | IP5: Average time for decision-making |
| | | IP9: MTBF |
| | | IP10: MTTR |
| | | IP11: Percentage of new product development projects completed on time |
| | (VII) Partnership: PN | IP8: Supplier on-time delivery |
| | | IP12: Total supply chain delivery performance to end customer |
| | (VII) Operational and technical Quality: OT | IP1: On - time delivery |
| | | IP7: Maintenance cost per Revenue |
| Innovation and Learning | (IX) Product innovation: PI | IL1: R&D expense per Total expenses |
| | | IL4: Marketing expense per Customer |
| | | IL5: Information coverage ratio |
| | (X) Quality of work life: QW | IL3: Satisfied - employee index |
| | | IL2: Competence development expenses per Employee |
| | | IL6: Investment in new product support and training per Total employee |
| | | IP7: Staff turnover |

After classifying KPIs into ten focus areas, the task was to quantify time-lag effects. In order to quantify time-lag effect among the ten focus areas, the MCPMT was again applied. The results from each KPI within individual focus areas were converted into a common non-dimensional scale of 0-100. The time-lag effects from one focus area to the others were tested by the correlation analysis with the same conditions to that of the BSC development namely (1) no time consideration, and (2) time-lag consideration for one, two, three, and four month-periods. The correlation analysis was to test the relationship between the paired focus areas, based on the significance level of 0.05. The relationship can be statistically described as follows:

$H_0$: There is no correlation between the paired focus areas.

$H_1$: There is correlation between the paired focus areas.

From the statistical results, the P-value is less than the significance level (0.05), so there is evidence to reject the null hypothesis in favor of the alternative hypothesis. In other words there is a statistically significant linear relationship between the paired focus areas.

For company #1, some of the computational results are shown in Table 21 and 22. See Appendix C for more details. Table 23 shows the relationship between the paired focus areas under no time and the time-lag effect. Some pairs of focus areas had only immediate impact (no – time consideration). Some pairs of focus areas had time – lag effect. In the same way, some pairs of focus areas had both immediate impact and time – lag effect.

**Table 21** The correlation analysis of ten focus areas for Company #1 under no time consideration

| Relationship between | LQ | PF | CC | SQ | CR | PP | PN | OT | PI |
|---|---|---|---|---|---|---|---|---|---|
| PF | 0.965 | | | | | | | | |
| | (0.000) | | | | | | | | |
| CC | 0.552 | 0.583 | | | | | | | |
| | (0.017) | (0.011) | | | | | | | |
| SQ | 0.187 | 0.163 | 0.140 | | | | | | |
| | (0.458) | (0.519) | (0.578) | | | | | | |
| CR | 0.138 | 0.107 | 0.316 | 0.463 | | | | | |
| | (0.585) | (0.674) | (0.201) | (0.053) | | | | | |
| PP | 0.708 | 0.668 | 0.245 | 0.604 | 0.361 | | | | |
| | (0.001) | (0.002) | (0.328) | (0.008) | (0.141) | | | | |
| PN | 0.669 | 0.660 | 0.281 | 0.284 | 0.360 | 0.716 | | | |
| | (0.002) | (0.003) | (0.258) | (0.253) | (0.142) | (0.001) | | | |
| OT | -0.267 | -0.300 | -0.019 | 0.485 | 0.083 | 0.171 | -0.184 | | |
| | (0.285) | (0.226) | (0.940) | (0.041) | (0.744) | (0.497) | (0.466) | | |
| PI | 0.488 | 0.437 | 0.443 | -0.402 | -0.029 | 0.037 | 0.156 | -0.374 | |
| | (0.040) | (0.070) | (0.066) | (0.098) | (0.909) | (0.885) | (0.537) | (0.126) | |
| QW | 0.582 | 0.600 | 0.015 | 0.144 | 0.027 | 0.536 | 0.521 | -0.338 | 0.287 |
| | (0.011) | (0.008) | (0.953) | (0.570) | (0.916) | (0.022) | (0.027) | (0.170) | (0.248) |

**Note:** - LQ = Liquidity, PF = Profitability, CC = Corporate Competency, SQ = Service Quality, CR = Customer Relation, PP = Productivity and Process Efficiency, PN = Partnership, OT = Operational and Technical Quality, PI = Product Innovation, and QW = Quality of Work Life.

- Upper results show the Pearson correlation value while the lower results illustrate the P-value. Given the significance level of 0.05, immediate impact (no–time effect) appeared to be suitable.

**Table 22** Demonstration of productivity and process efficiency and liquidity areas under time-lag consideration

| | **$PP_{(t-1)}$** | $PP_{(t-2)}$ | $PP_{(t-3)}$ | $PP_{(t-4)}$ |
|---|---|---|---|---|
| Liquidity (LQ) | 0.571 | 0.427 | 0.419 | 0.333 |
| | (0.017) | (0.099) | (0.120) | (0.245) |

**Note:** - $PP_{(t-1)}$, $PP_{(t-2)}$, $PP_{(t-3)}$, and $PP_{(t-4)}$ denoted productivity and process efficiency under time-lag effect consideration for one, two, three, and four month-periods respectively.

- Upper results show the Pearson correlation value while the lower results illustrate the P-value. Given the significance level of 0.05, the time-lag effect on one period appeared to be suitable.

**Table 23** The relationship between the paired focus areas for Company # 1

| Relationship between | | LQ | PF | CC | SQ | CR | PP | PN | OT | PI | QW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LQ | No time | | √ | √ | | | | | | | |
| | t – 1 | | √ | - | | | | | | | |
| | t – 2 | | - | - | | | | | | | |
| | t – 3 | | - | - | | | | | | | |
| | t – 4 | | - | - | | | | | | | |
| PF | No time | √ | | √ | | | | | | | |
| | t – 1 | √ | | - | | | | | | | |
| | t – 2 | - | | - | | | | | | | |
| | t – 3 | - | | - | | | | | | | |
| | t – 4 | - | | √ | | | | | | | |
| CC | No time | √ | √ | | | | | | | | |
| | t – 1 | - | - | | | | | | | | |
| | t – 2 | - | - | | | | | | | | |
| | t – 3 | - | - | | | | | | | | |
| | t – 4 | - | - | | | | | | | | |
| SQ | No time | - | - | - | | - | | | | | |
| | t – 1 | - | - | - | | - | | | | | |
| | t – 2 | - | - | - | | - | | | | | |
| | t – 3 | - | - | - | | - | | | | | |
| | t – 4 | - | - | - | | - | | | | | |
| CR | No time | - | - | - | - | | | | | | |
| | t – 1 | - | - | - | - | | | | | | |
| | t – 2 | - | - | - | - | | | | | | |
| | t – 3 | - | - | - | - | | | | | | |
| | t – 4 | - | - | - | - | | | | | | |
| PP | No time | √ | √ | - | √ | - | | √ | - | | |
| | t – 1 | √ | √ | - | √ | - | | √ | - | | |
| | t – 2 | - | - | - | - | - | | √ | - | | |
| | t – 3 | - | - | - | - | - | | - | - | | |
| | t – 4 | - | - | - | - | - | | - | - | | |
| PN | No time | √ | √ | - | - | - | √ | | - | | |
| | t – 1 | √ | - | - | - | - | √ | | - | | |
| | t – 2 | - | - | - | - | - | √ | | - | | |
| | t – 3 | - | - | - | - | - | √ | | - | | |
| | t – 4 | - | - | - | - | - | √ | | - | | |
| OT | No time | - | - | - | √ | - | - | - | | | |
| | t – 1 | - | - | - | - | - | - | - | | | |
| | t – 2 | - | - | - | - | - | - | - | | | |
| | t – 3 | - | - | - | - | - | - | - | | | |
| | t – 4 | - | - | - | √ | - | - | - | | | |
| PI | No time | √ | - | - | - | - | - | - | - | | - |
| | t – 1 | - | - | - | - | - | - | - | - | | - |
| | t – 2 | - | - | - | - | - | - | - | √ | | - |
| | t – 3 | - | - | - | - | - | - | - | - | | - |
| | t – 4 | - | - | - | - | - | - | - | - | | - |
| QW | No time | √ | √ | - | - | - | √ | √ | - | - | |
| | t – 1 | - | - | - | - | - | √ | - | - | - | |
| | t – 2 | - | - | - | - | - | - | - | - | - | |
| | t – 3 | - | - | √ | - | - | - | - | - | - | |
| | t – 4 | - | - | - | - | - | - | - | - | - | |

**Table 22** (Continued)

**Note:** - "√" = The relationship is significant at the 0.05 level, "–" = The relationship is not significant at the 0.05 level.

- LQ = Liquidity, PF = Profitability, CC = Corporate Competency, SQ = Service Quality, CR = Customer Relation, PP = Productivity and Process Efficiency, PN = Partnership, OT = Operational and Technical Quality, PI = Product Innovation, and QW = Quality of Work Life.
- No-time refers to the condition of without time factor or immediate impact.
- (t-1), (t-2), (t-3), and (t-4) refer to the condition under time-lag effect consideration for one, two, three, and four month-periods respectively.

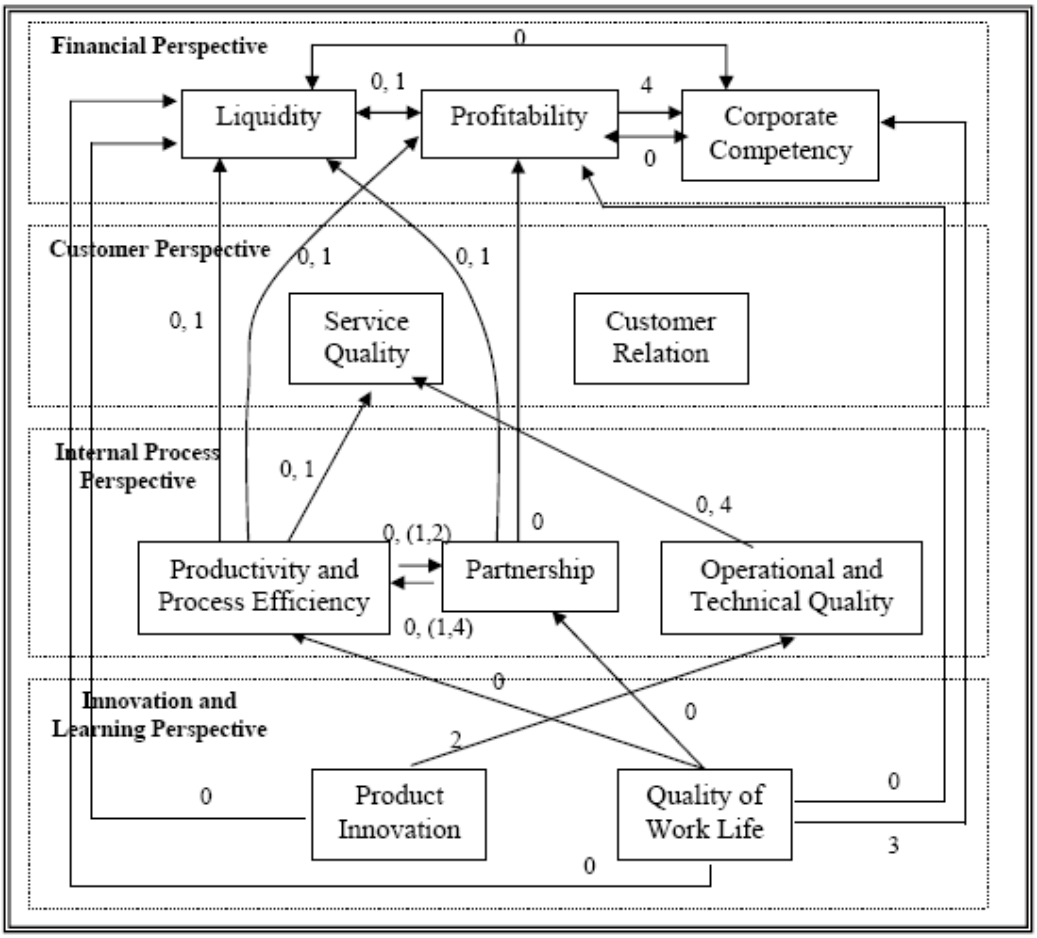
For only immediate impact, there were seven pairs that had significant relationships at the immediate impact: (1) product innovation on liquidity, (2) quality of work life on liquidity, (3) quality of work life on partnership, (4) quality of work life on profitability, (5) partnership on profitability, (6) liquidity on corporate competency, and (7) corporate competency on liquidity. The interpretation of the immediate impact is the result of the product innovation area from the current period would impact the results from the liquidity area in the present period (at the same period).

Some of the findings on the time-lag effects can be described as follows. There were five pairs that had significant relationships at the time-lag effects of one period: (1) quality of work life on productivity and process efficiency, (2) productivity and process efficiency on profitability, (3) productivity and process efficiency on service quality, (4) productivity and process efficiency impacting liquidity, and (5) partnership on liquidity. The interpretation on the one-period effect is quite simple. The results from the quality of work life area from the current period would impact the results from the liquidity area in the second period. There was a pair of product innovation impacting operational and technical quality that had significant relationships at the time-lag effects of two periods. The interpretation for two-period

effects is that the results from product innovation in the first period would affect the operational and technical quality results in the third period. Besides, a pair of quality of work life and corporate competency had significant relationships at the time-lag effects of three periods. The interpretation for three-period effects is that the results from quality of work life in the first period would affect the corporate competency results in the forth period. Interestingly, there were two significant pairs when the time-lag effects were for four periods. There were: (1) operational and technical quality on service quality, and (2) profitability on corporate competency. The interpretation for four-period effects is similar. The results from operational and technical quality in the first period would affect the service quality results in the fifth period. Due to a series of the time- lag effects examined, it was possible that the impact could be quantified in terms of the range. For examples, the results from the partnership area would eventually impact the results from productivity and process efficiency area in the next one to two periods.

In case, pairs of focus areas had both immediate impact and time – lag effect. For example, pair of productivity and process efficiency and liquidity has significant relationships at the immediate impact and the time – lag effect of one period. The interpretation for effects is that the results from productivity and process efficiency in the current period would affect the liquidity results not only in the present period but also in the second period.

From correlation analysis, in case the paired focus areas are two way relationships, the direction of relation will use one way direction from the innovation and learning perspective to business process perspective to customer perspective, and to financial perspective respectively. If the paired focus areas are the same level of perspective, the direction of relation can use two way directions. In case the paired focus areas are one way relationships that the direction is opposite from before, this way is omitted. Given possibilities of no – time impact, and time – lag effect, the strategy map was developed for the company # 1. See Figure 27.




**Note:** - The number represents the time- lag effects in terms of months.

- Zero stands for immediate impact
- The parenthesis represents the ranges of the time-lag effects
- The line reflects the impacts from one focus area to another.

**Figure 27** Strategy map for the Company #1

It should be noted that the time- lag effects for this strategy map is described in terms of months. Zero stands for immediate impact. The line reflects the impacts from one focus area to another. The parenthesis represents the ranges of the time-lag effects. Otherwise, the results indicate not only the immediate impact factor but also the exact period of the time-lag factor.

For company #2, some of the computational results are shown as Table 24 and 25. See Table 26 shows the relationship between the paired focus areas under no time and the time-lag effect.

**Table 24** The correlation analysis of ten focus areas for Company #2 under no time consideration

| Relationship between | LQ | PF | CC | SQ | CR | PP | PN | OT | PI |
|---|---|---|---|---|---|---|---|---|---|
| PF | 0.695 | | | | | | | | |
| | (0.001) | | | | | | | | |
| CC | -0.198 | -0.111 | | | | | | | |
| | (0.432) | (0.662) | | | | | | | |
| SQ | 0.122 | 0.018 | -0.113 | | | | | | |
| | (0.629) | (0.943) | (0.656) | | | | | | |
| CR | 0.578 | 0.297 | -0.264 | 0.543 | | | | | |
| | (0.012) | (0.231) | (0.290) | (0.020) | | | | | |
| PP | 0.668 | 0.706 | -0.643 | 0.074 | 0.392 | | | | |
| | (0.002) | (0.001) | (0.004) | (0.770) | (0.108) | | | | |
| PN | 0.524 | 0.475 | -0.523 | 0.124 | 0.261 | 0.717 | | | |
| | (0.026) | (0.046) | (0.026) | (0.624) | (0.296) | (0.001) | | | |
| OT | -0.335 | -0.222 | -0.306 | 0.255 | 0.192 | 0.043 | -0.114 | | |
| | (0.175) | (0.375) | (0.217) | (0.308) | (0.445) | (0.865) | (0.653) | | |
| PI | 0.356 | 0.522 | -0.558 | -0.233 | -0.071 | 0.770 | 0.481 | -0.063 | |
| | (0.147) | (0.026) | (0.016) | (0.352) | (0.780) | (0.000) | (0.043) | (0.805) | |
| QW | 0.497 | 0.700 | -0.622 | 0.044 | 0.226 | 0.909 | 0.668 | 0.111 | 0.839 |
| | (0.036) | (0.001) | (0.006) | (0.862) | (0.367) | (0.000) | (0.002) | (0.662) | (0.000) |

**Note:** - LQ = Liquidity, PF = Profitability, CC = Corporate Competency, SQ = Service Quality, CR = Customer Relation, PP = Productivity and Process Efficiency, PN = Partnership, OT = Operational and Technical Quality, PI = Product Innovation, and QW = Quality of Work Life.

- Upper results show the Pearson correlation value while the lower results illustrate the P-value. Given the significance level of 0.05, immediate impact (no–time effect) appeared to be suitable.

**Table 25** Demonstration of productivity and process efficiency and profitability areas under time-lag consideration

| | $\mathbf{PP_{(t-1)}}$ | $\mathbf{PP_{(t-2)}}$ | $\mathbf{PP_{(t-3)}}$ | $\mathbf{PP_{(t-4)}}$ |
|---|---|---|---|---|
| Profitability (PF) | 0.684 | 0.697 | 0.720 | 0.784 |
| | (0.002) | (0.003) | (0.002) | (0.001) |

**Note:** - $PP_{(t-1)}$, $PP_{(t-2)}$, $PP_{(t-3)}$, and $PP_{(t-4)}$ denoted productivity and process efficiency under time-lag effect consideration for one, two, three, and four month-periods respectively.

- Upper results show the Pearson correlation value while the lower results illustrate the P-value. Given the significance level of 0.05, the time-lag effect on the ranges between one and four periods appeared to be suitable.

**Table 26** The relationship between the paired focus areas for Company # 2

| Relationship between | | LQ | PF | CC | SQ | CR | PP | PN | OT | PI | QW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LQ | No time | | √ | - | | | | | | | |
| | t – 1 | | √ | - | | | | | | | |
| | t – 2 | | - | - | | | | | | | |
| | t – 3 | | - | - | | | | | | | |
| | t – 4 | | - | - | | | | | | | |
| PF | No time | √ | | - | | | | | | | |
| | t – 1 | √ | | - | | | | | | | |
| | t – 2 | - | | - | | | | | | | |
| | t – 3 | - | | - | | | | | | | |
| | t – 4 | - | | - | | | | | | | |
| CC | No time | - | - | | | | | | | | |
| | t – 1 | - | - | | | | | | | | |
| | t – 2 | - | - | | | | | | | | |
| | t – 3 | - | - | | | | | | | | |
| | t – 4 | - | √ | | | | | | | | |
| SQ | No time | - | - | - | | √ | | | | | |
| | t – 1 | - | - | - | | - | | | | | |
| | t – 2 | - | - | - | | - | | | | | |
| | t – 3 | - | - | - | | - | | | | | |
| | t – 4 | - | - | - | | - | | | | | |
| CR | No time | √ | - | - | √ | | | | | | |
| | t – 1 | - | - | - | - | | | | | | |
| | t – 2 | - | - | - | - | | | | | | |
| | t – 3 | - | - | - | - | | | | | | |
| | t – 4 | - | - | - | - | | | | | | |
| PP | No time | √ | √ | √ | - | - | | √ | - | | |
| | t – 1 | √ | √ | √ | - | - | | √ | - | | |
| | t – 2 | - | √ | - | - | - | | √ | - | | |
| | t – 3 | - | √ | - | - | - | | - | - | | |
| | t – 4 | - | √ | - | - | - | | - | - | | |
| PN | No time | √ | √ | √ | - | - | √ | | - | | |
| | t – 1 | - | - | - | - | - | √ | | - | | |
| | t – 2 | - | - | - | - | - | - | | - | | |
| | t – 3 | - | - | - | - | - | √ | | - | | |
| | t – 4 | - | - | - | - | - | √ | | - | | |
| OT | No time | - | - | - | - | - | - | - | | | |
| | t – 1 | - | - | - | - | - | - | - | | | |
| | t – 2 | - | - | - | - | - | - | - | | | |
| | t – 3 | - | - | - | - | - | - | - | | | |
| | t – 4 | - | - | - | - | √ | - | - | | | |
| PI | No time | - | √ | √ | - | - | √ | √ | - | | √ |
| | t – 1 | - | √ | - | - | - | √ | - | - | | √ |
| | t – 2 | - | √ | - | - | - | √ | - | - | | √ |
| | t – 3 | - | √ | - | - | - | √ | - | - | | √ |
| | t – 4 | - | √ | - | - | - | - | - | - | | - |
| QW | No time | √ | √ | √ | - | - | √ | √ | - | √ | |
| | t – 1 | - | √ | - | - | - | √ | √ | - | √ | |
| | t – 2 | - | √ | - | - | - | √ | - | - | √ | |
| | t – 3 | - | √ | - | - | - | √ | - | - | √ | |
| | t – 4 | - | √ | - | - | - | √ | - | - | - | |

**Table 26** (Continued)

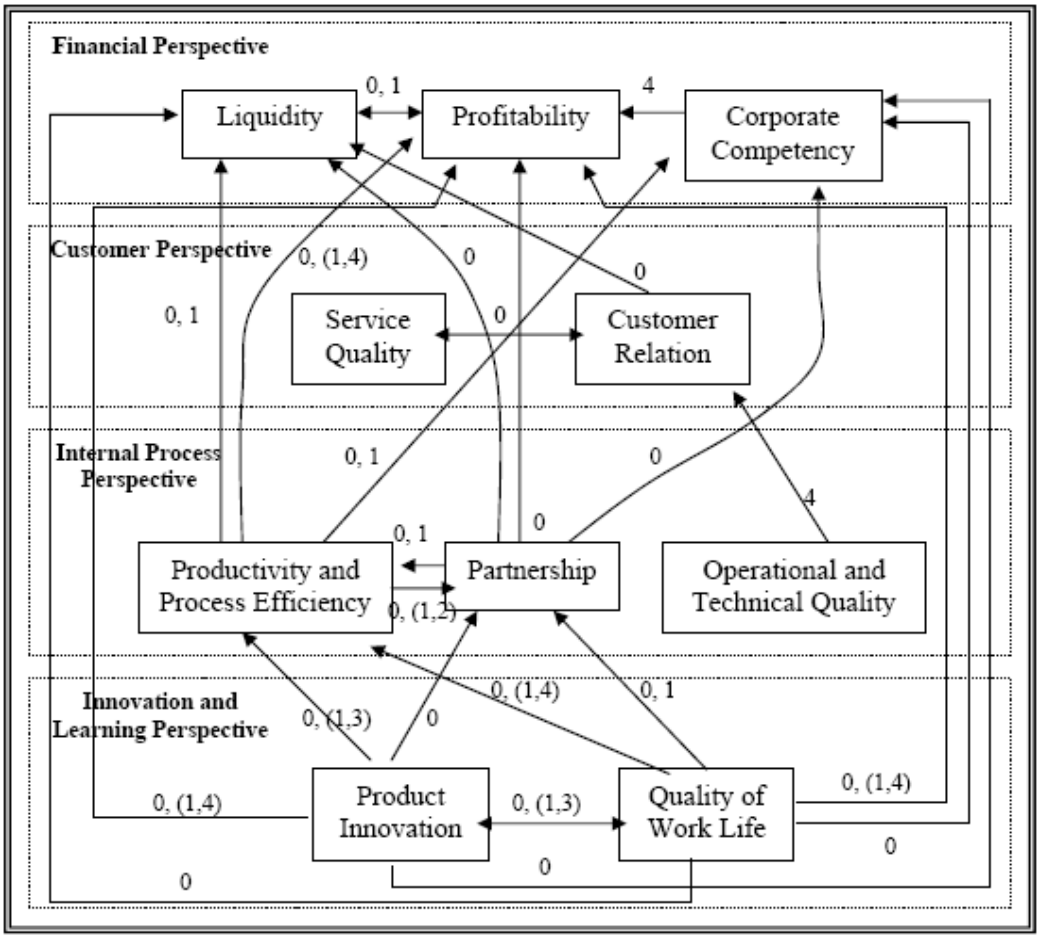
**Note:** - "√" = The relationship is significant at the 0.05 level, "–" = The relationship is not significant at the 0.05 level.

- LQ = Liquidity, PF = Profitability, CC = Corporate Competency, SQ = Service Quality, CR = Customer Relation, PP = Productivity and Process Efficiency, PN = Partnership, OT = Operational and Technical Quality, PI = Product Innovation, and QW = Quality of Work Life.
- No-time refers to the condition of without time factor or immediate impact.
- (t-1), (t-2), (t-3), and (t-4) refer to the condition under time-lag effect consideration for one, two, three, and four month-periods respectively.

For only immediate impact, there were nine pairs that had significant relationships at the immediate impact stage: (1) quality of work life on liquidity, (2) quality of work life on corporate competency, (3) product innovation on corporate competency, (4) product innovation on partnership, (5) partnership on profitability, (6) partnership on liquidity, (7) partnership on corporate competency, (8) service quality on corporate competency, and (9) customer relation on liquidity. The interpretation on the immediate impact is the results from the quality of work life area from the current period would impact the results from the liquidity area in the present period (at the same period).

Some of the findings on the time-lag effects can be described as follows. There were five pairs that had significant relationships at the time-lag effects of one period: (1) productivity and process efficiency on liquidity, (2) productivity and process efficiency on corporate competency, (3) quality of work life on partnership (4) partnership on productivity and process efficiency, and (5) profitability on liquidity. The interpretation on the one-period effect is that the results from the productivity and process efficiency from the current period would impact the results from the liquidity area in the second period. There was a pair of product innovation impacting operational and technical quality that had significant relationships at the

time-lag effects of two periods. The interpretation for two-period effects is that the results from product innovation in the first period would affect the operational and technical quality results in the third period. In addition, there were two significant pairs when the time-lag effects were for four periods. There were: (1) operational and technical quality on customer relation, and (2) corporate competency on profitability. The interpretation for four-period effects is similar. The results from operational and technical quality in the first period would affect the customer relation results in the fifth period. Owing to a series of the time- lag effects examined, it was possible that the impact could be quantified in terms of the range. For example, the results from the product innovation area would eventually impact the results from productivity and process efficiency area in the next one to three periods. In case, pairs of focus areas had both immediate impact and time – lag effects. For example, pair of productivity and process efficiency and liquidity has significant relationships at the immediate impact and the time – lag effect of one period. The interpretation for effects is that the results from productivity and process efficiency in the current period would affect the liquidity results not only in the present period but also in the second period. Given possibilities of no– time impact, and time – lag effect, the strategy map was developed for company # 2. See Figure 28.




**Note:** - The number represents the time- lag effects in terms of months.

- Zero stands for immediate impact
- The parenthesis represents the ranges of the time-lag effects
- The line reflects the impacts from one focus area to another.

**Figure 28** Strategy map for the Company #2

For company #3, some of the computational results are shown as Table 27 and 28. See Table 29 shows the relationship between the paired focus areas under no time and time-lag effect.

**Table 27** The correlation analysis of ten focus areas for Company #3 under no time consideration

| Relationship between | LQ | PF | CC | SQ | CR | PP | PN | OT | PI |
|---|---|---|---|---|---|---|---|---|---|
| PF | 0.725 | | | | | | | | |
| | (0.001) | | | | | | | | |
| CC | -0.251 | 0.365 | | | | | | | |
| | (0.316) | (0.136) | | | | | | | |
| SQ | -0.682 | -0.177 | 0.477 | | | | | | |
| | (0.002) | (0.482) | (0.045) | | | | | | |
| CR | -0.461 | -0.553 | -0.242 | 0.344 | | | | | |
| | (0.054) | (0.017) | (0.333) | (0.162) | | | | | |
| PP | 0.518 | 0.234 | -0.343 | -0.444 | 0.285 | | | | |
| | (0.028) | (0.350) | (0.164) | (0.065) | (0.252) | | | | |
| PN | 0.062 | 0.033 | -0.133 | -0.064 | 0.125 | 0.195 | | | |
| | (0.806) | (0.896) | (0.599) | (0.801) | (0.623) | (0.437) | | | |
| OT | -0.116 | 0.083 | 0.127 | 0.266 | 0.236 | 0.205 | 0.308 | | |
| | (0.648) | (0.743) | (0.616) | (0.286) | (0.346) | (0.414) | (0.214) | | |
| PI | 0.436 | -0.016 | -0.629 | -0.558 | 0.400 | 0.813 | 0.276 | 0.084 | |
| | (0.070) | (0.949) | (0.005) | (0.016) | (0.100) | (0.000) | (0.267) | (0.740) | |
| QW | 0.661 | 0.658 | 0.152 | -0.472 | -0.765 | 0.274 | 0.120 | 0.029 | -0.025 |
| | (0.003) | (0.003) | (0.547) | (0.048) | (0.000) | (0.271) | (0.637) | (0.908) | (0.922) |

**Note:** - LQ = Liquidity, PF = Profitability, CC = Corporate Competency, SQ = Service Quality, CR = Customer Relation, PP = Productivity and Process Efficiency, PN = Partnership, OT = Operational and Technical Quality, PI = Product Innovation, and QW = Quality of Work Life.

- Upper results show the Pearson correlation value while the lower results illustrate the P-value. Given the significance level of 0.05, immediate impact (no–time effect) appeared to be suitable.

**Table 28** Demonstration of product innovation and liquidity areas under time-lag consideration

| | $PI_{(t-1)}$ | **$PI_{(t-2)}$** | **$PI_{(t-3)}$** | **$PI_{(t-4)}$** |
|---|---|---|---|---|
| Liquidity (LQ) | 0.456 | 0.505 | 0.582 | 0.750 |
| | (0.066) | (0.046) | (0.023) | (0.002) |

**Note:** - $PI_{(t-1)}$, $PI_{(t-2)}$, $PI_{(t-3)}$, and $PI_{(t-4)}$ denoted product innovation under time-lag effect consideration for one, two, three, and four month-periods respectively.

- Upper results show the Pearson correlation value while the lower results illustrate the P-value. Given the significance level of 0.05, the time-lag effect on the ranges between two and four periods appeared to be suitable.

**Table 29** The relationship between the paired focus areas for Company # 3

| Relationship | between | LQ | PF | CC | SQ | CR | PP | PN | OT | PI | QW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LQ | No time | | √ | - | | | | | | | |
| | t – 1 | | √ | - | | | | | | | |
| | t – 2 | | - | - | | | | | | | |
| | t – 3 | | - | - | | | | | | | |
| | t – 4 | | - | - | | | | | | | |
| PF | No time | √ | | - | | | | | | | |
| | t – 1 | √ | | - | | | | | | | |
| | t – 2 | - | | - | | | | | | | |
| | t – 3 | - | | - | | | | | | | |
| | t – 4 | - | | - | | | | | | | |
| CC | No time | - | - | | | | | | | | |
| | t – 1 | - | - | | | | | | | | |
| | t – 2 | - | - | | | | | | | | |
| | t – 3 | - | - | | | | | | | | |
| | t – 4 | √ | - | | | | | | | | |
| SQ | No time | √ | - | √ | | - | | | | | |
| | t – 1 | √ | - | - | | - | | | | | |
| | t – 2 | √ | √ | - | | - | | | | | |
| | t – 3 | √ | √ | - | | - | | | | | |
| | t – 4 | √ | √ | - | | √ | | | | | |
| CR | No time | - | √ | - | - | | | | | | |
| | t – 1 | - | √ | - | - | | | | | | |
| | t – 2 | - | - | - | - | | | | | | |
| | t – 3 | - | - | - | - | | | | | | |
| | t – 4 | - | - | - | √ | | | | | | |
| PP | No time | √ | - | - | - | - | | - | - | | |
| | t – 1 | - | - | √ | - | - | | - | - | | |
| | t – 2 | - | - | √ | √ | - | | - | - | | |
| | t – 3 | - | - | √ | √ | - | | - | - | | |
| | t – 4 | - | - | - | √ | - | | - | - | | |
| PN | No time | - | - | - | - | - | - | | - | | |
| | t – 1 | - | - | - | - | - | - | | - | | |
| | t – 2 | - | - | - | - | - | - | | - | | |
| | t – 3 | - | - | - | - | - | - | | - | | |
| | t – 4 | - | - | - | - | - | - | | - | | |
| OT | No time | - | - | - | - | - | - | - | | | |
| | t – 1 | - | - | - | - | - | - | - | | | |
| | t – 2 | - | - | - | - | - | - | - | | | |
| | t – 3 | - | - | - | - | - | - | - | | | |
| | t – 4 | - | - | - | - | - | - | - | | | |
| PI | No time | - | - | √ | √ | - | √ | - | - | | - |
| | t – 1 | - | - | √ | √ | - | √ | - | - | | - |
| | t – 2 | √ | - | √ | √ | - | √ | - | - | | - |
| | t – 3 | √ | - | - | √ | - | √ | - | - | | - |
| | t – 4 | √ | - | - | √ | √ | - | - | - | | √ |
| QW | No time | √ | √ | - | √ | √ | - | - | - | - | |
| | t – 1 | √ | - | - | - | - | - | - | - | - | |
| | t – 2 | - | - | - | - | - | - | - | - | - | |
| | t – 3 | - | - | - | - | - | - | - | - | - | |
| | t – 4 | - | - | - | - | - | - | - | - | - | |

**Table 29** (Continued)

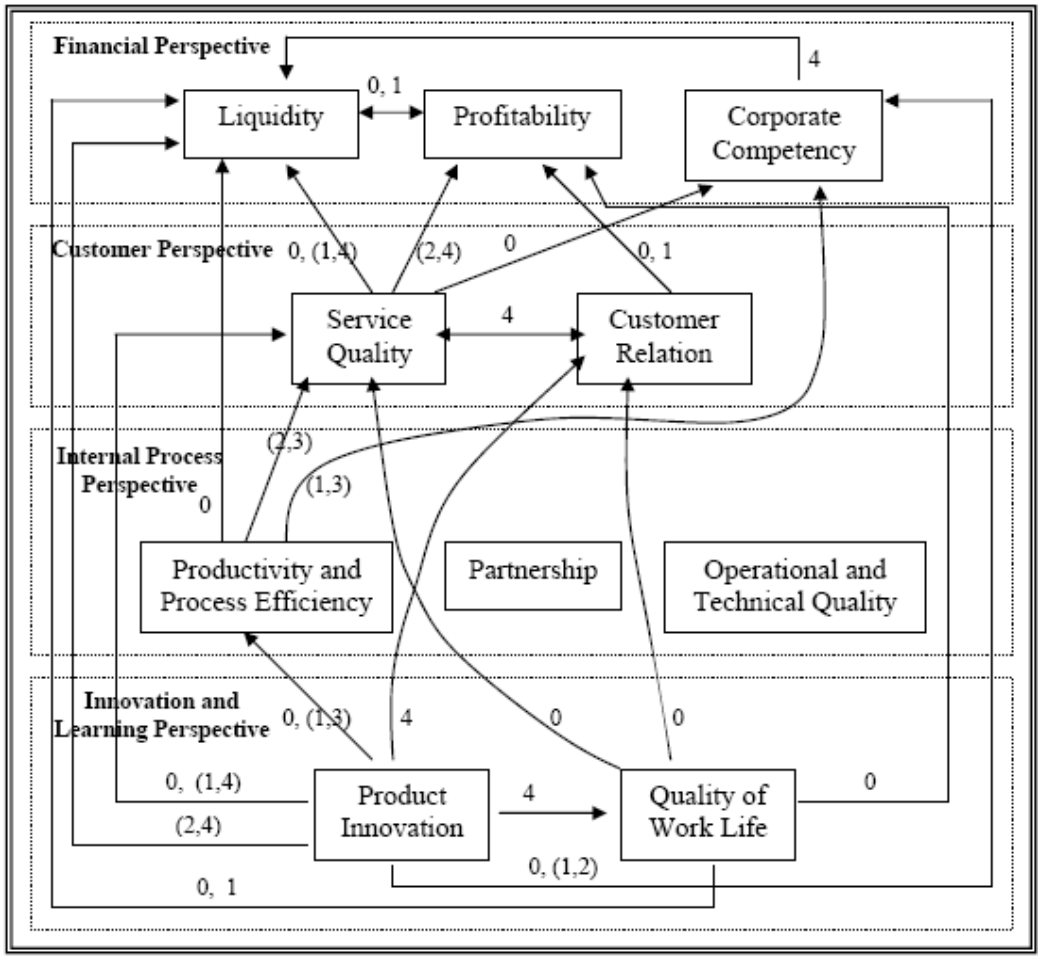
**Note:** - "√" = The relationship is significant at the 0.05 level, "–" = The relationship is not significant at the 0.05 level.

- LQ = Liquidity, PF = Profitability, CC = Corporate Competency, SQ = Service Quality, CR = Customer Relation, PP = Productivity and Process Efficiency, PN = Partnership, OT = Operational and Technical Quality, PI = Product Innovation, and QW = Quality of Work Life.
- No-time refers to the condition of without time factor or immediate impact.
- (t-1), (t-2), (t-3), and (t-4) refer to the condition under time-lag effect consideration for one, two, three, and four month-periods respectively.

For only immediate impact, there were five pairs that had significant relationships at the immediate impact: (1) quality of work life on service quality, (2) quality of work life on profitability, (3) quality of work life on customer relation, (4) corporate competency on liquidity, and (5) service quality on corporate competency. The interpretation on the immediate impact is the results of the quality of work life area from the current period would impact the results from the service quality area in the present period (at the same period).

Some of the findings on the time-lag effects can be described as follows. There were three pairs that had significant relationships at the time-lag effects of one period: (1) quality of work life on liquidity, (2) quality of work life on profitability, and (3) profitability on liquidity. The interpretation on the one-period effect is similar. The results from the quality of work life area from the current period would impact the results from the liquidity area in the second period. Besides, there were four significant pairs when the time-lag effects were for four periods. There were: (1) product innovation on customer relation, (2) service quality on customer relation, (3) corporate competency on liquidity, and (4) product innovation impacting quality of work life. The interpretation for four-period effects is similar. The results from product innovation in the first period would affect the customer relation results in the

fifth period. Because a series of time- lag effects examined, it was possible that the impact could be quantified in terms of the range. For example, the results from the product innovation area would eventually impact the results from liquidity area in the next two to four periods. For some pairs of focus areas both had immediate impact and time – lag effect, such as pairs of customer relation and profitability has significant relationships at the immediate impact and the time – lag effect of one period. The interpretation for effects is that the results from customer relation in the current period would affect the profitability results not only in the present period but also in the second period. Given possibilities of no – time impact, and time – lag effect, the strategy map was developed for company # 3. See Figure 29.




**Note:** - The number represents the time- lag effects in terms of months.

- Zero stands for immediate impact
- The parenthesis represents the ranges of the time-lag effects
- The line reflects the impacts from one focus area to another.

**Figure 29** Strategy map for the Company #3

After developing a strategy map for each participating company, they were somewhat surprised initially by a lack of clear impacts from some pairs of focus areas, such as service quality and liquidity (for company #1 and #2), and quality of work life and productivity and process efficiency (for company #3).

Since, some KPI can reflect more than one focus area, for example, customer payment on–time (C8) is an indicator that can indicate both service quality area and customer relation area. Then, this step tries to adjust the set of KPIs in order to find out the result (a strategy map) when the set of KPIs is changed. The adjustment will try in 2 cases, namely (1) adjust the set of KPIs by moving some KPI to anther focus area (adjustment #1), and (2) adjusting the set of KPIs by deleting some KPI under focus area (adjustment #2).

Due to customer payment on–time (C8) reflecting both service quality area and customer relation area, for adjustment #1, customer payment on–time (C8) is moved from service quality (SQ) area to customer relation (CR) area. For adjustment #2, the average customer size indicator under service quality (SQ) area and brand-image index indicator under customer relation (CR) area are deleted because other indicators under those focus areas seem more important than the average customer size and brand-image index indicators. Table 29 and 30 show the new set of KPIs in service quality (SQ) and customer relation (CR) under adjustment #1 and adjustment #2 respectively.

**Table 30** The new set of KPIs under adjustment #1

| Perspective | Focus Areas | KPIs |
|---|---|---|
| Financial | (I) Liquidity: LQ | F1: Current rate |
| | | F7: Return on capital employed |
| | | F9: Cash flow |
| | | F10: Return on investment |
| | (II) Profitability: PF | F2: Interest expense to sales ratio |
| | | F3: Revenues per Total assets |
| | | F4: Revenues per Employee |
| | | F5: Profits per Employee |
| | | F6: Market value |
| | | F8: Profit margin |
| | | F11: EBITDAR |
| | | F12: Revenues from new product per Total revenue |
| | | F13: Revenues per Cost of goods sold |
| | | F14: Revenues per Marketing expense |
| | | F15: Revenues per Raw material cost |
| | | F16: Revenues per Energy cost |
| | (III) Corporate Competency: CC | F17: Market share |
| | | F18: Profit per Customer |
| | | F19: Revenue per Service expense |
| Customer | **(IV) Service Quality: SQ** | C3: Satisfied - customer index |
| | | C4: Customer - loyalty index |
| | | C5: Number of customer complaints |
| | | C7: Average customer size |
| | | ~~C8: Customer payment on – time~~ |
| | **(V) Customer relation: CR** | C9: Average direct communications to customers |
| | | C1: New customers per Total customers |
| | | C2: Customer lost |
| | | C6: Brand - image index |
| | | **C8: Customer payment on – time** |
| Internal Business Process | (VI) Productivity and Process Efficiency: PP | IP2: Average lead time |
| | | IP3: Lead time, from order to delivery |
| | | IP4: Lead time, production |
| | | IP6: Inventory turnover |
| | | IP5: Average time for decision-making |
| | | IP9: MTBF |
| | | IP10: MTTR |
| | | IP11: Percentage of new product development projects completed on time |
| | (VII) Partnership: PN | IP8: Supplier on-time delivery |
| | | IP12: Total supply chain delivery performance to end customer |
| | (VII) Operational and technical Quality: OT | IP1: On - time delivery |
| | | IP7: Maintenance cost per Revenue |
| Innovation and Learning | (IX) Product innovation: PI | IL1: R&D expense per Total expenses |
| | | IL4: Marketing expense per Customer |
| | | IL5: Information coverage ratio |
| | (X) Quality of work life: QW | IL3: Satisfied - employee index |
| | | IL2: Competence development expenses per Employee |
| | | IL6: Investment in new product support and training per Total employee |
| | | IP7: Staff turnover |

**Table 31** The new set of KPIs under adjustment #2

| Perspective | Focus Areas | KPIs |
|---|---|---|
| Financial | (I) Liquidity: LQ | F1: Current rate |
| | | F7: Return on capital employed |
| | | F9: Cash flow |
| | | F10: Return on investment |
| | (II) Profitability: PF | F2: Interest expense to sales ratio |
| | | F3: Revenues per Total assets |
| | | F4: Revenues per Employee |
| | | F5: Profits per Employee |
| | | F6: Market value |
| | | F8: Profit margin |
| | | F11: EBITDAR |
| | | F12: Revenues from new product per Total revenue |
| | | F13: Revenues per Cost of goods sold |
| | | F14: Revenues per Marketing expense |
| | | F15: Revenues per Raw material cost |
| | | F16: Revenues per Energy cost |
| | (III) Corporate Competency: CC | F17: Market share |
| | | F18: Profit per Customer |
| | | F19: Revenue per Service expense |
| Customer | **(IV) Service Quality: SQ** | C3: Satisfied - customer index |
| | | C4: Customer - loyalty index |
| | | C5: Number of customer complaints |
| | | ~~C7: Average customer size~~ |
| | | C8: Customer payment on – time |
| | **(V) Customer relation: CR** | C9: Average direct communications to customers |
| | | C1: New customers per Total customers |
| | | C2: Customer lost |
| | | ~~C6: Brand - image index~~ |
| Internal Business Process | (VI) Productivity and Process Efficiency: PP | IP2: Average lead time |
| | | IP3: Lead time, from order to delivery |
| | | IP4: Lead time, production |
| | | IP6: Inventory turnover |
| | | IP5: Average time for decision-making |
| | | IP9: MTBF |
| | | IP10: MTTR |
| | | IP11: Percentage of new product development projects completed on time |
| | (VII) Partnership: PN | IP8: Supplier on-time delivery |
| | | IP12: Total supply chain delivery performance to end customer |
| | (VII) Operational and technical Quality: OT | IP1: On - time delivery |
| | | IP7: Maintenance cost per Revenue |
| Innovation and Learning | (IX) Product innovation: PI | IL1: R&D expense per Total expenses |
| | | IL4: Marketing expense per Customer |
| | | IL5: Information coverage ratio |
| | (X) Quality of work life: QW | IL3: Satisfied - employee index |
| | | IL2: Competence development expenses per Employee |
| | | IL6: Investment in new product support and training per Total employee |
| | | IP7: Staff turnover |

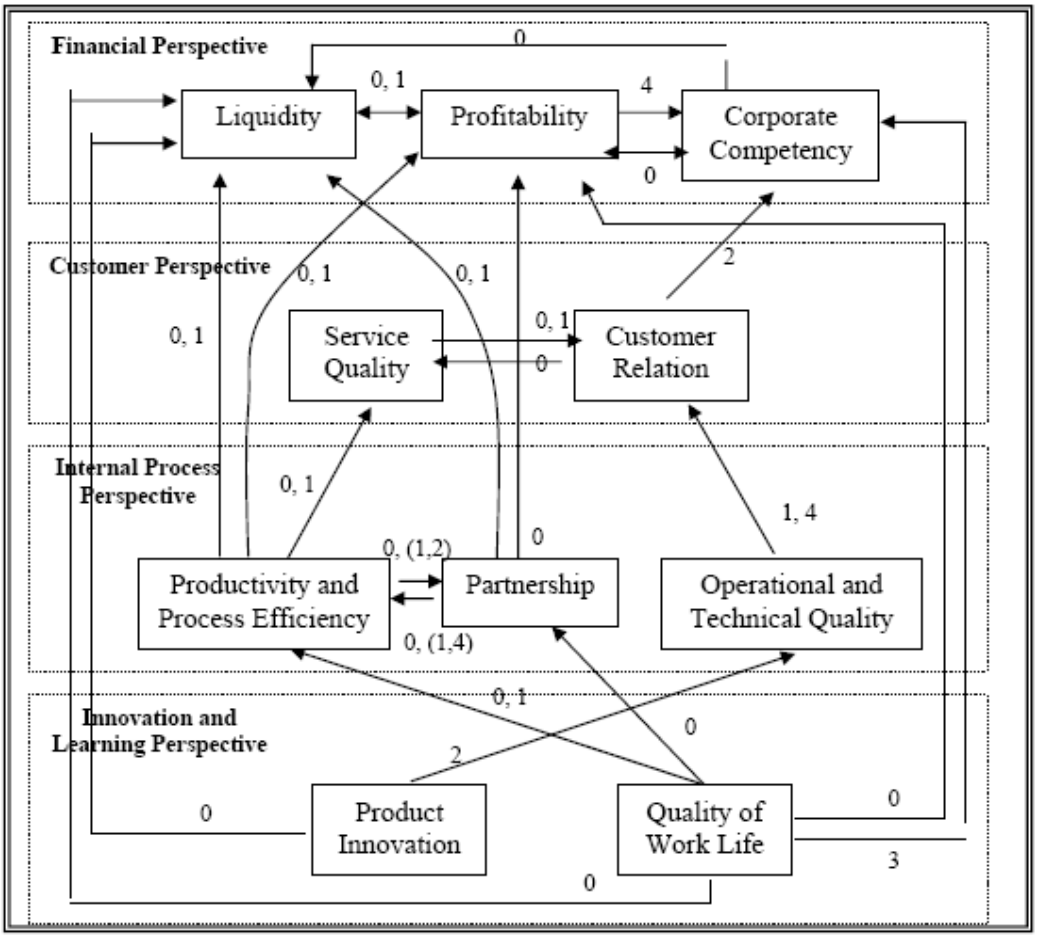
The next task was to repeat the step of verify the interrelationships between scorecards and the step of quantify the time – lag effects among the ten focus areas. The result of the adjustment can be demonstrated as follows.

**The results of Adjustment #1**

When the set of KPIs in focus areas is changed, namely customer payment on–time (C8) is moved from service quality (SQ) area to customer relation (CR) area, the strategy map was developed for each participating company shown as Figures 30, 31, and 32 respectively.

**The results of Adjustment #2**

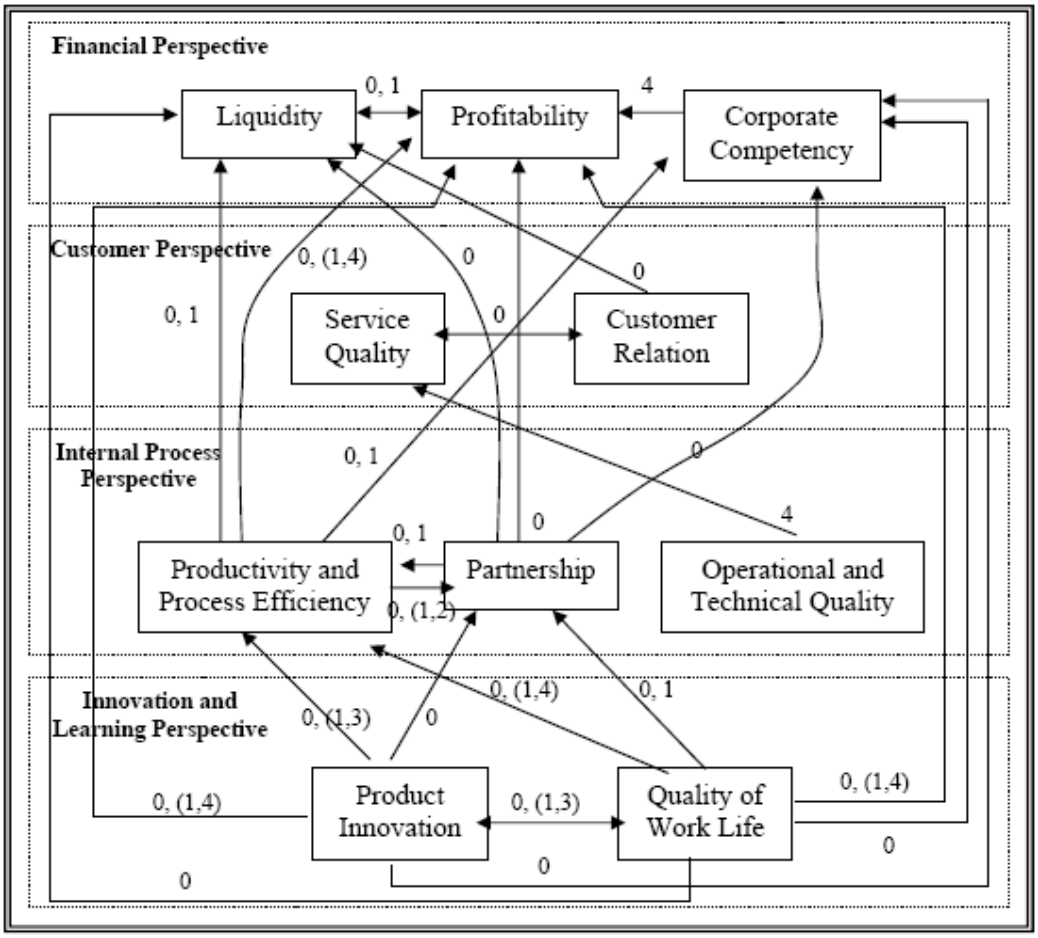
When the set of KPIs in focus areas is changed, namely the average customer size indicator under service quality (SQ) area and brand-image index indicator under customer relation (CR) area are deleted, the strategy map was developed for the each participating company shown as Figures 33, 34, and 35 respectively.




**Note:** - The number represents the time- lag effects in terms of months.

- Zero stands for immediate impact
- The parenthesis represents the ranges of the time-lag effects
- The line reflects the impacts from one focus area to another.

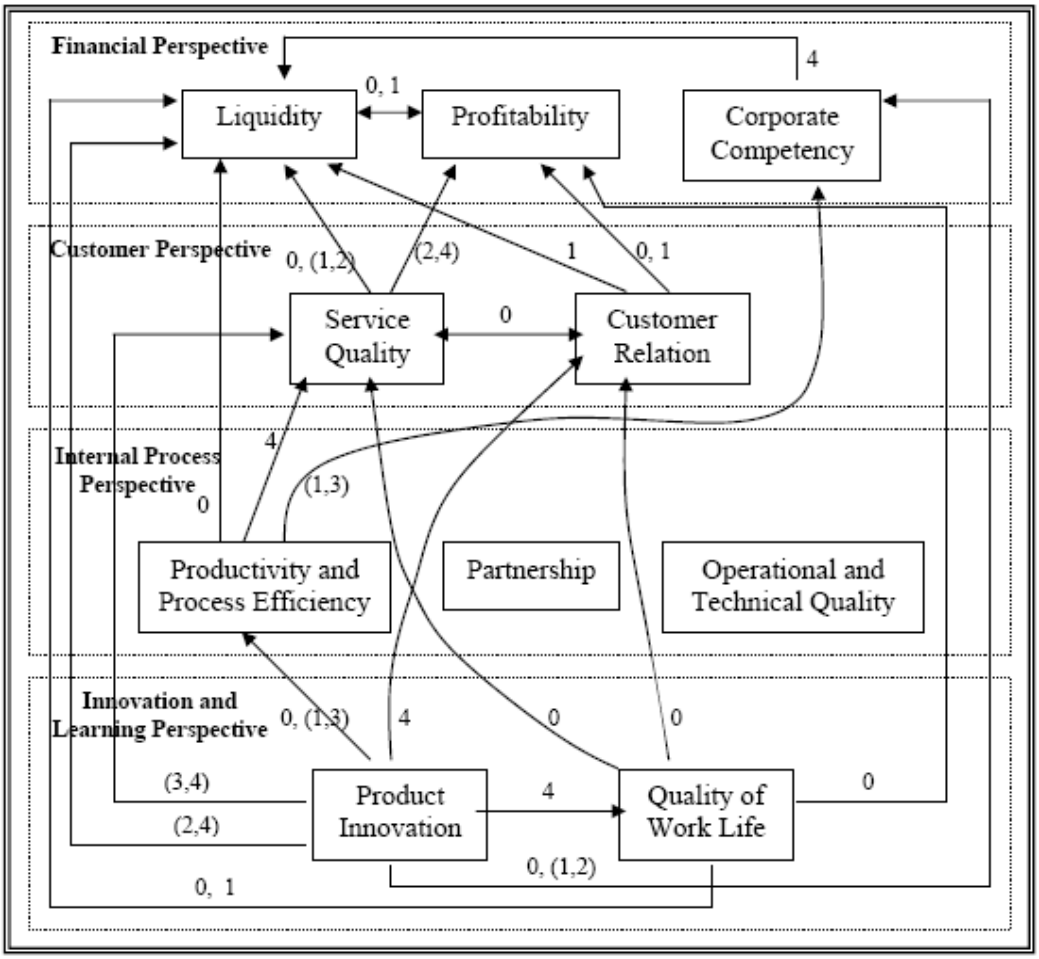
**Figure 30** Strategy map under adjustment #1 for the Company #1




**Note:** - The number represents the time- lag effects in terms of months.

- Zero stands for immediate impact
- The parenthesis represents the ranges of the time-lag effects
- The line reflects the impacts from one focus area to another.

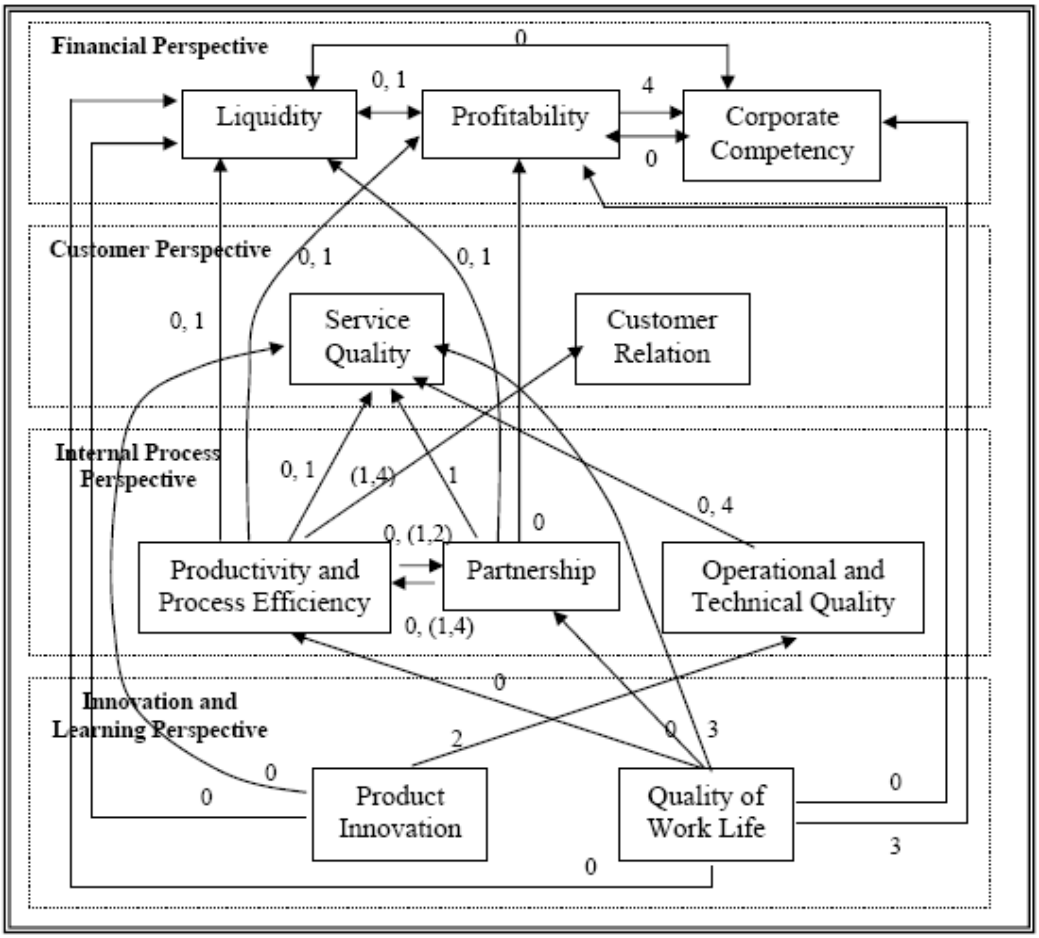
**Figure 31** Strategy map under adjustment #1 for the Company #2




**Note:** - The number represents the time- lag effects in terms of months.

- Zero stands for immediate impact
- The parenthesis represents the ranges of the time-lag effects
- The line reflects the impacts from one focus area to another.

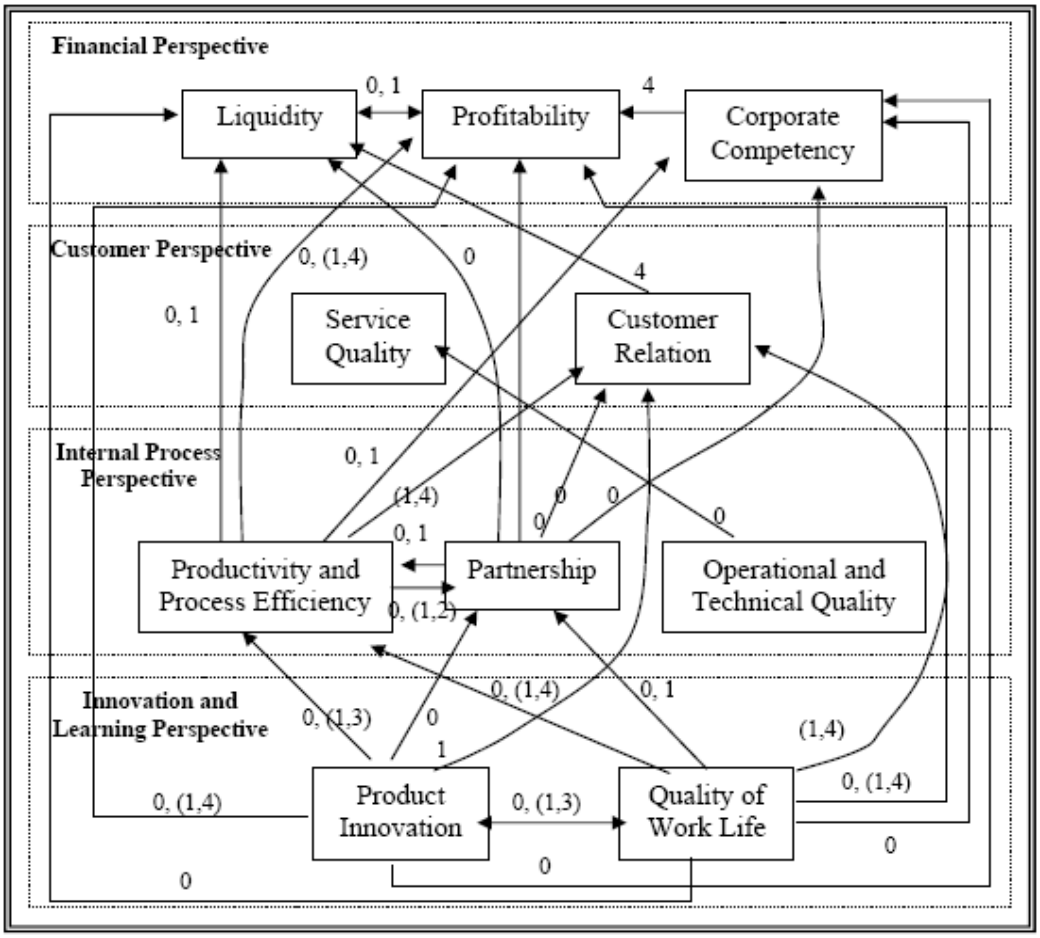
**Figure 32** Strategy Map under adjustment #1 for the Company #3




**Note:** - The number represents the time- lag effects in terms of months.

- Zero stands for immediate impact
- The parenthesis represents the ranges of the time-lag effects
- The line reflects the impacts from one focus area to another.

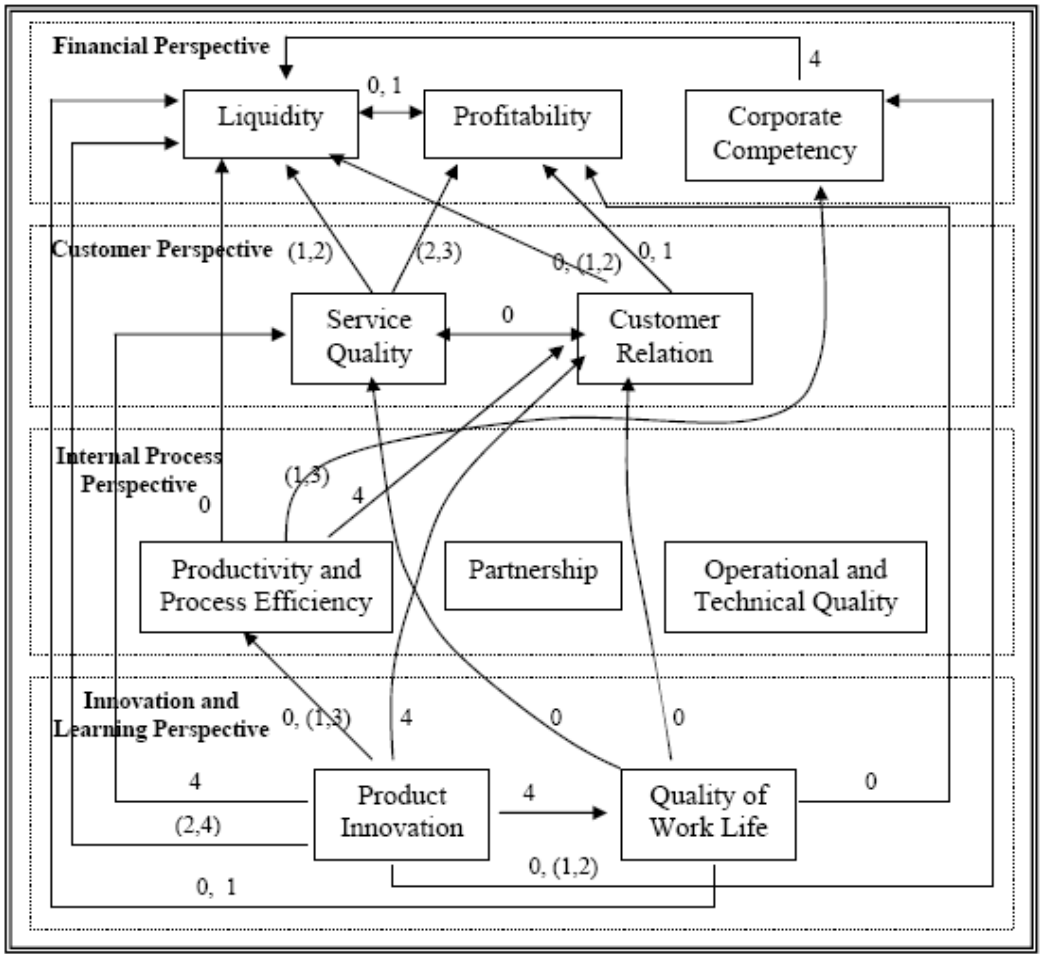
**Figure 33** Strategy Map under adjustment #2 for the Company #1




**Note:** - The number represents the time- lag effects in terms of months.

- Zero stands for immediate impact
- The parenthesis represents the ranges of the time-lag effects
- The line reflects the impacts from one focus area to another.

**Figure 34** Strategy map under adjustment #2 for the Company #2




**Note:** - The number represents the time- lag effects in terms of months.

- Zero stands for immediate impact
- The parenthesis represents the ranges of the time-lag effects
- The line reflects the impacts from one focus area to another.

**Figure 35** Strategy map under adjustment #2 for the Company #3

Some findings, derived from the adjustment of the set of KPIs, include the following. The interrelationship computations – representing the strategy map, appeared the significant relationship between some focus areas. For examples; for the company#1, the area of customer relation has influence on corporate competency; for the company#2, the operational and technical quality area impact on service quality area; for the company#3, the customer relation area affects on liquidity of a company. In the contrary, the relationship between some focus areas was disappeared, i.e. the relationship between operational and technical quality area and customer relation was disappeared for company #2.

Therefore, the set of KPIs in the focus area are important in developing a strategy map. If the KPIs that identify the focus areas do not completely and comprehensively reflect each of the focus areas, the relationships between focus areas may not appear. Furthermore, the set of KPIs – past performance information, used in this study, were mainly in the ratio format KPIs and were quantitative in nature. Other qualitative KPIs may be needed to truly represent their focus areas.

Finally, the alternative approach for a strategy map development has eight steps as follows:

1. Survey key performance indicator (KPIs) in the organization. The suitable KPIs for this approach focus on ratio format.
2. Identify the focus areas the BSC perspectives, namely finance, customer, internal business process, and innovation and learning. The focus areas represent key performance drivers for successful strategy executive.
3. Classify the KPIs into the different groups of focus areas
4. Collect the data of KPIs (past performance information). The time scale for the data collection is important. This step should be selected by time frequency for the data collection, such as monthly, quarterly, and yearly.
5. Determine the sequential order of the four perspectives in the BSC. For example, the private firms are the emphasis on financial results then the sequential

order of a strategy map is finance, customer, internal business process, and innovation and learning respectively.

6. Convert performance results from each KPI within individual focus areas into non-dimensional scale information by the Multi – Criteria Performance Measurement Technique (MCPMT). It should be noted that each KPI has been assigned an equal weight when converting to a non-dimensional scale.

7. Verify the impact from one focus area to the others by correlation analysis under two conditions namely no-time consideration, and time-lag consideration.

8. Formulate a strategy map by arranging the focus areas following the sequential order of the four perspectives and linkage between pairs of focus areas when these pairs found impact

**Part II: The validation of the strategy map**

In order to confirm the alternative approach of a strategy map development, in this phase, the proposed strategy map, the approach's output, has been validated from three aspects including (1) the comparing with manufacturing strategic surveys, (2) the interview of executives from three participating companies on their acceptability (in term of usefulness and benefit) of the proposed strategy map to their business operations, and (3) the compatibility with literatures.

**The manufacturing strategic survey**

For the first aspect, the proposed strategy map is compared with the manufacturing strategy survey. It is important that the focus areas embedded propose strategy map address or match strategic priorities for organizational operation. . It is because the strategy map is supposed to be a primary management tool for performance analysis. See Helo (2005) for the need to link strategic priorities with measurement/ analysis. There were ten manufacturers who participated in this survey. All participating firms were locally owned with more than 25 years of business experience. There were generally considered as high performers in their

businesses. See Appendix D for these profiles. The survey consisted of 6 competitive priorities and 31 dimensions. See Appendix F. Based on top managers' opinions, the participating SMEs have prioritized their operational strategies as follows: (1) product quality, (2) customer-focus, (3) delivery, (4) flexibility, (5) know-how, and (6) cost-competitiveness respectively. See Table 32.

**Table 32** Operational strategies of the ten participating SMEs

| Criteria | Average Weight | Rank | |
|---|---|---|---|
| Product Quality (Q) | 0.285 | 1 | Strategic Prioritie |
| Customer Focus (CF) | 0.185 | 2 | |
| Delivery (D) | 0.177 | 3 | |
| Flexibility (F) | 0.153 | 4 | |
| Know-how (K) | 0.107 | 5 | |
| Costs-Competitiveness (C) | 0.093 | 6 | |
| **Total** | **1.000** | | |

Again, strategic priorities in this study, representing the top half of the list, are product quality, customer-focus, and delivery. In the proposed strategy map, the productivity/ process efficiency and operational/ technical quality areas correspond to product quality. The service quality and customer relation areas deal with customer-focus. Moreover, partnership addresses the concern on delivery. Given this evaluation, it is reasonable to conclude that the focus areas within the proposed strategy map reflect strategic priorities of a company's operation. See Figure 36.

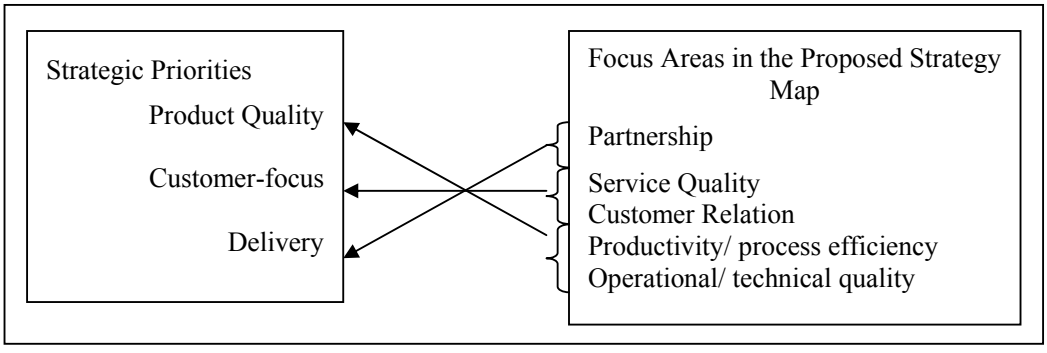



**Figure 36** Comparison between focus areas and strategic priorities

The linkages between focus areas are compared with the relationships between dimensions of the strategic priorities in order to confirm the relationships. The relationships among 31 dimensions were tested by correlation analysis. See Appendix G. Some of the findings on the relationships between dimensions can be describes as follows. There are 11 pairs that had significant relationships shown in Table 33. For example, the product performance dimension under quality priority had a significant relationship on mix change dimensions under the flexibility priority. It is important to note that a dimension could be perceived as a strategic objective or a manufacturing strategy. See Table 33 again that illustrates the compatible linkage between manufacturing strategy survey and focus area in the proposed strategy map.

**Table 33** The compatible linkage between manufacturing strategy survey and focus area in the proposed strategy map

| **Comparison linkage between Manufacturing Strategy and Focus areas** | | | | |
|---|---|---|---|---|
| **Manufacturing Strategy** | | | **Focus Areas** | |
| **The relationship between:** | | **Correlation coefficient** | **The relationship between:** | |
| Product Performance (Q_PP) | Mix Changes (F_MC) | -0.877* | Productivity and process efficiency | Product Innovation |
| Product Performance (Q_PP) | Creativity (K_CT) | -0.787* | Productivity and process efficiency | Quality of Work Life |
| On Agreed Time (D_OT) | Design Adjustment (F_DA) | 0.661* | Partnership | Product Innovation |
| Dependable Promises (D_DP) | Broad Product Line (F_BP) | 0.733* | Partnership | Product Innovation |
| Measurement of Satisfaction (CF_MS) | Reliability (Q_RL) | 0.646* | Service Quality | Productivity and process efficiency |
| Low Cost (C_LC) | Design Adjustment (F_DA) | -0.720* | Profitability | Product Innovation |
| Value Added Cost (C_VA) | Continuous Learning (K_CL) | 0.644* | Profitability | Quality of Work Life |
| Value Added Cost (C_VA) | R&D (K_RD) | 0.669* | Profitability | Product Innovation |
| Quality Costs (C_QC) | Dependable Promises (D_DP) | -0.784* | Corporate Competency | Partnership |
| Continuous Improvement (C_CI) | Right Amount (D_RA) | -0.685* | Corporate Competency | Partnership |
| Continuous Improvement (C_CI) | Broad Product Line (F_BP) | -0.693* | Corporate Competency | Product Innovation |

**Note:** * Significance at the 0.05 levels

Therefore, the focus areas embedded propose strategy map address or match with strategic priorities and the some linkage between focus areas are accordant with strategic objectives or manufacturing strategy for organizational operation. Skinner (1996) used competitive priorities to formulate the manufacturing strategy and argued that manufacturing's key decisions should be geared towards improving performance on selected priorities. Frohlich and Dixon (2001), Prajogo (2007), and Prajogo *et al*., (2007) suggested that strategies and performance were closely interrelated. In other words, performance areas should be consistent with a set of strategies at the organizational and operational levels. Given this evaluation, it is reasonable to conclude that the proposed strategy map reflect strategic priorities and manufacturing strategy of a company's operation.

**The interview of executives**

The second aspect for the analysis of the proposed strategy map is to interview with top executives from three participating companies on their acceptability (in terms of usefulness and benefit). The first company produced construction and chemical materials. The second company manufactured plastics and packages. The third company's primary output was drinking water.

The open questions were mainly used during the interview. The questions of interview mainly focus the linkage of the performance information for the decision making. The feedback from these sessions indicates reasonable acceptance on this proposed strategy map. The company's executives were pleased to verify their thoughts on the relationships of some of the key strategic priorities.

For example, the executives from companies #1 agree that the roles of technology for construction and chemical materials industrial are still limited and should be less explicit by integrating with other focus areas such as product innovation and productivity/ process efficiency (a separate focus area). Moreover, the executives from companies #1 and #2 also provide positive feedback on including the

term quality of work life, and on the interrelationships between partnership and productivity/ process efficiency. On the other hand, they suggest the impacts from service quality on liquidity.

For the executives from companies #3, he agrees that the product innovation has effect on productivity and process efficiency. In addition, productivity and process efficiency has impact on service quality and on liquidity. Moreover, the executives from companies #2 and #3, they realized that, in the current competitive environment, customer relation would contribute positively to profitability and liquidity. On the contrary, he is somewhat surprised initially by a lack of clear impacts from partnership on service quality due to this company has outsource suppliers for transportation and maintenance service therefore partnership is an importance.

Although, some linkage between focus areas is recommended, the general feedback appears to be positive. The feedback from these executives is consistent with the need to have a comprehensive view during performance analysis. According to Hoehn (2003), it is important that an analysis is based on performance information with clear understanding of consequences from improvement interventions. In order to gain this understanding, an effort should be made in developing a strategy map that integrates all four perspectives within the BSC. Moreover, time-lag information would be helpful for planning, communicating to staffs, and monitoring and evaluation. This map can possibly help top and functional managers in terms of result communication and strategy's deployment (Lin *et* al., 2006). Dixon *et al.* (1990), and Kaplan and Cooper (1998) stress the need to anticipate future impacts (intentional and unintentional) during performance analysis. In addition, given the proposed strategy map, it is possible that a mechanism should be in-place to ensure the consistency and the linkage between performance measurement effort and a task on information analysis. See Kurstedt (1992), and Neely (1998 and 2002). In addition, the proposed approach appears to clearly link between performance measurement and analysis.

**Compatibility with literature**

The final aspect for the analysis of the proposed strategy map is to compare with other literature. This would further ensure confidence. Fortunately, there had been various studies on the interrelationships between some of the focus areas. Wang and Chang (2005) demonstrated the impact from product innovation on liquidity and service quality. They found that there had been mutual relationships between capital allocated into new product development and business performance for the Taiwanese information-technology industry. Youndt *et al*. (2004) indicated that intellectual capital investments had positively contributed to corporate profits. Cheng and Chun (2005) discovered that investment of innovation capital had had positive effects (in a non-linear relationship or inverted U-shape) on firms' performance. Furthermore, based Jauhari (2001), Hewlett Packard India had focused on employee satisfaction as a prerequisite for both productivity improvement and increased market share. Also see Yu and Stough (2006).

The study's computation also showed that productivity and process efficiency were expected to impact both liquidity and profitability later. This implication was supported by Franklin (1983) where improved productivity increased profitability. Moreover, productivity and process efficiency would impact service quality area within one month and would influence the results from customer relation within four months. Furthermore, operational/ technical quality would affect service quality within four months. Van de Ven and Astley (1981) and Black *et al*., (2001) generally supported these implications. In a study on Malaysian manufacturing firms, Agus and Abdullah (2000) showed empirical evidence of the impacts on financial performance from customer satisfaction (i.e., service quality and profitability). Barker and Cagwin (2000) found that TQM likely improved financial results in a delayed manner (i.e., operational/ technical and service quality on profitability). Finally, Terziovski (2006) found that quality management had significant and positive effects on productivity levels and customer satisfaction. See Table 34.

**Table 34** Verification of the findings on some of the time effects

| Relevant Literatures | Time Effects between Focus Areas |
|---|---|
| Youndt *et al*. (2004)<br>Wang and Chang (2005)<br>Cheng and Chun (2005) | Product Innovation and Liquidity |
| Jauhari (2001)<br>Wang and Chang (2005) | Quality of Work Life and Productivity/ Process Efficiency |
| Wang and Chang (2005) | Productivity/ Process Efficiency and Liquidity |
| Franklin (1983)<br>Wang and Chang (2005) | Productivity/ Process Efficiency and Profitability |
| Agus and Abdullah (2000) | Service quality and profitability |
| Barker and Cagwin (2000) | Operational/ technical and service quality on profitability |
| Van de Ven and Astley (1981) | Productivity/ Process Efficiency and Service Quality |
| Black *et al*. (2001) | Productivity/ Process Efficiency and Customer Relation |
| Terziovski (2006) | Operational/ Technical Quality and Service Quality |

Given the comparisons with previous literature on the key time-lag effects between focus areas, the relationships in the proposed strategy map had more confidence in the findings that represent to confirm the alternative approach was acceptable.

At the same time, top executives from the participating companies asserted that the integration of the time-lag effects was very positive and would greatly enhance the effectiveness of a strategy map. This development assured that the company would have an objective evidence to demonstrate its compliance with Requirement # 8 of ISO 9001: 2000.

## Discussions

Part I: The proposed strategy map

Given the results of validation, it is possible that explicitly using information from the performance measurement could potentially be used as a premise to formulate a strategy map. Nevertheless, it is important that past performance (reflecting realistic circumstances) has to be learned, understood, communicated, shared, and integrated into this development (Kaplan and Norton, 2004). The reason is that this formulation should not be derived largely from what senior managers hypothesize. In fact, understanding past performance levels represents one of the critical factors when strengthening SMEs (Wickramansnghe and Sharma, 2005; and Garcia- Morales *et al*., 2006).

The feedback from these executives is consistent with the need to have a comprehensive view during performance analysis. It is important that an analysis is based on performance information with clear understanding on consequences from improvement interventions. In order to gain this understanding, an effort should be made on developing a strategy map that integrates all four perspectives within the BSC. This map can possibly help top and functional managers in terms of result communication and strategy's deployment. In addition, given the proposed strategy map, it is possible that a mechanism should be in-place to ensure the consistency and the linkage between performance measurement effort and a task on information analysis.

Part II: The proposed approach for development a strategy map

Kaplan and Norton (2004) proposed that a strategy map would build upon the premise of strategy as hypotheses, namely the balanced scorecard commences with the strategic understanding of top management which is then translated into operational measures at lower levels. The hypotheses underlying the strategy are

made explicit through the strategy map's cause-and-effect linkage across the four perspectives. The hypotheses are just the assumptions under the experience or forecasting of the executives. Nevertheless, the balances scorecard is the lack of identification of time delays between cause and effect. After the performance data about the strategy are collected, the hypotheses about the interrelationship among strategic objectives are validated. If the managerial anticipations have errors, the strategy map could cause an organization to fail because of getting wrong information for decision making. Manville (2007) found that the manager did not clearly relate the linkage of the KPIs to the business plan as many had not had access to the plan. Thus, managerial background and actual task environment was one of the important effect on managers' attention to differences in the design causal relationships in the balanced scorecard.

For this proposed approach, past information from performance measurement is used instead of managerial anticipation or hypotheses and applies statistical analysis to verify the relationship between focus areas representing key strategic objectives. Those relationships formulate the strategy map. This approach develops the strategy map regarding the time impact not only immediately impact but also time-lag effect. Due to the effects of the different areas involved on different time scales. For example, the introduction of process innovation might yield more satisfied customer within a period of three months, an innovative intervention might not affect the financial results until a few years have passed. Meyer (2002) argued that BSC has no strong basis in theory namely it did not provide guidance on how to combine the dissimilar measures into an overall appraisal of performance. This proposed approach applies the MCPMT to convert the dissimilar measures, using different units, into non-dimensional scale information, representing an overall performance level. Although, the strategy map maker should be top managers. For this proposed approach, head of department can help top managers to develop a strategy map in a part of finding the relationships by apply statistical analysis. It is important to recognize that head of department should have knowledge for the performance management system and statistical analysis. Ittner and Larcker (2000) agreed that

using a statistical analysis of leading and lagging indicators to test the causal links between performance indicators rather than asking managers their perceptions of causality. Table 35 illustrates the key different issues in developing a strategy map between the Kaplan and Norton approach and the proposed approach.

**Table 35** The key different issues between the Kaplan and Norton approach and the proposed approach

| Issue | The Kaplan and Norton approach | The proposed approach |
|---|---|---|
| • Cause-and-effect linkage | • Managerial anticipation and experience: "Opinion based" | • Past Performance information, and verify the relationship by applied the statistical analysis : "Information based" |
| • Validating linkage | • Testing after formulate strategy map by need to collect performance data for testing | • Testing before formulate strategy map |
| • Time condition | • Without considering any time lag | • Considering any time lag |
| • Combine the dissimilar measures | • Not provide guidance | • Applies the MCPMT to convert the performance results into non-dimensional scale information |
| • Strategy map maker | • Top managers | • Top managers and/or Head of department |
| • Strategy map maker skill | • More experience in the business | • Understand the performance management system and statistical analysis |

Kaplan and Norton developed the ideas of mapping causal relationships between strategic objectives and their measure in to a strategy map. Recent studies have found that about half of the firms employing formal performance measurement systems visualized causal links between measures using cause-and-effect diagrams (Marr, 2005). However, only half of the companies with formal performance measurement systems have implemented and tested causal relationships between measures (Marr, 2005); and other firms implemented strategy map that simply resembled process map without any connection to firms' strategy and competitive advantages (Wilkes, 2005)

Davis and Albright (2004) reported that 77 percent of BSC adopters in the USA failed to develop a causal model of their strategy. Similar findings are reported in studies on BSC adoption in India, Finland, Austria, Malaysia and Germany (Anand *et al*., 2005, Malmi, 2001; Othman, 2006; Speckbacher *et al*.,2003). Haapasalo *et al*. (2006) point that implementing the scorecard was not vary problematic, but finding the adequate metrics and defining their root cause and relationships was considered the most difficult in the implementation.

There are many researchers which attempt to propose a method for developing a causal model of the strategy map. For example, Abernethy *et al*.(2005) proposed the method of building causal performance maps from expert knowledge workers. They point that the top management might understand the organization's intended strategy and policies but might be ignorant of or unwilling to discuss actual observed system behavior. Othman (2008) proposed the idea of linking the balanced scorecard with scenario planning. This idea helps the organization to develop a series of strategy maps to depict the dynamics of the organization's strategy, instead of developing a single static strategy map. In the same way, Kunc (2008) presented to use systems thinking to identify the complex situation for mapping out managerial cognitive. It is important to note that the personal knowledge and own work experience are the main stay of judgment. This research proposes to use information from performance measurement to formulate the strategy map by using the statistical analysis for testing the relationship. The relationship that appears in the strategy map represents the actual relationship because it comes from the actual data instead of opinion.

The proposed approach can develop a strategy map that provides a comprehensive view (i.e., an integrated picture) that is valuable for performance analysis (and subsequently a performance measurement). It also helps improve performance analysis due to clear understanding on probable consequences among the focus areas – representing key performance objectives for an organization to achieve successful results. The proposed approach could potentially align database,

performance measurement, and information analysis— representing an improvement in a management process (Helo and Szekely, 2004; and Rao, 2006).

However, the proposed approach has some of difficulties or shortcomings embedded in the approach as follows:

1. This proposed strategy map is strictly based on the past performance and relies tremendously on the quantitative data. From a theoretical point of view, the availability of KPIs influenced the formulation of a strategy map. It is necessary that KPIs need to be often audited to ensure that they truly reflect the BSC perspectives and the focus areas.

2. From a practical perspective, although the integration of time-lag effects appeared to be useful, the company would have to continuously update the impacts as well as to explore other new interactions among the ten focus areas. This dynamic feature would inevitably add more workload to staffs.

3. For data conversion in the MCPMT, the equal- weight assignment is probably not realistic since it may not accurately reflect organizational policies and objectives. This was also the case from the weight assignment on each KPI in the ten focus areas. Because the importance of each KPI depends on the organizational policies that a dynamic. The unequal weight should be considered since different companies may emphasize on different focus area. Further, the MCPMT applications had certain limitations, especially the identification of three initial points on the preference curve. This determination was based primarily on the 18-month data without any consideration into external factors.

4. When developing the focus areas, the attention on the qualitative aspect such as culture needs to be made. It is important to recognize that an individual company or business needs to settle on its own set of focus areas.

5. The development of this map depends on the KPIs with some of their results converted into a monthly basis. This somehow impact on the final development of the strategy map.

6. The past information should be collected in the long term, because the short data-collection period can be the one of the reason that causes the sufficient data to the formulate relationships.

7. The computations on time-lag effects were up to only four months which not be sufficient to understand the actual impacts. It was possible that there could be longer time-lag periods among the focus areas.

The lessons learned from this research can be discussed as follows. Firstly, the relationship on the strategy map formulate from actual data which represents the actual relationship, on the contrary, when the relationships between focus areas does not appear, it does not imply that these focus areas are not relationships, but it implies that the collected data do not show the relationship. Then, when the company develops the strategy map it should formulate from this proposed approach (information based) parallels the experience of the executives because the relationship from the actual data can support the opinions of executives and confirm the decision making. In the same way, the experience of the executives can fulfill the strategy map from information based. Finally, from the result of validation, the information from performance measurement could potentially be used as a premise to formulate a strategy map. It is to note that, previously the participating companies collected data of performance measurement to only evaluate the organizational performance. The choice of KPIs should be linked to factors such as organizational objectives and the competitive environment. In addition, companies should remember that performance measurement choice is a dynamic process – KPIs may be appropriate today, but the system needs to be continually reassessed as strategies and competitive environments evolved.

# CONCLUSIONS AND RECOMENDATIONS

The research demonstrates the alternative approach for the development of a strategy map. It is based on past performance information resulted and applied the statistical analysis in order to test the relationship before formulating the strategy map. There are three participating companies in this research. This research prefers to use common KPIs and focus areas with three participating companies due to the similarities in size (SMEs), ownership structure, and operating environment. From the research results, there are 8 steps of the proposed approach for the development of a strategy map:

1. Survey key performance indicator (KPIs) in the organization. The suitable KPIs for this approach focus on ratio format.
2. Identify the focus areas based on the BSC perspectives, namely finance, customer, internal business process, and innovation and learning. The focus areas represent key performance drivers for successful strategy executive.
3. Classify the KPIs into different groups of focus areas
4. Collect the data of KPIs (past performance information). The time scale for the data collection is important. This step should be selected by frequency for the data collection, such as monthly, quarterly, and yearly.
5. Determine the sequential order of the four perspectives in the BSC. For example, private firms are the emphasis on financial results then the sequence of the strategy map is finance, customer, internal business process, and innovation and learning respectively.
6. Convert performance results from each KPI within individual focus areas into non-dimensional scale information by the Multi – Criteria Performance Measurement Technique (MCPMT). It should be noted that each KPI has been assigned an equal weight when converting to a non-dimensional scale.
7. Verify and quantify the impact from one focus area to the others by the correlation analysis under two conditions namely no-time consideration, and time-lag consideration.

8. Formulate a strategy map by arranging the focus areas following the sequential order of the four perspectives and linkage between pairs of focus areas when these pairs affect each other.

This proposed alternative of a strategy map development can be useful and acceptable. The results are confirmed by comparing with manufacturing strategic surveys, the interview of executives from all participating companies, and the comparison with literature. The strategy map from the proposed approach reflects strategic priority and manufacturing of a company's operation. The feedback from the top managers indicates reasonable acceptance of the relationships that appear in this proposed strategy map. The developed strategy provides a comprehensive view that is valuable for performance analysis and the time-lag information will be helpful for planning, communicating to staffs, and monitoring and evaluation. Lastly, the relationships that appear in the strategy, some part, agreed with previous literature.

Therefore, this development of a strategy map was entirely based on information from past performance. The integration time-lag effect would greatly enhance the effectiveness of a strategy map. This research should provide other SMEs with a roadmap to implement BSC with some minor adjustments to their specific industry.

Lessons learned from this research, the significant statistical results provide support the relationship between focus areas. On the other hand, the lack of statistical relationships between focus areas does not mean that these focus areas are not relationships, but it implies that the collected data do not show the relationship. Therefore, when developing the strategy map, this proposed approach; information relationship; should be conducted in parallel with the experience of executives; hypotheses relationship. This proposed approach would give the executives greatly increased confidence in their prediction of organizational strategies.

**Limitations of the study**

There are several limitations that need to be recognized and addressed. Firstly, the MCPMT applications had certain limitations, especially the identification of three initial points on the preference curve. This determination was based primarily on the 18-month data without any consideration into external factors such as industrial standards, or competitor results. Secondly, due to the limited data (only18-month data), the computations on time-lag effects were up to only four months. It was possible that there could be longer time-lag periods among the focus areas. Thirdly, the past performance relies tremendously on quantitative data. It is highly possible that general KPIs used in the study may not truly reflect each of the four BSC perspectives and of the agreed focus areas. Other qualitative KPIs may be needed to truly represent these perspectives and focus areas. Finally, it is important to recognize that there might be other time-lag effects that did not appear on the company' strategy map (due to several attributes such as KPIs, weight assignment, data availability).

It is important to note that a strategy map is based entirely future expectation; due to this proposed approach based on past performance information; therefore it should bring forward the thinking about the aspect of the strategy to before the development of the strategy map.

**Future research**

Although the proposed strategy map has positive feedback from three participating companies, some recommendation for future work provides as follows.

- To ensure that realize usages of this proposed strategy map, future research are needed to implement the proposed strategy map with three participating companies for testing its applicability and acceptability.
- Due to the dynamic aspect of strategies. Strategic objectives often changed due to competition, technology, and customer preference (Dixon, *et al*., 1990; and

Kaplan and Norton, 2004). Therefore, Continuous updates on this proposed map are also necessary.

- Due to focus areas represent the company's key strategic objectives for the next decade. The revision and updates of focus areas are essential. At the same time, executive needs to monitor the competitive environments to assess any changes that can render the focus areas invalid.

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# APPENDICES

# Appendix A

## Data Collection from Three Participating Companies

**Appendix Table A1** Data collection from Company # 1 on financial perspective

| Period | Data of Each KPIs (Company #1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 |
| 1 | 1.90 | 0.00324 | 17.00 | 80,952.38 | 7,380.95 | 70,000,000.00 | 3.88 | 35.00 | 5,000,000.00 |
| 2 | 1.90 | 0.00289 | 18.10 | 90,476.19 | 8,142.86 | 77,000,000.00 | 3.96 | 35.00 | 7,000,000.00 |
| 3 | 1.90 | 0.00239 | 21.50 | 109,523.81 | 10,000.00 | 95,000,000.00 | 4.46 | 35.00 | 8,000,000.00 |
| 4 | 2.32 | 0.00229 | 19.35 | 110,091.74 | 9,954.13 | 98,000,000.00 | 3.77 | 34.81 | 10,000,000.00 |
| 5 | 2.32 | 0.00220 | 19.23 | 114,678.90 | 10,321.10 | 100,000,000.00 | 3.65 | 35.00 | 12,000,000.00 |
| 6 | 2.32 | 0.00220 | 19.23 | 114,678.90 | 10,756.88 | 105,000,000.00 | 3.67 | 35.16 | 13,000,000.00 |
| 7 | 2.37 | 0.00173 | 19.70 | 119,266.06 | 10,733.94 | 104,000,000.00 | 3.72 | 34.62 | 12,000,000.00 |
| 8 | 2.37 | 0.00173 | 19.70 | 119,266.06 | 10,821.10 | 100,000,000.00 | 3.73 | 35.22 | 11,000,000.00 |
| 9 | 2.43 | 0.00180 | 18.94 | 109,649.12 | 9,868.42 | 99,000,000.00 | 3.54 | 35.00 | 14,000,000.00 |
| 10 | 2.40 | 0.00180 | 19.08 | 109,649.12 | 10,307.02 | 100,000,000.00 | 3.57 | 35.20 | 12,000,000.00 |
| 11 | 2.40 | 0.00173 | 18.44 | 114,035.09 | 10,307.02 | 105,000,000.00 | 3.36 | 35.08 | 13,000,000.00 |
| 12 | 2.40 | 0.00196 | 16.31 | 100,877.19 | 9,429.82 | 91,000,000.00 | 2.98 | 35.00 | 12,000,000.00 |
| 13 | 2.36 | 0.00157 | 21.05 | 121,739.13 | 11,191.30 | 110,000,000.00 | 3.96 | 35.00 | 14,000,000.00 |
| 14 | 2.39 | 0.00148 | 21.80 | 126,086.96 | 11,282.61 | 106,000,000.00 | 3.97 | 37.93 | 13,000,000.00 |
| 15 | 2.18 | 0.00167 | 20.30 | 117,391.30 | 10,760.87 | 105,000,000.00 | 3.88 | 35.19 | 14,000,000.00 |
| 16 | 2.26 | 0.00167 | 20.61 | 117,391.30 | 11,239.13 | 107,000,000.00 | 3.87 | 36.30 | 15,000,000.00 |
| 17 | 2.35 | 0.00154 | 19.72 | 121,739.13 | 11,260.87 | 111,000,000.00 | 3.63 | 35.71 | 16,000,000.00 |
| 18 | 2.35 | 0.00167 | 19.01 | 117,391.30 | 10,282.61 | 97,000,000.00 | 3.14 | 35.37 | 15,000,000.00 |

**Appendix Table A1** (Continued)

| Period | Data of Each KPIs (Company #1) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | F10 | F11 | F12 | F13 | F14 | F15 | F16 | F17 | F18 | F19 |
| 1 | 1.55 | 2,550,000.00 | 12.06 | 1.538 | 113.33 | 1.619 | 309.09 | 24.29 | 5,849.06 | 136.00 |
| 2 | 1.63 | 2,850,000.00 | 12.00 | 1.538 | 126.67 | 1.619 | 339.29 | 24.68 | 6,151.08 | 152.00 |
| 3 | 1.96 | 3,450,000.00 | 11.93 | 1.538 | 153.33 | 1.619 | 407.08 | 24.21 | 7,368.42 | 184.00 |
| 4 | 1.75 | 3,600,000.00 | 12.00 | 1.534 | 137.14 | 1.615 | 421.05 | 24.49 | 7,355.93 | 137.14 |
| 5 | 1.73 | 3,750,000.00 | 12.00 | 1.538 | 142.86 | 1.707 | 432.53 | 25.00 | 7,377.05 | 142.86 |
| 6 | 1.80 | 3,850,000.00 | 12.64 | 1.542 | 142.86 | 1.736 | 420.17 | 23.81 | 7,444.44 | 142.86 |
| 7 | 1.77 | 3,900,000.00 | 12.02 | 1.529 | 144.44 | 1.825 | 400.00 | 25.00 | 7,548.39 | 148.57 |
| 8 | 1.79 | 3,950,000.00 | 12.03 | 1.544 | 54.74 | 1.857 | 390.98 | 26.00 | 7,258.46 | 148.57 |
| 9 | 1.70 | 3,780,000.00 | 12.68 | 1.538 | 138.89 | 1.732 | 365.76 | 25.25 | 6,838.91 | 142.86 |
| 10 | 1.79 | 3,800,000.00 | 13.15 | 1.543 | 138.89 | 1.645 | 359.71 | 25.00 | 7,014.93 | 142.86 |
| 11 | 1.67 | 3,900,000.00 | 12.04 | 1.540 | 54.17 | 1.677 | 366.20 | 24.76 | 7,014.93 | 148.57 |
| 12 | 1.52 | 3,450,000.00 | 12.41 | 1.538 | 46.00 | 1.742 | 310.81 | 25.27 | 6,417.91 | 131.43 |
| 13 | 1.92 | 3,600,000.00 | 11.63 | 1.538 | 152.51 | 1.836 | 405.80 | 24.55 | 7,417.87 | 149.17 |
| 14 | 1.95 | 3,650,000.00 | 12.07 | 1.611 | 59.86 | 1.933 | 417.27 | 22.61 | 7,393.16 | 143.65 |
| 15 | 1.89 | 3,450,000.00 | 12.48 | 1.543 | 146.74 | 1.862 | 393.87 | 25.71 | 6,913.41 | 149.17 |
| 16 | 1.99 | 3,445,000.00 | 13.70 | 1.570 | 145.55 | 1.688 | 388.49 | 26.17 | 7,200.56 | 154.70 |
| 17 | 1.86 | 3,700,000.00 | 13.93 | 1.556 | 57.19 | 1.697 | 391.61 | 23.64 | 7,174.52 | 143.65 |
| 18 | 1.70 | 3,200,000.00 | 12.78 | 1.547 | 52.94 | 1.599 | 385.71 | 24.51 | 6,569.44 | 138.12 |

**Appendix Table A2** Data collection from Company # 1 on the customer perspective

| Period | Data of Each KPIs (Company #1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 |
| 1 | 5.28 | 0.75 | 83.00 | 94.34 | 0.00 | 80.00 | 64,150.94 | 88.68 | 1.132 |
| 2 | 5.40 | 1.08 | 83.00 | 88.13 | 5.00 | 80.00 | 68,345.32 | 88.49 | 1.151 |
| 3 | 3.51 | 0.00 | 83.00 | 89.47 | 2.00 | 80.00 | 80,701.75 | 87.37 | 1.147 |
| 4 | 3.39 | 0.68 | 83.00 | 97.63 | 0.00 | 80.00 | 81,355.93 | 90.85 | 1.153 |
| 5 | 3.28 | 0.00 | 83.00 | 95.08 | 0.00 | 80.00 | 81,967.21 | 90.82 | 1.148 |
| 6 | 3.81 | 1.90 | 83.00 | 94.60 | 0.00 | 80.00 | 79,365.08 | 88.89 | 1.159 |
| 7 | 3.23 | 0.00 | 88.00 | 91.94 | 0.00 | 85.00 | 83,870.97 | 91.94 | 1.161 |
| 8 | 4.62 | 0.00 | 88.00 | 91.08 | 0.00 | 85.00 | 80,000.00 | 91.38 | 1.123 |
| 9 | 1.22 | 0.00 | 88.00 | 91.79 | 0.00 | 85.00 | 75,987.84 | 89.67 | 1.140 |
| 10 | 1.79 | 0.00 | 88.00 | 95.82 | 0.00 | 85.00 | 74,626.87 | 97.01 | 1.134 |
| 11 | 0.00 | 0.00 | 88.00 | 94.33 | 0.00 | 85.00 | 77,611.94 | 95.52 | 1.149 |
| 12 | 0.00 | 0.00 | 88.00 | 93.13 | 0.00 | 85.00 | 68,656.72 | 97.31 | 1.164 |
| 13 | 5.19 | 1.44 | 90.00 | 83.57 | 3.00 | 88.00 | 77,809.80 | 90.00 | 1.052 |
| 14 | 6.27 | 0.85 | 90.00 | 86.04 | 1.00 | 88.00 | 74,074.07 | 83.56 | 1.040 |
| 15 | 2.51 | 0.56 | 90.00 | 85.75 | 0.00 | 88.00 | 75,418.99 | 87.59 | 1.061 |
| 16 | 3.34 | 0.28 | 92.00 | 90.53 | 1.00 | 90.00 | 77,994.43 | 87.62 | 1.072 |
| 17 | 2.77 | 0.28 | 92.00 | 90.86 | 1.00 | 90.00 | 72,022.16 | 93.14 | 1.080 |
| 18 | 3.89 | 1.11 | 92.00 | 89.72 | 0.00 | 90.00 | 69,444.44 | 92.45 | 1.106 |

**Appendix Table A3** Data collection from Company # 1 on the internal process perspective

| Period | Data of Each KPIs (Company #1) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | IP1 | IP2 | IP3 | IP4 | IP5 | IP6 | IP7 | IP8 | IP9 | IP10 | IP11 | IP12 |
| 1 | 94.72 | 48 | 30 | 18 | 5 | 2.60 | 0.500 | 77.78 | 210 | 72 | 41.67 | 0.00 |
| 2 | 96.91 | 47 | 21 | 17 | 5 | 2.60 | 0.500 | 73.33 | 210 | 72 | 60.00 | 2.08 |
| 3 | 94.78 | 46 | 21 | 16 | 4 | 2.60 | 0.500 | 84.78 | 210 | 72 | 70.00 | 4.17 |
| 4 | 96.10 | 45 | 24 | 14 | 4 | 2.61 | 0.500 | 67.35 | 250 | 60 | 80.00 | 6.25 |
| 5 | 98.05 | 45 | 18 | 14 | 3 | 2.60 | 0.500 | 73.81 | 210 | 60 | 70.00 | 6.25 |
| 6 | 98.25 | 41 | 19 | 15 | 3 | 2.59 | 0.520 | 84.44 | 250 | 60 | 71.43 | 14.58 |
| 7 | 97.10 | 41 | 18 | 12 | 3 | 2.62 | 0.519 | 87.50 | 250 | 60 | 60.00 | 14.58 |
| 8 | 98.00 | 41 | 18 | 12 | 3 | 2.53 | 0.558 | 94.87 | 250 | 50 | 60.00 | 14.58 |
| 9 | 97.26 | 41 | 18 | 12 | 3 | 2.65 | 0.460 | 95.35 | 250 | 50 | 40.00 | 14.58 |
| 10 | 97.16 | 44 | 18 | 12 | 3 | 2.40 | 0.460 | 89.80 | 275 | 50 | 80.00 | 8.33 |
| 11 | 98.50 | 48 | 18 | 12 | 3 | 2.73 | 0.442 | 94.12 | 300 | 48 | 80.00 | 0.00 |
| 12 | 98.53 | 46 | 18 | 12 | 3 | 2.69 | 0.500 | 94.29 | 275 | 48 | 80.00 | 4.17 |
| 13 | 91.11 | 41 | 18 | 12 | 3 | 2.68 | 0.518 | 85.45 | 270 | 55 | 60.00 | 16.67 |
| 14 | 86.53 | 41 | 18 | 12 | 3 | 2.59 | 0.517 | 92.59 | 270 | 55 | 60.00 | 14.58 |
| 15 | 96.32 | 41 | 18 | 12 | 3 | 2.71 | 0.463 | 83.02 | 270 | 50 | 40.00 | 14.58 |
| 16 | 92.70 | 44 | 17 | 12 | 3 | 2.47 | 0.426 | 84.00 | 275 | 50 | 80.00 | 8.33 |
| 17 | 89.05 | 48 | 17 | 12 | 3 | 2.78 | 0.482 | 94.12 | 265 | 50 | 80.00 | 6.25 |
| 18 | 90.28 | 46 | 18 | 12 | 3 | 2.68 | 0.426 | 93.02 | 275 | 50 | 80.00 | 2.08 |

**Appendix Table A4** Data collection from Company # 1 on the innovation and learning perspective

| Period | Data of Each KPIs (Company #1) | | | | | | |
|---|---|---|---|---|---|---|---|
| | IL1 | IL2 | IL3 | IL4 | IL5 | IL6 | IP7 |
| 1 | 2.110 | 45.283 | 79.000 | 566.038 | 80.000 | 71.429 | 0.00 |
| 2 | 4.286 | 43.165 | 79.000 | 539.568 | 80.000 | 71.429 | 0.95 |
| 3 | 4.928 | 42.105 | 79.000 | 526.316 | 80.000 | 71.429 | 0.48 |
| 4 | 4.474 | 40.678 | 82.000 | 593.220 | 80.000 | 68.807 | 0.00 |
| 5 | 2.000 | 39.344 | 82.000 | 573.770 | 80.000 | 68.807 | 0.46 |
| 6 | 1.974 | 38.095 | 82.000 | 555.556 | 80.000 | 114.679 | 0.00 |
| 7 | 1.923 | 38.710 | 82.000 | 580.645 | 87.000 | 114.679 | 0.00 |
| 8 | 3.797 | 36.923 | 82.000 | 1,461.538 | 87.000 | 114.679 | 0.00 |
| 9 | 1.948 | 36.474 | 82.000 | 547.112 | 87.000 | 109.649 | 0.00 |
| 10 | 2.000 | 35.821 | 85.000 | 537.313 | 87.000 | 65.789 | 0.00 |
| 11 | 1.923 | 35.821 | 85.000 | 1,432.836 | 87.000 | 65.789 | 0.00 |
| 12 | 2.174 | 35.821 | 85.000 | 1,492.537 | 87.000 | 65.789 | 0.00 |
| 13 | 1.923 | 45.455 | 85.000 | 576.369 | 90.000 | 90.909 | 0.87 |
| 14 | 3.797 | 45.455 | 85.000 | 1,424.501 | 90.000 | 90.909 | 0.00 |
| 15 | 1.948 | 45.455 | 85.000 | 418.994 | 90.000 | 75.758 | 0.00 |
| 16 | 2.000 | 45.455 | 90.000 | 417.827 | 90.000 | 75.758 | 0.00 |
| 17 | 1.923 | 45.455 | 90.000 | 831.025 | 90.000 | 75.758 | 0.00 |
| 18 | 2.174 | 45.455 | 90.000 | 1,388.889 | 90.000 | 75.758 | 0.00 |

**Appendix Table A5** Data collection from Company # 2 on the financial perspective

| Period | Data of Each KPIs (Company #2) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 |
| 1 | 5.83 | 0.0075 | 13.33 | 88,888.89 | 13,333.33 | 26,000,000.00 | 2.17 | 40.00 | 25,000,000.00 |
| 2 | 5.83 | 0.0075 | 13.33 | 88,888.89 | 13,333.33 | 30,000,000.00 | 2.17 | 40.50 | 17,000,000.00 |
| 3 | 5.83 | 0.0075 | 12.90 | 88,888.89 | 13,333.33 | 35,000,000.00 | 2.10 | 41.00 | 28,000,000.00 |
| 4 | 6.82 | 0.0069 | 13.38 | 93,333.33 | 14,000.00 | 37,000,000.00 | 2.40 | 40.24 | 28,000,000.00 |
| 5 | 6.82 | 0.0066 | 14.01 | 97,777.78 | 14,666.67 | 40,000,000.00 | 2.40 | 40.00 | 28,000,000.00 |
| 6 | 6.82 | 0.0066 | 14.01 | 93,617.02 | 14,042.55 | 40,000,000.00 | 2.40 | 40.40 | 28,000,000.00 |
| 7 | 6.55 | 0.0079 | 12.10 | 80,851.06 | 12,127.66 | 35,000,000.00 | 2.57 | 41.05 | 29,000,000.00 |
| 8 | 6.55 | 0.0071 | 13.38 | 89,361.70 | 13,404.26 | 35,000,000.00 | 2.57 | 40.57 | 27,000,000.00 |
| 9 | 6.55 | 0.0079 | 11.88 | 80,851.06 | 12,127.66 | 35,000,000.00 | 2.52 | 41.58 | 27,000,000.00 |
| 10 | 5.83 | 0.0066 | 13.75 | 93,617.02 | 14,042.55 | 35,000,000.00 | 2.57 | 40.23 | 27,000,000.00 |
| 11 | 5.83 | 0.0066 | 13.33 | 93,617.02 | 14,255.32 | 40,000,000.00 | 2.48 | 40.25 | 28,000,000.00 |
| 12 | 5.83 | 0.0066 | 13.33 | 93,617.02 | 14,212.77 | 40,000,000.00 | 2.48 | 40.41 | 28,000,000.00 |
| 13 | 6.90 | 0.0054 | 17.42 | 114,893.62 | 12,734.04 | 37,000,000.00 | 2.72 | 40.74 | 31,000,000.00 |
| 14 | 6.90 | 0.0052 | 18.06 | 119,148.94 | 14,042.55 | 40,000,000.00 | 2.72 | 42.86 | 32,000,000.00 |
| 15 | 6.90 | 0.0054 | 17.42 | 114,893.62 | 12,734.04 | 37,000,000.00 | 2.76 | 40.74 | 29,000,000.00 |
| 16 | 5.83 | 0.0054 | 16.88 | 114,893.62 | 14,744.68 | 37,000,000.00 | 2.78 | 42.59 | 27,000,000.00 |
| 17 | 5.83 | 0.0050 | 18.13 | 123,404.26 | 15,000.00 | 41,000,000.00 | 2.87 | 41.21 | 31,000,000.00 |
| 18 | 5.83 | 0.0048 | 18.75 | 127,659.57 | 15,319.15 | 42,000,000.00 | 2.91 | 41.67 | 33,000,000.00 |

**Appendix Table A5** (Continued)

| Period | Data of Each KPIs (Company #2) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | F10 | F11 | F12 | F13 | F14 | F15 | F16 | F17 | F18 | F19 |
| 1 | 2.00 | 4,000,000.00 | 10.00 | 1.667 | 37.04 | 1.667 | 444.44 | 69.23 | 10,714.29 | 133.33 |
| 2 | 2.00 | 4,000,000.00 | 10.00 | 1.702 | 31.75 | 1.702 | 454.55 | 70.00 | 10,033.44 | 133.33 |
| 3 | 1.94 | 4,000,000.00 | 10.00 | 1.739 | 27.78 | 1.739 | 444.44 | 68.57 | 9,677.42 | 133.33 |
| 4 | 2.01 | 4,200,000.00 | 11.90 | 1.633 | 26.92 | 1.633 | 488.37 | 70.27 | 10,161.29 | 93.33 |
| 5 | 2.10 | 4,400,000.00 | 11.14 | 1.612 | 26.19 | 1.612 | 500.00 | 70.00 | 10,509.55 | 97.78 |
| 6 | 2.10 | 4,400,000.00 | 12.05 | 1.612 | 26.19 | 1.612 | 517.65 | 70.00 | 10,312.50 | 97.78 |
| 7 | 1.85 | 3,800,000.00 | 14.47 | 1.810 | 25.33 | 1.810 | 441.86 | 71.43 | 8,584.34 | 76.00 |
| 8 | 2.05 | 4,200,000.00 | 13.14 | 1.687 | 26.92 | 1.687 | 494.12 | 74.29 | 8,823.53 | 84.00 |
| 9 | 1.78 | 3,800,000.00 | 13.16 | 1.774 | 25.33 | 1.774 | 448.64 | 71.43 | 7,983.19 | 76.00 |
| 10 | 2.06 | 4,400,000.00 | 12.95 | 1.678 | 29.33 | 1.678 | 517.65 | 71.43 | 9,192.20 | 88.00 |
| 11 | 2.03 | 4,400,000.00 | 13.05 | 1.662 | 27.16 | 1.662 | 488.89 | 67.50 | 9,203.30 | 88.00 |
| 12 | 2.02 | 4,400,000.00 | 13.50 | 1.653 | 26.19 | 1.653 | 494.38 | 70.00 | 8,766.40 | 88.00 |
| 13 | 1.82 | 4,100,000.00 | 11.11 | 1.688 | 262.14 | 1.688 | 540.00 | 72.97 | 7,875.00 | 105.88 |
| 14 | 2.01 | 4,500,000.00 | 10.36 | 1.750 | 90.61 | 1.750 | 538.46 | 70.00 | 8,461.54 | 109.80 |
| 15 | 1.82 | 4,100,000.00 | 9.81 | 1.688 | 262.14 | 1.688 | 554.41 | 72.97 | 7,673.08 | 105.88 |
| 16 | 2.10 | 4,800,000.00 | 11.08 | 1.742 | 245.45 | 1.742 | 593.41 | 72.97 | 8,662.50 | 105.88 |
| 17 | 2.14 | 4,750,000.00 | 10.39 | 1.701 | 93.55 | 1.701 | 644.44 | 70.73 | 8,725.25 | 113.73 |
| 18 | 2.18 | 4,850,000.00 | 10.37 | 1.714 | 66.67 | 1.714 | 674.16 | 71.43 | 8,716.71 | 117.65 |

**Appendix Table A6** Data collection from Company # 2 on the customer perspective

| Period | Data of Each KPIs (Company #2) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 |
| 1 | 12.50 | 1.79 | 85.00 | 98.21 | 2.00 | 75.00 | 71,428.57 | 98.21 | 1.250 |
| 2 | 3.68 | 0.00 | 85.00 | 100.00 | 0.00 | 75.00 | 66,889.63 | 96.66 | 1.204 |
| 3 | 1.61 | 0.97 | 85.00 | 100.00 | 3.00 | 75.00 | 64,516.13 | 96.77 | 1.219 |
| 4 | 0.65 | 0.00 | 80.00 | 100.00 | 0.00 | 85.00 | 67,741.94 | 96.77 | 1.287 |
| 5 | 3.18 | 0.00 | 80.00 | 100.00 | 0.00 | 85.00 | 70,063.69 | 98.73 | 1.309 |
| 6 | 1.56 | 0.00 | 80.00 | 100.00 | 0.00 | 85.00 | 68,750.00 | 93.75 | 1.344 |
| 7 | 9.64 | 1.20 | 85.00 | 98.80 | 0.00 | 85.00 | 57,228.92 | 95.48 | 1.295 |
| 8 | 0.00 | 0.00 | 85.00 | 100.00 | 0.00 | 85.00 | 58,823.53 | 97.76 | 1.218 |
| 9 | 0.00 | 0.00 | 85.00 | 100.00 | 0.00 | 85.00 | 53,221.29 | 98.04 | 1.232 |
| 10 | 0.56 | 0.84 | 90.00 | 99.16 | 2.00 | 90.00 | 61,281.34 | 96.10 | 1.242 |
| 11 | 1.37 | 0.00 | 90.00 | 100.00 | 0.00 | 90.00 | 60,439.56 | 96.15 | 1.228 |
| 12 | 4.46 | 0.52 | 90.00 | 99.48 | 0.00 | 90.00 | 57,742.78 | 98.95 | 1.257 |
| 13 | 3.95 | 1.32 | 90.00 | 90.79 | 0.00 | 90.00 | 71,052.63 | 94.20 | 1.263 |
| 14 | 2.31 | 0.77 | 90.00 | 94.87 | 1.00 | 90.00 | 71,794.87 | 97.26 | 1.249 |
| 15 | 2.56 | 1.03 | 90.00 | 96.15 | 1.00 | 90.00 | 69,230.77 | 98.65 | 1.259 |
| 16 | 3.00 | 0.75 | 93.00 | 95.00 | 1.00 | 95.00 | 67,500.00 | 94.67 | 1.113 |
| 17 | 3.71 | 0.99 | 93.00 | 96.53 | 1.00 | 95.00 | 71,782.18 | 97.26 | 1.262 |
| 18 | 3.63 | 0.73 | 93.00 | 93.22 | 0.00 | 95.00 | 72,639.23 | 94.81 | 1.247 |

**Appendix Table A7** Data collection from Company # 2 on the internal process perspective

| Period | Data of Each KPIs (Company #2) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | IP1 | IP2 | IP3 | IP4 | IP5 | IP6 | IP7 | IP8 | IP9 | IP10 | IP11 | IP12 |
| 1 | 94.69 | 38 | 28 | 22 | 3 | 3.00 | 0.600 | 85.71 | 220 | 72 | 71.43 | 0.00 |
| 2 | 97.39 | 37 | 27 | 21 | 3 | 3.01 | 0.600 | 80.00 | 220 | 60 | 83.33 | 2.63 |
| 3 | 97.27 | 36 | 26 | 20 | 3 | 2.99 | 1.250 | 62.96 | 220 | 60 | 71.43 | 5.26 |
| 4 | 89.83 | 35 | 25 | 19 | 2 | 4.68 | 0.476 | 72.41 | 255 | 75 | 60.00 | 7.89 |
| 5 | 98.40 | 35 | 25 | 19 | 2 | 5.15 | 0.455 | 71.88 | 260 | 75 | 40.00 | 7.89 |
| 6 | 96.30 | 31 | 21 | 15 | 2 | 5.25 | 0.455 | 84.00 | 275 | 60 | 80.00 | 18.42 |
| 7 | 98.54 | 31 | 21 | 15 | 2 | 4.20 | 0.526 | 78.57 | 275 | 60 | 100.00 | 18.42 |
| 8 | 97.12 | 31 | 21 | 15 | 2 | 5.08 | 0.476 | 86.21 | 275 | 60 | 100.00 | 18.42 |
| 9 | 98.53 | 31 | 21 | 15 | 2 | 4.76 | 0.658 | 87.88 | 275 | 60 | 100.00 | 18.42 |
| 10 | 97.84 | 39 | 19 | 13 | 2 | 6.10 | 0.568 | 89.74 | 275 | 60 | 100.00 | -2.63 |
| 11 | 98.12 | 38 | 18 | 12 | 2 | 6.46 | 0.568 | 92.50 | 275 | 60 | 80.00 | 0.00 |
| 12 | 98.98 | 36 | 16 | 10 | 2 | 6.25 | 0.568 | 92.00 | 275 | 60 | 100.00 | 5.26 |
| 13 | 96.48 | 30 | 17 | 13 | 2 | 5.93 | 0.407 | 90.00 | 265 | 50 | 100.00 | 7.89 |
| 14 | 95.17 | 31 | 16 | 14 | 2 | 5.82 | 0.429 | 90.63 | 265 | 50 | 100.00 | 15.79 |
| 15 | 96.60 | 31 | 15 | 12 | 2 | 5.82 | 0.426 | 85.71 | 265 | 50 | 100.00 | 18.42 |
| 16 | 96.62 | 33 | 17 | 12 | 2 | 5.25 | 0.426 | 94.87 | 255 | 55 | 100.00 | 10.53 |
| 17 | 96.15 | 29 | 17 | 12 | 2 | 5.78 | 0.397 | 92.50 | 255 | 55 | 80.00 | 15.79 |
| 18 | 98.04 | 27 | 15 | 11 | 2 | 5.87 | 0.383 | 94.29 | 255 | 55 | 100.00 | 21.05 |

**Appendix Table A8** Data collection from Company # 2 on the innovation and learning perspective

| Period | Data of Each KPIs (Company #2) | | | | | | |
|---|---|---|---|---|---|---|---|
| | IL1 | IL2 | IL3 | IL4 | IL5 | IL6 | IL7 |
| 1 | 2.500 | 44.444 | 80.000 | 566.038 | 89.000 | 44.444 | 0.44 |
| 2 | 2.500 | 44.444 | 80.000 | 539.568 | 89.000 | 44.444 | 0.44 |
| 3 | 2.500 | 44.444 | 80.000 | 526.316 | 89.000 | 44.444 | 0.44 |
| 4 | 2.381 | 44.444 | 80.000 | 593.220 | 89.000 | 44.444 | 0.00 |
| 5 | 2.273 | 44.444 | 80.000 | 573.770 | 89.000 | 44.444 | 0.00 |
| 6 | 2.273 | 42.553 | 80.000 | 555.556 | 89.000 | 42.553 | 0.00 |
| 7 | 3.947 | 63.830 | 89.000 | 580.645 | 95.000 | 63.830 | 0.00 |
| 8 | 3.571 | 63.830 | 89.000 | 1,461.538 | 95.000 | 63.830 | 0.00 |
| 9 | 3.947 | 63.830 | 89.000 | 547.112 | 95.000 | 63.830 | 0.00 |
| 10 | 3.409 | 63.830 | 89.000 | 537.313 | 95.000 | 63.830 | 0.00 |
| 11 | 3.409 | 63.830 | 89.000 | 1,432.836 | 95.000 | 63.830 | 0.00 |
| 12 | 3.409 | 63.830 | 89.000 | 1,492.537 | 95.000 | 63.830 | 0.00 |
| 13 | 4.177 | 63.830 | 90.000 | 271.053 | 95.000 | 106.383 | 0.43 |
| 14 | 3.750 | 63.830 | 90.000 | 792.308 | 95.000 | 106.383 | 0.85 |
| 15 | 4.125 | 63.830 | 90.000 | 264.103 | 95.000 | 106.383 | 0.43 |
| 16 | 3.261 | 63.830 | 90.000 | 275.000 | 95.000 | 106.383 | 0.00 |
| 17 | 3.191 | 63.830 | 90.000 | 767.327 | 95.000 | 106.383 | 0.43 |
| 18 | 3.226 | 63.830 | 90.000 | 1,089.588 | 95.000 | 106.383 | 0.00 |

**Appendix Table A9** Data collection from Company # 3 on the financial perspective

| Period | Data of Each KPIs (Company #-3) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 |
| 1 | 0.700 | 0.0047 | 15.32 | 141,176.47 | 13,333.33 | 154,000,000.00 | 3.09 | 28.33 | 10,200,000.00 |
| 2 | 0.700 | 0.0041 | 15.74 | 145,098.04 | 13,725.49 | 159,000,000.00 | 3.13 | 28.38 | 10,500,000.00 |
| 3 | 0.698 | 0.0043 | 15.57 | 149,019.61 | 14,430.98 | 167,000,000.00 | 3.02 | 29.21 | 11,039,000.00 |
| 4 | 0.699 | 0.0047 | 15.51 | 149,019.61 | 15,058.82 | 175,000,000.00 | 3.46 | 30.39 | 11,520,000.00 |
| 5 | 0.700 | 0.0049 | 15.38 | 149,019.61 | 15,254.90 | 176,000,000.00 | 3.32 | 30.66 | 11,640,000.00 |
| 6 | 0.700 | 0.0047 | 15.64 | 149,019.61 | 14,843.14 | 172,000,000.00 | 3.32 | 29.89 | 11,358,000.00 |
| 7 | 0.700 | 0.0038 | 15.73 | 147,169.81 | 14,339.62 | 150,000,000.00 | 3.17 | 29.29 | 11,415,000.00 |
| 8 | 0.700 | 0.0043 | 15.79 | 147,169.81 | 14,150.94 | 151,000,000.00 | 3.07 | 28.85 | 11,250,000.00 |
| 9 | 0.700 | 0.0051 | 13.94 | 132,075.47 | 14,113.21 | 150,000,000.00 | 3.17 | 32.07 | 11,220,000.00 |
| 10 | 0.700 | 0.0052 | 13.85 | 135,849.06 | 14,377.36 | 152,000,000.00 | 2.95 | 31.74 | 11,417,700.00 |
| 11 | 0.700 | 0.0047 | 14.61 | 147,169.81 | 14,150.94 | 151,500,000.00 | 2.82 | 28.85 | 11,250,000.00 |
| 12 | 0.700 | 0.0052 | 13.96 | 139,622.64 | 15,000.00 | 158,000,000.00 | 3.01 | 32.19 | 11,910,000.00 |
| 13 | 1.119 | 0.0045 | 16.50 | 158,888.89 | 15,185.19 | 165,000,000.00 | 5.55 | 30.07 | 13,200,000.00 |
| 14 | 1.192 | 0.0044 | 16.10 | 159,259.26 | 15,277.78 | 170,000,000.00 | 4.85 | 30.23 | 13,250,000.00 |
| 15 | 1.150 | 0.0049 | 14.53 | 142,592.59 | 15,370.37 | 165,000,000.00 | 5.20 | 30.39 | 14,000,000.00 |
| 16 | 1.145 | 0.0050 | 15.19 | 146,296.30 | 15,555.56 | 167,000,000.00 | 6.26 | 30.38 | 13,500,000.00 |
| 17 | 1.134 | 0.0043 | 16.10 | 159,259.26 | 15,277.78 | 165,500,000.00 | 5.19 | 30.23 | 14,250,000.00 |
| 18 | 1.128 | 0.0048 | 15.47 | 151,851.85 | 16,666.67 | 175,000,000.00 | 5.53 | 30.49 | 14,000,000.00 |

**Appendix Table A9** (Continued)

| Period | Data of Each KPIs (Company #3) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | F10 | F11 | F12 | F13 | F14 | F15 | F16 | F17 | F18 | F19 |
| 1 | 1.45 | 5,750,000.00 | 7.50 | 1.513 | 6.55 | 1.513 | 266.67 | 24.83 | 714.29 | 65.45 |
| 2 | 1.49 | 5,950,000.00 | 7.57 | 1.510 | 6.85 | 1.510 | 276.12 | 25.34 | 714.29 | 68.52 |
| 3 | 1.51 | 6,250,000.00 | 7.76 | 1.479 | 5.85 | 1.479 | 262.07 | 25.85 | 750.23 | 58.46 |
| 4 | 1.57 | 6,515,000.00 | 8.16 | 1.415 | 6.67 | 1.415 | 265.73 | 25.33 | 782.87 | 66.67 |
| 5 | 1.57 | 6,595,000.00 | 8.29 | 1.400 | 5.85 | 1.400 | 263.89 | 25.33 | 747.07 | 58.46 |
| 6 | 1.56 | 6,500,000.00 | 8.03 | 1.434 | 6.67 | 1.434 | 266.67 | 25.33 | 718.63 | 66.67 |
| 7 | 1.53 | 6,475,000.00 | 8.21 | 1.465 | 4.88 | 1.465 | 272.73 | 26.90 | 720.11 | 48.75 |
| 8 | 1.52 | 6,375,000.00 | 7.69 | 1.486 | 9.75 | 1.486 | 273.68 | 25.16 | 651.04 | 97.50 |
| 9 | 1.49 | 6,360,000.00 | 8.55 | 1.337 | 7.78 | 1.337 | 245.87 | 23.33 | 632.29 | 77.78 |
| 10 | 1.47 | 7,475,000.00 | 8.75 | 1.352 | 7.66 | 1.352 | 252.63 | 24.00 | 631.74 | 76.60 |
| 11 | 1.40 | 6,375,000.00 | 7.50 | 1.486 | 8.13 | 1.486 | 268.97 | 26.00 | 621.58 | 81.25 |
| 12 | 1.50 | 6,745,000.00 | 8.03 | 1.331 | 3.70 | 1.331 | 256.06 | 24.67 | 647.50 | 37.00 |
| 13 | 1.55 | 6,993,000.00 | 7.93 | 1.430 | 8.17 | 1.430 | 295.86 | 26.88 | 659.16 | 51.07 |
| 14 | 1.66 | 6,885,000.00 | 7.33 | 1.433 | 7.88 | 1.433 | 286.67 | 25.29 | 632.67 | 102.38 |
| 15 | 1.64 | 6,868,000.00 | 8.31 | 1.437 | 7.32 | 1.437 | 261.28 | 24.24 | 636.50 | 81.48 |
| 16 | 1.62 | 8,075,000.00 | 8.48 | 1.436 | 7.45 | 1.436 | 271.48 | 24.24 | 620.38 | 79.80 |
| 17 | 1.54 | 6,900,000.00 | 7.22 | 1.433 | 7.88 | 1.433 | 296.55 | 26.06 | 596.10 | 85.32 |
| 18 | 1.70 | 7,300,000.00 | 8.05 | 1.439 | 7.30 | 1.439 | 283.74 | 24.85 | 645.62 | 39.05 |

**Appendix Table A10** Data collection from Company # 3 on the customer perspective

| Period | Data of Each KPIs (Company #3) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 |
| 1 | 0.57 | 0.00 | 90.00 | 100.00 | 3.00 | 85.00 | 7,563.03 | 96.45 | 0.100 |
| 2 | 2.88 | 0.00 | 90.00 | 100.00 | 0.00 | 85.00 | 7,551.02 | 91.00 | 0.100 |
| 3 | 0.10 | 0.14 | 90.00 | 99.76 | 3.00 | 85.00 | 7,747.20 | 94.70 | 0.100 |
| 4 | 0.00 | 0.10 | 90.00 | 99.90 | 4.00 | 85.00 | 7,747.20 | 94.91 | 0.101 |
| 5 | 5.80 | 0.00 | 90.00 | 100.00 | 0.00 | 85.00 | 7,297.87 | 93.31 | 0.100 |
| 6 | 1.14 | 0.00 | 90.00 | 100.00 | 0.00 | 85.00 | 7,214.73 | 89.96 | 0.100 |
| 7 | 9.15 | 0.00 | 92.00 | 100.00 | 0.00 | 90.00 | 7,390.56 | 91.47 | 0.100 |
| 8 | 2.69 | 0.00 | 92.00 | 100.00 | 0.00 | 90.00 | 6,770.83 | 90.80 | 0.100 |
| 9 | 1.96 | 0.00 | 92.00 | 100.00 | 0.00 | 90.00 | 5,917.16 | 93.09 | 0.100 |
| 10 | 0.03 | 0.00 | 92.00 | 100.00 | 0.00 | 90.00 | 5,969.16 | 88.36 | 0.102 |
| 11 | 1.76 | 0.00 | 92.00 | 100.00 | 0.00 | 90.00 | 6,464.45 | 86.60 | 0.103 |
| 12 | 0.20 | 0.00 | 92.00 | 100.00 | 0.00 | 90.00 | 6,027.04 | 85.54 | 0.106 |
| 13 | 1.01 | 0.19 | 95.00 | 98.87 | 3.00 | 90.00 | 6,897.11 | 89.43 | 0.088 |
| 14 | 1.07 | 0.08 | 95.00 | 95.71 | 6.00 | 90.00 | 6,595.09 | 91.13 | 0.089 |
| 15 | 1.15 | 0.11 | 95.00 | 94.33 | 3.00 | 90.00 | 5,904.91 | 90.84 | 0.090 |
| 16 | 0.86 | 0.10 | 95.00 | 95.27 | 5.00 | 90.00 | 5,834.56 | 94.28 | 0.091 |
| 17 | 1.01 | 0.13 | 95.00 | 96.82 | 3.00 | 90.00 | 6,213.87 | 94.69 | 0.090 |
| 18 | 0.93 | 0.07 | 95.00 | 92.25 | 0.00 | 90.00 | 5,882.35 | 94.05 | 0.093 |

**Appendix Table A11** Data collection from Company # 3 on the internal process perspective

| Period | Data of Each KPIs (Company #3) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | IP1 | IP2 | IP3 | IP4 | IP5 | IP6 | IP7 | IP8 | IP9 | IP10 | IP11 | IP12 |
| 1 | 94.30 | 21 | 14 | 5 | 3 | 3.40 | 0.756 | 95.38 | 215 | 72 | 33.33 | 0.00 |
| 2 | 89.89 | 14 | 7 | 3 | 3 | 3.55 | 0.757 | 95.65 | 220 | 72 | 33.33 | 33.33 |
| 3 | 93.43 | 14 | 7 | 8 | 3 | 3.75 | 0.776 | 93.33 | 250 | 72 | 33.33 | 33.33 |
| 4 | 97.82 | 14 | 7 | 2 | 3 | 3.98 | 0.816 | 95.69 | 300 | 60 | 66.67 | 33.33 |
| 5 | 91.88 | 23 | 16 | 2 | 3 | 4.08 | 0.795 | 90.16 | 315 | 48 | 66.67 | -9.52 |
| 6 | 97.91 | 15 | 8 | 2 | 2 | 3.49 | 0.800 | 95.60 | 300 | 48 | 66.67 | 28.57 |
| 7 | 97.95 | 14 | 8 | 2 | 2 | 3.55 | 0.769 | 95.97 | 300 | 48 | 66.67 | 33.33 |
| 8 | 95.65 | 14 | 7 | 2 | 2 | 3.52 | 0.756 | 95.49 | 300 | 48 | 100.00 | 33.33 |
| 9 | 97.57 | 14 | 7 | 2 | 2 | 3.17 | 0.869 | 93.64 | 300 | 48 | 100.00 | 33.33 |
| 10 | 97.01 | 14 | 7 | 2 | 2 | 3.27 | 0.861 | 94.17 | 300 | 48 | 66.67 | 33.33 |
| 11 | 98.85 | 14 | 7 | 2 | 2 | 2.90 | 0.808 | 95.37 | 300 | 48 | 66.67 | 33.33 |
| 12 | 98.29 | 14 | 7 | 2 | 2 | 3.04 | 0.797 | 95.91 | 300 | 48 | 100.00 | 33.33 |
| 13 | 95.45 | 13 | 7 | 2 | 2 | 4.00 | 0.727 | 92.55 | 300 | 48 | 50.00 | 33.33 |
| 14 | 90.62 | 12 | 7 | 2 | 2 | 4.03 | 0.714 | 91.09 | 300 | 48 | 66.67 | 33.33 |
| 15 | 94.71 | 12 | 7 | 2 | 2 | 3.25 | 0.818 | 92.83 | 300 | 48 | 50.00 | 42.86 |
| 16 | 91.87 | 12 | 7 | 2 | 2 | 3.37 | 0.816 | 91.84 | 300 | 48 | 50.00 | 42.86 |
| 17 | 91.62 | 12 | 7 | 2 | 2 | 3.31 | 0.762 | 96.02 | 300 | 48 | 50.00 | 42.86 |
| 18 | 96.34 | 12 | 7 | 2 | 2 | 3.12 | 0.748 | 94.23 | 300 | 48 | 66.67 | 42.86 |

**Appendix Table A12** Data collection from Company # 3 on the innovation and learning perspective

| Period | Data of Each KPIs (Company #3) | | | | | | |
|---|---|---|---|---|---|---|---|
| | IL1 | IL2 | IL3 | IL4 | IL5 | IL6 | IP7 |
| 1 | 1.500 | 39.216 | 82.000 | 1,052.632 | 85.000 | 47.059 | 0.78 |
| 2 | 1.500 | 39.216 | 82.000 | 1,063.395 | 85.000 | 47.059 | 1.18 |
| 3 | 1.500 | 392.157 | 82.000 | 1,041.879 | 85.000 | 47.059 | 1.96 |
| 4 | 1.500 | 490.196 | 82.000 | 1,041.879 | 85.000 | 47.059 | 0.39 |
| 5 | 1.500 | 39.216 | 82.000 | 982.659 | 85.000 | 47.059 | 0.39 |
| 6 | 1.500 | 39.216 | 82.000 | 971.429 | 85.000 | 47.059 | 0.00 |
| 7 | 1.474 | 37.736 | 85.000 | 969.582 | 92.000 | 45.283 | 0.00 |
| 8 | 1.500 | 37.736 | 85.000 | 922.863 | 92.000 | 45.283 | 0.00 |
| 9 | 1.485 | 37.736 | 85.000 | 864.700 | 92.000 | 45.283 | 0.00 |
| 10 | 1.478 | 37.736 | 85.000 | 848.021 | 92.000 | 45.283 | 0.00 |
| 11 | 1.496 | 37.736 | 85.000 | 880.984 | 92.000 | 45.283 | 0.00 |
| 12 | 1.497 | 37.736 | 85.000 | 890.232 | 92.000 | 45.283 | 0.00 |
| 13 | 1.393 | 37.74 | 90.000 | 844.051 | 95.000 | 45.283 | 0.00 |
| 14 | 1.426 | 37.74 | 90.000 | 837.270 | 95.000 | 45.283 | 0.00 |
| 15 | 1.418 | 37.74 | 90.000 | 806.595 | 95.000 | 45.283 | 0.00 |
| 16 | 1.406 | 37.74 | 90.000 | 782.866 | 95.000 | 45.283 | 0.00 |
| 17 | 1.423 | 37.74 | 90.000 | 788.873 | 95.000 | 45.283 | 0.00 |
| 18 | 1.427 | 37.74 | 90.000 | 806.313 | 95.000 | 45.283 | 0.00 |

**Appendix B**

MCPMT Demonstration

This appendix demonstrates the application of the MCPMT. This technique has been used in this study twice during the BSC verification and the development of a strategy map. This demonstration only covers the innovation and learning perspective for company # 1. See Appendix Table B1.

**Appendix Table B1** Results from Company # 1 on the innovation and learning perspective

| Period | Data of Each KPIs (Company #1) | | | | | | |
|---|---|---|---|---|---|---|---|
| | IL1 | IL2 | IL3 | IL4 | IL5 | IL6 | IL7 |
| 1 | 2.11 | 45.28 | 79.00 | 566.04 | 80.00 | 71.43 | 0.00 |
| 2 | 4.29 | 43.17 | 79.00 | 539.57 | 80.00 | 71.43 | 0.95 |
| 3 | 4.93 | 42.11 | 79.00 | 526.32 | 80.00 | 71.43 | 0.48 |
| 4 | 4.47 | 40.68 | 82.00 | 593.22 | 80.00 | 68.81 | 0.00 |
| 5 | 2.00 | 39.34 | 82.00 | 573.77 | 80.00 | 68.81 | 0.46 |
| 6 | 1.97 | 38.09 | 82.00 | 555.57 | 80.00 | 114.68 | 0.00 |
| 7 | 1.92 | 38.71 | 82.00 | 580.66 | 87.00 | 114.68 | 0.00 |
| 8 | 3.80 | 36.92 | 82.00 | 1,461.59 | 87.00 | 114.68 | 0.00 |
| 9 | 1.95 | 36.47 | 82.00 | 547.11 | 87.00 | 109.65 | 0.00 |
| 10 | 2.00 | 35.82 | 85.00 | 537.31 | 87.00 | 65.79 | 0.00 |
| 11 | 1.92 | 35.82 | 85.00 | 1,432.84 | 87.00 | 65.79 | 0.00 |
| 12 | 2.17 | 35.82 | 85.00 | 1,492.54 | 87.00 | 65.79 | 0.00 |
| 13 | 1.92 | 45.46 | 85.00 | 576.37 | 90.00 | 90.91 | 0.87 |
| 14 | 3.79 | 45.46 | 85.00 | 1,424.51 | 90.00 | 90.91 | 0.00 |
| 15 | 1.95 | 45.46 | 85.00 | 418.99 | 90.00 | 75.76 | 0.00 |
| 16 | 2.01 | 45.46 | 90.00 | 417.83 | 90.00 | 75.76 | 0.00 |
| 17 | 1.92 | 45.46 | 90.00 | 831.02 | 90.00 | 75.76 | 0.00 |
| 18 | 2.17 | 45.46 | 90.00 | 1,388.89 | 90.00 | 75.76 | 0.00 |

**Note:** Due to the fact that there are three data-collection frequencies (i.e., monthly, quarterly, semi-annually) from the three companies, information from the quarterly- and semi annually-basis has to be converted into a monthly basis. The KPIs belonging to the innovation and learning perspective tend to have its data collected quarterly and semi-annually. On the contrary, KPIs in the financial perspective have their data collected more often. The monthly results after the conversion are shared and receive management consent for a further use.

**Appendix Table B1** (Continued)

**Note:** IL1: R&D expense per total expenses (%)
IL2: Competence development expenses per Employee (Baht/employee)
IL3: Satisfied - employee index (%)
IL4: Marketing expense per Customer (Baht/customer)
IL5: Information coverage ratio (%)
IL6: Investment in new product support and training per total employees (Baht/employee)
IL7: Staff turnover (%)

The performance scale of 0 to 100 is selected for all KPIs in this study. Furthermore, there are three points (the maximum, minimum, and average) that help form a preference curve for individual KPIs. For KPIs with a desirable increasing trend, the highest result over the 18-period duration receives the score of 100 while the lowest result is assigned the value of 0. On the other hand, for a KPI with a desirable decreasing trend, the highest result receives the score of 0 while the lowest result is assigned the value of 100. The score of 50 is for the average result over the 18 month-period duration. Then, the next task is to convert the results from each KPI into a common 0-100 scale. Afterward, the following task is to derive an overall result from one perspective by assigning an equal weight to corresponding KPIs. The overall result can be computed by multiplying the individual results from each KPI by the assigned weight. In this demonstration, each KPI is assigned a weight of 1/7. See Appendix Tables B2, B3, and B4. For the preference curve, see Appendix Figure B1.

**Appendix Table B2** Preference curve formulation

| Period | Company # 1 | | | | | | |
|---|---|---|---|---|---|---|---|
| | IL1 | IL2 | IL3 | IL4 | IL5 | IL6 | IL7 |
| 1 | 2.11 | 45.28 | 79 (W) | 566.04 | 80(W) | 71.43 | 0.00 (B) |
| 2 | 4.29 | 43.17 | 79 | 539.57 | 80 | 71.43 | 0.95 (W) |
| 3 | 4.93 (B) | 42.11 | 79 | 526.32 | 80 | 71.43 | 0.48 |
| 4 | 4.47 | 40.68 | 82 | 593.22 | 80 | 68.81 | 0.00 |
| 5 | 2.00 | 39.34 | 82 | 573.77 | 80 | 68.81 | 0.46 |
| 6 | 1.97 | 38.09 | 82 | 555.57 | 80 | 114.68 (B) | 0.00 |
| 7 | 1.92 (W) | 38.71 | 82 | 580.66 | 87 | 114.68 | 0.00 |
| 8 | 3.80 | 36.92 | 82 | 1,461.59 | 87 | 114.68 | 0.00 |
| 9 | 1.95 | 36.47 | 82 | 547.11 | 87 | 109.65 | 0.00 |
| 10 | 2.00 | 35.82 (W) | 85 | 537.31 | 87 | 65.79 (W) | 0.00 |
| 11 | 1.92 | 35.82 | 85 | 1,432.84 | 87 | 65.79 | 0.00 |
| 12 | 2.17 | 35.82 | 85 | 1,492.54 (W) | 87 | 65.79 | 0.00 |
| 13 | 1.92 | 45.46 (B) | 85 | 576.37 | 90 (B) | 90.91 | 0.87 |
| 14 | 3.79 | 45.46 | 85 | 1,424.51 | 90 | 90.91 | 0.00 |
| 15 | 1.95 | 45.46 | 85 | 418.99 | 90 | 75.76 | 0.00 |
| 16 | 2.01 | 45.46 | 90 (B) | 417.83 (B) | 90 | 75.76 | 0.00 |
| 17 | 1.92 | 45.46 | 90 | 831.02 | 90 | 75.76 | 0.00 |
| 18 | 2.17 | 45.46 | 90 | 1,388.89 | 90 | 75.76 | 0.00 |
| **Average** | **2.63** | **41.17** | **83.83** | **803.56** | **85.67** | **82.66** | **0.15** |

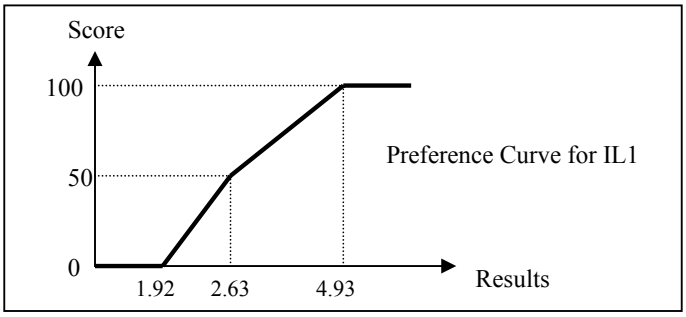
**Note:** - "B" represents the best performance level.

- "W" reflects the worst level of performance.

**Appendix Table B3** Conversion to a common performance scale of 0-100

| Period | Scores Based on the Scale of 0-100 | | | | | | |
|---|---|---|---|---|---|---|---|
| | IL1 | IL2 | IL3 | IL4 | IL5 | IL6 | IL7 |
| 1 | 13.24 | 98.00 | 0.00 | 80.79 | 0.00 | 16.72 | 100.00 |
| 2 | 86.05 | 73.32 | 0.00 | 84.22 | 0.00 | 16.72 | 0.00 |
| 3 | 100.00 | 60.96 | 0.00 | 85.94 | 0.00 | 16.72 | 29.79 |
| 4 | 90.13 | 45.44 | 31.03 | 77.26 | 0.00 | 8.95 | 100.00 |
| 5 | 5.46 | 32.97 | 31.03 | 79.79 | 0.00 | 8.95 | 30.88 |
| 6 | 3.59 | 21.28 | 31.03 | 82.15 | 0.00 | 100.00 | 100.00 |
| 7 | 0.00 | 27.03 | 31.03 | 78.89 | 65.38 | 100.00 | 100.00 |
| 8 | 75.43 | 10.31 | 31.03 | 2.25 | 65.38 | 100.00 | 100.00 |
| 9 | 1.77 | 6.11 | 31.03 | 83.24 | 65.38 | 92.15 | 100.00 |
| 10 | 5.46 | 0.00 | 59.46 | 84.51 | 65.38 | 0.00 | 100.00 |
| 11 | 0.00 | 0.00 | 59.46 | 4.33 | 65.38 | 0.00 | 100.00 |
| 12 | 17.80 | 0.00 | 59.46 | 0.00 | 65.38 | 0.00 | 100.00 |
| 13 | 0.00 | 100.00 | 59.46 | 79.45 | 100.00 | 62.89 | 5.18 |
| 14 | 75.43 | 100.00 | 59.46 | 4.94 | 100.00 | 62.89 | 100.00 |
| 15 | 1.77 | 100.00 | 59.46 | 99.85 | 100.00 | 29.55 | 100.00 |
| 16 | 5.46 | 100.00 | 100.00 | 100.00 | 100.00 | 29.55 | 100.00 |
| 17 | 0.00 | 100.00 | 100.00 | 48.01 | 100.00 | 29.55 | 100.00 |
| 18 | 17.80 | 100.00 | 100.00 | 7.52 | 100.00 | 29.55 | 100.00 |

**Note:** The interpolation is also used for this conversion. At the same time, each KPI's monthly result is multiplied by 1/7 to help determine an overall performance level at that month.




**Appendix Figure B1** Preference curve example

**Appendix Table B4** Overall result for the innovation and learning perspective for Company # 1

| Period | Overall Performance Score |
|---|---|
| 1 | 44.11 |
| 2 | 37.19 |
| 3 | 41.92 |
| 4 | 50.40 |
| 5 | 27.01 |
| 6 | 48.29 |
| 7 | 57.48 |
| 8 | 54.92 |
| 9 | 54.24 |
| 10 | 44.97 |
| 11 | 32.74 |
| 12 | 34.66 |
| 13 | 58.14 |
| 14 | 71.82 |
| 15 | 70.09 |
| 16 | 76.43 |
| 17 | 68.22 |
| 18 | 64.98 |

**Appendix C**

Correlation Analysis among 10 Focus areas

**Appendix Table C1** Correlation analysis among 10 focus areas under time-lag consideration for Company #1

| | PF(t-1) | PF(t-2) | PF(t-3) | PF(t-4) | CC(t-1) | CC(t-2) | CC(t-3) | CC(t-4) | SQ(t-1) | SQ(t-2) | SQ(t-3) | SQ(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LQ | 0.538 | 0.177 | 0.363 | -0.015 | 0.412 | -0.110 | 0.074 | -0.231 | -0.006 | 0.102 | 0.201 | 0.170 |
| | (0.026) | (0.512) | (0.184) | (0.959) | (0.100) | (0.686) | (0.794) | (0.426) | (0.983) | (0.708) | (0.472) | (0.562) |

| | CR(t-1) | CR(t-2) | CR(t-3) | CR(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LQ | 0.069 | -0.009 | -0.015 | -0.098 | 0.571 | 0.427 | 0.419 | 0.333 | 0.502 | 0.260 | 0.075 | 0.059 |
| | (0.792) | (0.973) | (0.957) | (0.738) | (0.017) | (0.099) | (0.120) | (0.245) | (0.040) | (0.331) | (0.791) | (0.841) |

| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LQ | -0.106 | -0.092 | -0.107 | 0.462 | 0.435 | -0.232 | -0.105 | -0.055 | 0.309 | 0.281 | 0.023 | -0.281 |
| | (0.686) | (0.733) | (0.703) | (0.096) | (0.081) | (0.386) | (0.708) | (0.851) | (0.228) | (0.292) | (0.935) | (0.330) |

| | LQ(t-1) | LQ(t-2) | LQ(t-3) | LQ(t-4) | CC(t-1) | CC(t-2) | CC(t-3) | CC(t-4) | SQ(t-1) | SQ(t-2) | SQ(t-3) | SQ(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PF | 0.561 | 0.143 | 0.235 | -0.072 | 0.395 | -0.106 | 0.077 | -0.352 | -0.015 | 0.045 | 0.097 | 0.071 |
| | (0.019) | (0.597) | (0.398) | (0.808) | (0.116) | (0.697) | (0.785) | (0.217) | (0.955) | (0.868) | (0.731) | (0.809) |

| | CR(t-1) | CR(t-2) | CR(t-3) | CR(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PF | -0.068 | -0.178 | 0.042 | -0.179 | 0.511 | 0.358 | 0.302 | 0.137 | 0.425 | 0.180 | -0.114 | -0.172 |
| | (0.796) | (0.509) | (0.882) | (0.541) | (0.036) | (0.174) | (0.275) | (0.639) | (0.089) | (0.506) | (0.685) | (0.557) |

| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PF | -0.194 | -0.169 | -0.056 | 0.495 | 0.404 | -0.207 | -0.103 | -0.013 | 0.327 | 0.157 | -0.242 | -0.420 |
| | (0.456) | (0.532) | (0.843) | (0.072) | (0.107) | (0.442) | (0.715) | (0.965) | (0.200) | (0.562) | (0.384) | (0.135) |

| | LQ(t-1) | LQ(t-2) | LQ(t-3) | LQ(t-4) | PF(t-1) | PF(t-2) | PF(t-3) | PF(t-4) | SQ(t-1) | SQ(t-2) | SQ(t-3) | SQ(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CC | -0.161 | -0.107 | -0.125 | -0.479 | -0.028 | -0.030 | -0.160 | -0.612 | -0.172 | -0.339 | -0.024 | 0.071 |
| | (0.538) | (0.694) | (0.657) | (0.083) | (0.914) | (0.911) | (0.570) | (0.020) | (0.510) | (0.198) | (0.933) | (0.810) |

**Appendix Table C1** (Continued)

| | CR(t-1) | CR(t-2) | CR(t-3) | CR(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CC | -0.200 | -0.436 | -0.076 | -0.113 | -0.129 | -0.369 | -0.177 | -0.267 | 0.009 | -0.112 | -0.424 | -0.481 |
| | (0.441) | (0.091) | (0.787) | (0.700) | (0.623) | (0.159) | (0.528) | (0.355) | (0.972) | (0.680) | (0.116) | (0.082) |
| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
| CC | -0.008 | -0.424 | -0.202 | 0.399 | 0.175 | -0.414 | -0.047 | -0.207 | -0.063 | -0.053 | -0.517 | -0.447 |
| | (0.977) | (0.102) | (0.471) | (0.157) | (0.501) | (0.111) | (0.869) | (0.478) | (0.810) | (0.846) | (0.048) | (0.109) |
| | CR(t-1) | CR(t-2) | CR(t-3) | CR(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
| SQ | 0.302 | 0.185 | 0.060 | -0.144 | 0.495 | 0.074 | -0.296 | -0.279 | 0.424 | 0.291 | 0.032 | -0.102 |
| | (0.238) | (0.492) | (0.832) | (0.623) | (0.043) | (0.786) | (0.283) | (0.333) | (0.090) | (0.275) | (0.911) | (0.729) |
| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
| SQ | 0.337 | 0.032 | -0.402 | -0.534 | 0.069 | 0.350 | 0.235 | 0.006 | 0.126 | 0.011 | 0.284 | 0.244 |
| | (0.186) | (0.906) | (0.137) | (0.049) | (0.791) | (0.184) | (0.400) | (0.983) | (0.630) | (0.968) | (0.305) | (0.400) |
| | SQ(t-1) | SQ(t-2) | SQ(t-3) | SQ(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
| CR | 0.303 | 0.204 | 0.182 | 0.149 | 0.274 | 0.089 | 0.191 | -0.064 | 0.314 | 0.284 | 0.091 | -0.018 |
| | (0.237) | (0.450) | (0.517) | (0.611) | (0.287) | (0.743) | (0.496) | (0.827) | (0.220) | (0.286) | (0.746) | (0.950) |
| CR | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
| | 0.262 | 0.054 | -0.062 | -0.408 | 0.013 | -0.263 | 0.052 | 0.148 | 0.341 | 0.151 | 0.237 | 0.097 |
| | (0.311) | (0.843) | (0.827) | (0.148) | (0.961) | (0.324) | (0.853) | (0.613) | (0.181) | (0.576) | (0.395) | (0.742) |
| | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) |
| PP | 0.733 | 0.753 | 0.839 | 0.778 | 0.191 | 0.244 | 0.049 | -0.066 | 0.091 | 0.162 | 0.128 | 0.123 |
| | (0.001) | (0.001) | (0.000) | (0.001) | (0.462) | (0.363) | (0.862) | (0.823) | (0.730) | (0.548) | (0.650) | (0.675) |

**Appendix Table C1** (Continued)

| | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) | | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | OT(t-1) | OT(t-2) | OT(t-3) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PP | 0.490 | 0.450 | 0.507 | 0.432 | PN | 0.689 | 0.601 | 0.462 | 0.113 | -0.062 | 0.219 | 0.370 |
| | (0.046) | (0.081) | (0.054) | (0.123) | | (0.002) | (0.014) | (0.083) | (0.701) | (0.814) | (0.416) | (0.175) |

| | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
|---|---|---|---|---|---|---|---|---|---|
| PN | 0.354 | -0.138 | -0.472 | -0.367 | 0.229 | 0.329 | 0.215 | -0.103 | -0.479 |
| | (0.214) | (0.597) | (0.065) | (0.178) | (0.431) | (0.198) | (0.423) | (0.715) | (0.083) |

| | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OT | 0.030 | 0.004 | -0.066 | -0.086 | 0.117 | 0.417 | 0.331 | -0.105 | -0.028 | 0.522 | 0.141 | -0.524 |
| | (0.910) | (0.988) | (0.814) | (0.770) | (0.654) | (0.108) | (0.228) | (0.722) | (0.914) | (0.038) | (0.616) | (0.054) |

| | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) | | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
|---|---|---|---|---|---|---|---|---|---|
| OT | -0.027 | 0.238 | 0.199 | 0.136 | PI | 0.296 | 0.194 | 0.087 | -0.233 |
| | (0.919) | (0.375) | (0.477) | (0.644) | | (0.248) | (0.472) | (0.758) | (0.423) |

| | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) |
|---|---|---|---|---|
| QW | 0.304 | 0.165 | 0.054 | 0.288 |
| | (0.235) | (0.541) | (0.849) | (0.319) |

**Note:** Upper results show the correlation value while the lower values illustrated the P-value.

**Appendix Table C2** Correlation analysis among 10 focus areas under time-lag consideration for Company #2

| | PF(t-1) | PF(t-2) | PF(t-3) | PF(t-4) | CC(t-1) | CC(t-2) | CC(t-3) | CC(t-4) | SQ(t-1) | SQ(t-2) | SQ(t-3) | SQ(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LQ | 0.653 | 0.489 | 0.300 | 0.306 | -0.275 | -0.145 | 0.033 | -0.063 | -0.020 | 0.187 | 0.199 | -0.148 |
| | (0.005) | (0.055) | (0.277) | (0.287) | (0.285) | (0.593) | (0.908) | (0.831) | (0.940) | (0.489) | (0.476) | (0.613) |
| | CR(t-1) | CR(t-2) | CR(t-3) | CR(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
| LQ | 0.375 | 0.259 | -0.150 | -0.370 | 0.506 | 0.309 | -0.015 | 0.093 | 0.264 | -0.052 | -0.408 | -0.245 |
| | (0.138) | (0.332) | (0.593) | (0.193) | (0.038) | (0.243) | (0.957) | (0.752) | (0.305) | (0.849) | (0.131) | (0.399) |
| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | OW(t-1) | OW(t-2) | OW(t-3) | OW(t-4) |
| LQ | -0.343 | 0.196 | 0.260 | -0.015 | 0.323 | 0.057 | 0.023 | 0.343 | 0.397 | 0.195 | 0.017 | 0.171 |
| | (0.178) | (0.466) | (0.349) | (0.959) | (0.206) | (0.834) | (0.934) | (0.230) | (0.115) | (0.469) | (0.952) | (0.559) |
| | LQ(t-1) | LQ(t-2) | LQ(t-3) | LQ(t-4) | CC(t-1) | CC(t-2) | CC(t-3) | CC(t-4) | SQ(t-1) | SQ(t-2) | SQ(t-3) | SQ(t-4) |
| PF | 0.507 | 0.402 | 0.405 | 0.321 | -0.236 | -0.334 | -0.475 | -0.536 | 0.053 | 0.111 | 0.053 | -0.005 |
| | (0.038) | (0.123) | (0.135) | (0.263) | (0.362) | (0.205) | (0.074) | (0.048) | (0.841) | (0.682) | (0.850) | (0.988) |
| | CR(t-1) | CR(t-2) | CR(t-3) | CR(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
| PF | 0.204 | 0.081 | 0.012 | 0.027 | 0.684 | 0.697 | 0.720 | 0.784 | 0.293 | 0.316 | 0.256 | 0.357 |
| | (0.433) | (0.765) | (0.965) | (0.927) | (0.002) | (0.003) | (0.002) | (0.001) | (0.254) | (0.233) | (0.358) | (0.211) |
| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | OW(t-1) | OW(t-2) | OW(t-3) | OW(t-4) |
| PF | -0.122 | 0.027 | -0.048 | -0.111 | 0.684 | 0.570 | 0.748 | 0.719 | 0.676 | 0.670 | 0.715 | 0.736 |
| | (0.642) | (0.922) | (0.865) | (0.704) | (0.002) | (0.021) | (0.001) | (0.004) | (0.003) | (0.004) | (0.003) | (0.003) |
| | LQ(t-1) | LQ(t-2) | LQ(t-3) | LQ(t-4) | PF(t-1) | PF(t-2) | PF(t-3) | PF(t-4) | SQ(t-1) | SQ(t-2) | SQ(t-3) | SQ(t-4) |
| CC | -0.269 | -0.102 | -0.254 | -0.129 | -0.124 | 0.179 | 0.190 | 0.168 | 0.136 | -0.125 | -0.060 | 0.190 |
| | (0.297) | (0.706) | (0.360) | (0.660) | (0.634) | (0.506) | (0.498) | (0.566) | (0.604) | (0.645) | (0.831) | (0.515) |

**Appendix Table C2** (Continued)

| | CR(t-1) | CR(t-2) | CR(t-3) | CR(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CC | -0.127 | -0.334 | -0.359 | -0.080 | -0.540 | -0.306 | -0.186 | 0.058 | -0.456 | -0.357 | -0.474 | -0.163 |
| | (0.627) | (0.206) | (0.188) | (0.787) | (0.025) | (0.249) | (0.506) | (0.844) | (0.066) | (0.175) | (0.075) | (0.578) |
| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | OW(t-1) | OW(t-2) | OW(t-3) | OW(t-4) |
| CC | -0.232 | -0.313 | -0.208 | -0.098 | -0.229 | -0.332 | 0.190 | 0.036 | -0.428 | -0.370 | -0.097 | -0.008 |
| | (0.370) | (0.237) | (0.456) | (0.740) | (0.376) | (0.209) | (0.498) | (0.904) | (0.086) | (0.158) | (0.730) | (0.978) |
| | CR(t-1) | CR(t-2) | CR(t-3) | CR(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
| SQ | -0.138 | -0.324 | 0.048 | -0.067 | -0.034 | 0.177 | -0.034 | 0.019 | -0.158 | 0.023 | 0.290 | 0.011 |
| | (0.596) | (0.221) | (0.864) | (0.820) | (0.897) | (0.512) | (0.905) | (0.948) | (0.545) | (0.932) | (0.294) | (0.969) |
| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | OW(t-1) | OW(t-2) | OW(t-3) | OW(t-4) |
| SQ | -0.121 | 0.272 | 0.218 | -0.403 | -0.002 | 0.337 | -0.085 | 0.216 | 0.165 | 0.154 | -0.048 | 0.212 |
| | (0.644) | (0.308) | (0.434) | (0.153) | (0.995) | (0.201) | (0.763) | (0.459) | (0.527) | (0.568) | (0.865) | (0.467) |
| | SQ(t-1) | SQ(t-2) | SQ(t-3) | SQ(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
| CR | -0.043 | -0.094 | 0.004 | -0.179 | 0.101 | 0.042 | -0.375 | -0.323 | -0.121 | -0.155 | -0.112 | -0.146 |
| | (0.870) | (0.729) | (0.990) | (0.541) | (0.699) | (0.876) | (0.168) | (0.260) | (0.643) | (0.566) | (0.692) | (0.620) |
| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | OW(t-1) | OW(t-2) | OW(t-3) | OW(t-4) |
| CR | 0.119 | 0.278 | -0.173 | -0.584 | -0.161 | 0.080 | -0.144 | 0.141 | 0.069 | 0.045 | -0.334 | -0.139 |
| | (0.649) | (0.298) | (0.537) | (0.028) | (0.538) | (0.769) | (0.608) | (0.630) | (0.792) | (0.868) | (0.224) | (0.637) |
| | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) |
| PP | 0.700 | 0.465 | 0.537 | 0.598 | 0.029 | 0.250 | 0.361 | 0.224 | 0.660 | 0.607 | 0.584 | 0.513 |
| | (0.002) | (0.069) | (0.039) | (0.024) | (0.912) | (0.351) | (0.186) | (0.440) | (0.004) | (0.013) | (0.022) | (0.061) |

**Appendix Table C2** (Continued)

| | OW(t-1) | OW(t-2) | OW(t-3) | OW(t-4) | | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | OT(t-1) | OT(t-2) | OT(t-3) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PP | 0.843 | 0.823 | 0.773 | 0.701 | PN | 0.605 | 0.517 | 0.338 | 0.057 | -0.189 | 0.199 | 0.207 |
| | (0.000) | (0.000) | (0.001) | (0.005) | | (0.010) | (0.040) | (0.218) | (0.848) | (0.468) | (0.461) | (0.459) |

| | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | OW(t-1) | OW(t-2) | OW(t-3) | OW(t-4) |
|---|---|---|---|---|---|---|---|---|---|
| PN | -0.269 | 0.418 | 0.307 | -0.056 | 0.068 | 0.592 | 0.385 | 0.087 | 0.047 |
| | (0.353) | (0.095) | (0.247) | (0.842) | (0.817) | (0.012) | (0.141) | (0.759) | (0.874) |

| | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OT | -0.045 | 0.020 | 0.040 | -0.095 | 0.148 | 0.302 | 0.414 | 0.155 | -0.038 | 0.311 | 0.052 | -0.341 |
| | (0.865) | (0.940) | (0.889) | (0.746) | (0.571) | (0.256) | (0.125) | (0.597) | (0.885) | (0.242) | (0.854) | (0.234) |

| | OW(t-1) | OW(t-2) | OW(t-3) | OW(t-4) | | OW(t-1) | OW(t-2) | OW(t-3) | OW(t-4) |
|---|---|---|---|---|---|---|---|---|---|
| OT | 0.031 | 0.136 | -0.026 | -0.159 | PI | 0.689 | 0.683 | 0.591 | 0.403 |
| | (0.905) | (0.617) | (0.927) | (0.588) | | (0.002) | (0.004) | (0.020) | (0.153) |

| | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) |
|---|---|---|---|---|
| OW | 0.752 | 0.665 | 0.629 | 0.410 |
| | (0.000) | (0.005) | (0.012) | (0.145) |

**Note:** Upper results show the correlation value while the lower values illustrated the P-value.

**Appendix Table C3** Correlation analysis among 10 focus areas under time-lag consideration for Company #3

| | PF(t-1) | PF(t-2) | PF(t-3) | PF(t-4) | CC(t-1) | CC(t-2) | CC(t-3) | CC(t-4) | SQ(t-1) | SQ(t-2) | SQ(t-3) | SQ(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LQ | 0.520 | 0.353 | -0.002 | -0.243 | -0.235 | -0.286 | -0.474 | -0.642 | -0.757 | -0.798 | -0.828 | -0.814 |
| | (0.032) | (0.180) | (0.995) | (0.403) | (0.363) | (0.283) | (0.074) | (0.013) | (0.000) | (0.000) | (0.000) | (0.000) |
| | CR(t-1) | CR(t-2) | CR(t-3) | CR(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
| LQ | -0.418 | -0.234 | -0.080 | 0.156 | 0.472 | 0.424 | 0.390 | 0.498 | 0.118 | 0.027 | 0.015 | -0.073 |
| | (0.095) | (0.383) | (0.778) | (0.593) | (0.056) | (0.102) | (0.151) | (0.070) | (0.652) | (0.920) | (0.958) | (0.804) |
| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
| LQ | -0.092 | 0.028 | 0.087 | 0.072 | 0.456 | 0.505 | 0.582 | 0.750 | 0.550 | 0.349 | 0.132 | -0.082 |
| | (0.724) | (0.918) | (0.757) | (0.806) | (0.066) | (0.046) | (0.023) | (0.002) | (0.022) | (0.186) | (0.639) | (0.780) |
| | LQ(t-1) | LQ(t-2) | LQ(t-3) | LQ(t-4) | CC(t-1) | CC(t-2) | CC(t-3) | CC(t-4) | SQ(t-1) | SQ(t-2) | SQ(t-3) | SQ(t-4) |
| PF | 0.583 | 0.400 | 0.373 | 0.315 | -0.158 | -0.173 | -0.066 | -0.495 | -0.376 | -0.626 | -0.600 | -0.660 |
| | (0.014) | (0.125) | (0.171) | (0.273) | (0.544) | (0.522) | (0.816) | (0.072) | (0.137) | (0.009) | (0.018) | (0.010) |
| | CR(t-1) | CR(t-2) | CR(t-3) | CR(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
| PF | -0.531 | -0.390 | -0.303 | -0.178 | -0.014 | -0.028 | -0.032 | 0.158 | 0.081 | -0.001 | -0.230 | 0.064 |
| | (0.028) | (0.135) | 0.272) | (0.542) | (0.958) | (0.918) | (0.910) | (0.588) | (0.756) | (0.996) | (0.410) | (0.827) |
| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
| PF | -0.165 | -0.170 | -0.233 | -0.051 | -0.100 | 0.100 | 0.196 | 0.310 | 0.447 | 0.355 | 0.108 | 0.112 |
| | (0.526) | (0.528) | (0.403) | (0.863) | (0.702) | (0.712) | (0.484) | (0.281) | (0.072) | (0.177) | (0.701) | (0.704) |
| | LQ(t-1) | LQ(t-2) | LQ(t-3) | LQ(t-4) | PF(t-1) | PF(t-2) | PF(t-3) | PF(t-4) | SQ(t-1) | SQ(t-2) | SQ(t-3) | SQ(t-4) |
| CC | -0.252 | -0.415 | -0.422 | -0.344 | 0.013 | -0.267 | 0.060 | -0.247 | 0.325 | 0.278 | 0.252 | 0.224 |
| | (0.329) | (0.110) | (0.117) | (0.228) | (0.962) | (0.318) | (0.832) | (0.394) | (0.202) | (0.296) | (0.364) | (0.442) |

**Appendix Table C3** (Continued)

| | CR(t-1) | CR(t-2) | CR(t-3) | CR(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CC | -0.335 | -0.206 | -0.212 | -0.313 | -0.526 | -0.606 | -0.578 | -0.525 | -0.282 | -0.100 | -0.201 | 0.214 |
| | (0.189) | (0.445) | (0.448) | (0.276) | (0.030) | (0.013) | (0.024) | (0.054) | (0.273) | (0.713) | (0.471) | (0.462) |
| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
| CC | 0.032 | -0.031 | -0.141 | -0.198 | -0.767 | -0.568 | -0.439 | -0.446 | 0.056 | -0.086 | -0.121 | 0.038 |
| | (0.903) | (0.908) | (0.615) | (0.498) | (0.000) | (0.022) | (0.101) | (0.110) | (0.832) | (0.751) | (0.668) | (0.896) |
| | CR(t-1) | CR(t-2) | CR(t-3) | CR(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
| SQ | 0.118 | -0.056 | -0.415 | -0.667 | -0.470 | -0.570 | -0.516 | -0.690 | 0.181 | -0.193 | -0.151 | -0.292 |
| | (0.651) | (0.836) | (0.124) | (0.009) | (0.057) | (0.021) | (0.049) | (0.006) | (0.487) | (0.474) | (0.592) | (0.311) |
| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
| SQ | 0.141 | -0.291 | -0.497 | -0.340 | -0.610 | -0.651 | -0.765 | -0.847 | -0.151 | -0.072 | 0.254 | 0.336 |
| | (0.589) | (0.274) | (0.059) | (0.234) | (0.009) | (0.006) | (0.001) | (0.000) | (0.564) | (0.790) | (0.360) | (0.240) |
| | SQ(t-1) | SQ(t-2) | SQ(t-3) | SQ(t-4) | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) |
| CR | 0.339 | 0.376 | 0.490 | 0.545 | 0.319 | 0.327 | 0.180 | -0.340 | 0.130 | -0.279 | 0.090 | -0.039 |
| | (0.184) | (0.151) | (0.064) | (0.044) | (0.213) | (0.216) | (0.521) | (0.235) | (0.618) | (0.295) | (0.750) | (0.894) |
| | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
| CR | 0.403 | -0.085 | -0.026 | 0.026 | 0.188 | 0.056 | -0.226 | -0.592 | -0.135 | -0.067 | 0.209 | 0.295 |
| | (0.109) | (0.753) | (0.927) | (0.929) | (0.470) | (0.836) | (0.417) | (0.026) | (0.606) | (0.804) | (0.455) | (0.306) |
| | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) | OT(t-1) | OT(t-2) | OT(t-3) | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) |
| PP | 0.066 | 0.238 | -0.237 | -0.050 | 0.274 | 0.193 | 0.157 | -0.149 | 0.747 | 0.651 | 0.619 | 0.529 |
| | (0.800) | (0.374) | (0.395) | (0.866) | (0.288) | (0.473) | (0.577) | (0.611) | (0.001) | (0.006) | (0.014) | (0.052) |

**Appendix Table C3** (Continued)

| | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) | | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | OT(t-1) | OT(t-2) | OT(t-3) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PP | 0.204 | 0.168 | 0.150 | 0.259 | PN | -0.060 | 0.335 | 0.274 | 0.469 | -0.317 | -0.397 | 0.063 |
| | (0.432) | (0.535) | (0.593) | (0.371) | | (0.819) | (0.205) | (0.322) | (0.090) | (0.215) | (0.128) | (0.823) |

| | OT(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
|---|---|---|---|---|---|---|---|---|---|
| PN | 0.331 | 0.213 | 0.173 | 0.193 | 0.155 | -0.248 | 0.142 | 0.450 | 0.435 |
| | (0.247) | (0.411) | (0.521) | (0.491) | (0.596) | (0.337) | (0.600) | (0.093) | (0.120) |

| | PP(t-1) | PP(t-2) | PP(t-3) | PP(t-4) | PN(t-1) | PN(t-2) | PN(t-3) | PN(t-4) | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OT | 0.124 | 0.027 | -0.065 | 0.094 | 0.127 | -0.031 | -0.125 | 0.080 | 0.110 | 0.042 | 0.062 | -0.064 |
| | (0.635) | (0.920) | (0.818) | (0.748) | (0.627) | (0.910) | (0.658) | (0.787) | (0.675) | (0.8760 | (0.828) | (0.827) |

| | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) | | QW(t-1) | QW(t-2) | QW(t-3) | QW(t-4) |
|---|---|---|---|---|---|---|---|---|---|
| OT | -0.240 | -0.167 | 0.096 | 0.166 | PI | 0.025 | 0.087 | 0.078 | 0.328 |
| | (0.353) | (0.536) | (0.734) | (0.570) | | (0.923) | (0.750) | (0.781) | (0.253) |

| | PI(t-1) | PI(t-2) | PI(t-3) | PI(t-4) |
|---|---|---|---|---|
| QW | -0.007 | -0.047 | 0.146 | 0.576 |
| | (0.978) | (0.863) | (0.603) | (0.031) |

**Note:** Upper results show the correlation value while the lower values illustrated the P-value.

## Appendix D

Profiles of Participating Manufacturing Survey

**Appendix Table D1** Profiles from ten participating manufacturers

| Parameters | | Frequency | Percentage (%) |
|---|---|---|---|
| Number of Employees | | | |
| <50 | | 2 | 20.0 |
| 101-200 | | 3 | 30.0 |
| 201-500 | | 4 | 40.0 |
| >500 | | 1 | 10.0 |
| | Total | 10 | 100.0 |
| Number of Years in Business | | | |
| < 10 | | 2 | 20.0 |
| 11-15 | | 1 | 10.0 |
| 16-20 | | 1 | 10.0 |
| 21-25 | | 2 | 20.0 |
| >25 | | 4 | 40.0 |
| | Total | 10 | 100.0 |
| International Market Proportion | | | |
| <20% | | 2 | 20.0 |
| 20% -40% | | 2 | 20.0 |
| 41%-60% | | 2 | 20.0 |
| 61%-80% | | 3 | 30.0 |
| 81%-100% | | 1 | 10.0 |
| | Total | 10 | 100.0 |

## Appendix E

Illustration of the Survey

## Survey Demonstration

(Adapted from Takala, 2002)

| A | **9** | 8 | 7 | 6 | 5 | 4 | 3 | 2 | **1** | 2 | 3 | 4 | 5 | 6 | 7 | 8 | **9** | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A important | | | | | A and B equally important | | | | | | | B important | | | | | |

| **Main Priorities** | | |
|---|---|---|
| Costs | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Customer-focus |
| Costs | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Quality |
| Costs | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Delivery |
| Costs | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Flexibility |
| Costs | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Know-how |
| Customer-focus | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Quality |
| Customer-focus | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Delivery |
| Customer-focus | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Flexibility |
| Customer-focus | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Know-how |
| Quality | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Delivery |
| Quality | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Flexibility |
| Quality | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Know-how |
| Delivery | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Flexibility |
| Delivery | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Know-how |
| Flexibility | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Know-how |
| **Dimensions** | | |
| **Cost Priority** | | |
| Low Cost | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Value-added |
| Low Cost | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Quality Costs |
| Low Cost | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Activity-based Measurement |
| Low Cost | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Continuous Improvement |
| Value-added | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Quality Costs |
| Value-added | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Activity-based Measurement |
| Value-added | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Continuous Improvement |
| Quality Costs | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Activity-based Measurement |
| Quality Costs | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Continuous Improvement |
| Activity-based Measurement | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Continuous Improvement |
| | | |
| **Customer-focus Priority** | | |
| After-sales Services | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Product Customization |
| After-sales Services | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Product Support |
| After-sales Services | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Customer Information |
| After-sales Services | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Measurement of Satisfaction |
| After-sales Services | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Dependable Promises |
| Product Customization | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Product Support |
| Product Customization | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Customer Information |
| Product Customization | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Measurement of Satisfaction |
| Product Customization | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Dependable Promises |
| Product Support | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Customer Information |
| Product Support | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Measurement of Satisfaction |
| Product Support | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Dependable Promises |
| Customer Information | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Measurement of Satisfaction |
| Customer Information | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Dependable Promises |
| Measurement of Satisfaction | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Dependable Promises |

| | | |
|---|---|---|
| **Quality Priority** | | |
| Low Defect Rate | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Product Performance |
| Low Defect Rate | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Reliability |
| Low Defect Rate | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Environmental Aspects |
| Low Defect Rate | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Certification |
| Product Performance | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Reliability |
| Product Performance | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Environmental Aspects |
| Product Performance | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Certification |
| Reliability | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Environmental Aspects |
| Reliability | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Certification |
| Environmental Aspects | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Certification |
| | | |
| **Delivery Priority** | | |
| Fast Delivery | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | On Agreed Time |
| Fast Delivery | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Right Amount |
| Fast Delivery | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Right Quality |
| Fast Delivery | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Dependable Promises |
| On Agreed Time | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Right Amount |
| On Agreed Time | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Right Quality |
| On Agreed Time | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Dependable Promises |
| Right Amount | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Right Quality |
| Right Amount | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Dependable Promises |
| Right Quality | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Dependable Promises |
| | | |
| **Flexibility Priority** | | |
| Design Adjustment | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Volume Change |
| Design Adjustment | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Mix Changes |
| Design Adjustment | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Broad Product Line |
| Volume Change | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Mix Changes |
| Volume Change | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Broad Product Line |
| Mix Changes | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Broad Product Line |
| | | |
| **Know-how Priority** | | |
| Knowledge Management | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Creativity |
| Knowledge Management | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Continuous Learning |
| Knowledge Management | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Problem Solving Skills |
| Knowledge Management | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Training / Education |
| Knowledge Management | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | R & D |
| Creativity | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Continuous Learning |
| Creativity | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Problem Solving Skills |
| Creativity | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Training / Education |
| Creativity | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | R & D |
| Continuous Learning | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Problem Solving Skills |
| Continuous Learning | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Training / Education |
| Continuous Learning | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | R & D |
| Problem Solving Skills | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | Training / Education |
| Problem Solving Skills | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | R & D |
| Training / Education | 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 | R & D |

## Appendix F

Detailed Dimensions or Manufacturing Strategies

**Appendix Table F1** Detailed dimensions description

| Dimensions | Description |
|---|---|
| **Quality Criterion** | |
| Low defect rate | Tells how important is avoid the defects from manufacturing point of view |
| Product performance | The company's ability to fulfill or overfill customer's demands considering the product. |
| Reliability | More or less the dependability of the whole company and organization. |
| Environmental aspect | How important corporation values environmental things to be in their strategy |
| Certification | How important certification is for quality. |
| **Customer-focus Criterion** | |
| After-sales service | Things like maintenance, reparation, spare part and "Contact us" services |
| Product customization | Capability to produce individual entirety for customer e.g. tailor-made products |
| Product support | All the actions, which provide to customers necessary information about usage and installation of engines. |
| Customer information | Channels that company uses to inform customers about things like new products. |
| Measurement of satisfaction | Tells to the company what their customers are thinking about them which is a link between the customer satisfaction level and profits |
| Dependable promises | Importance of kept promises and trust. |
| **Delivery Criterion** | |
| Fast delivery | Simply the fastness of delivery |
| On agreed time | Basically the same as just in time |
| Right quality | Agreed product is on the agreed place in the quality that has been agreed in advance. |
| Right amount | Amount that customer has wanted and what company has promised to deliver. |
| Dependable promises | Ability to be able to keep the promises and what has been agreed. |
| **Flexibility Criterion** | |
| Design adjustments | How easily the engines are accommodated to fit with the circumstances where they are going to be used and how important it's to the corporation that the designs are flexible to meet the customers' needs. |
| Volume change | Productions ability to react to the different levels of demand. |
| Mix changes | How much corporation values the ability to change product mix rapidly |
| Broad product line | Wide product line gives competitive advantage to the corporation. |
| **Know-how Criterion** | |
| Knowledge management | Strategically important knowledge and skills to be developed and shared |
| Creativity | Capability to invent new innovation |
| Continuous learning | Organization developing operational models and shares new knowledge on all levels – individual, group, organization, and system |
| Problem solving skills | Skills and ways to solve problems in innovative way. |
| Training/education | Learning at individual level |
| R&D | Capability to search for and invent new products. |
| **Cost Criterion** | |
| Low costs | Cost of production |
| Value added costs | Costs that increase the value of product from customer's point of view. |
| Quality costs | Costs caused by avoiding poor quality like internal and external failures in order to keeping high quality of product. |
| Activity based measurement | Cost of measuring adds value |
| Continuous improvement | Cost are caused by improving production |

**Source**: Adapted from Takala *et al*. (2003)

**Appendix G**

Correlation Analysis among 31 Dimensions from Survey

**Appendix Table G1** Correlation analysis among 31 dimensions

| Correlations | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C_LC | C_VA | C_QC | C_AM | C_CI | CF_AS | CF_PC | CF_PS | CF_CI | CF_MS | CF_DP |
| | C_LC | 1.000 | 0.468 | 0.791** | 0.650* | 0.772** | 0.045 | 0.260 | 0.136 | -0.163 | 0.364 | 0.058 |
| | C_VA | 0.468 | 1.000 | 0.356 | 0.590 | 0.254 | -0.028 | 0.261 | -0.105 | 0.093 | -0.047 | 0.012 |
| | C_QC | 0.791** | 0.356 | 1.000 | 0.480 | 0.814** | 0.367 | 0.492 | 0.432 | 0.110 | 0.456 | 0.067 |
| | C_AM | 0.650* | 0.590 | 0.480 | 1.000 | 0.492 | 0.009 | 0.055 | -0.189 | -0.312 | 0.046 | -0.451 |
| | C_CI | 0.772** | 0.254 | 0.814** | 0.492 | 1.000 | 0.308 | 0.615 | 0.541 | 0.293 | 0.502 | 0.213 |
| | CF_AS | 0.045 | -0.028 | 0.369 | 0.009 | 0.308 | 1.000 | 0.654* | 0.462 | 0.604 | 0.862** | 0.085 |
| | CF_PC | 0.260 | 0.261 | 0.492 | 0.055 | 0.615 | 0.654* | 1.000 | 0.512 | 0.691* | 0.574 | 0.299 |
| | CF_PS | 0.136 | -0.105 | 0.432 | -0.189 | 0.541 | 0.462 | 0.512 | 1.000 | 0.766** | 0.543 | 0.370 |
| | CF_CI | -0.136 | 0.093 | 0.110 | -0.312 | 0.293 | 0.604 | 0.691* | 0.766** | 1.000 | 0.563 | 0.584 |
| | CF_MS | 0.364 | -0.047 | 0.456 | 0.046 | 0.502 | 0.862** | 0.574 | 0.543 | 0.563 | 1.000 | 0.280 |
| | CF_DP | 0.058 | 0.012 | 0.067 | -0.451 | 0.213 | 0.085 | 0.299 | 0.370 | 0.584 | 0.280 | 1.000 |
| | Q_LD | -0.226 | -0.401 | -0.328 | -0.701* | -0.274 | -0.529 | -0.311 | -0.067 | -0.067 | -0.335 | 0.624 |
| | Q_PP | 0.071 | -0.482 | 0.006 | -0.622 | -0.012 | 0.207 | 0.018 | 0.309 | 0.213 | 0.506 | 0.491 |
| | Q_R | 0.239 | -0.099 | 0.480 | 0.037 | 0.310 | 0.571 | 0.165 | 0.515 | 0.389 | 0.646* | 0.370 |
| | Q_EA | -0.494 | -0.075 | -0.443 | -0.411 | -0.761* | -0.162 | -0.549 | -0.128 | -0.028 | -0.245 | 0.061 |
| | Q_CT | -0.356 | -0.445 | -0.067 | -0.287 | -0.219 | 0.359 | -0.171 | 0.430 | 0.310 | 0.280 | 0.091 |
| | D_FQ | -0.187 | 0.204 | -0.140 | -0.122 | -0.234 | -0.261 | 0.232 | -0.309 | -0.170 | -0.488 | -0.309 |
| | D_OT | -0.436 | -0.062 | -0.297 | -0.469 | -0.471 | -0.107 | 0.190 | -0.207 | 0.037 | -0.344 | -0.006 |
| | D_RA | -0.579 | -0.183 | -0.578 | -0.460 | -0.685* | 0.306 | 0.043 | -0.299 | 0.125 | 0.110 | -0.122 |
| | D_RQ | -0.524 | -0.105 | -0.711* | -0.384 | -0.632* | 0.097 | 0.024 | -0.455 | 0.061 | -0.018 | -0.042 |
| | D_DP | -0.524 | -0.358 | -0.784** | -0.610 | -0.681* | -0.377 | -0.402 | -0.527 | -0.249 | -0.335 | 0.103 |
| | F_DA | -0.720* | -0.015 | -0.463 | -0.352 | -0.555 | 0.229 | 0.217 | -0.274 | 0.165 | -0.211 | -0.213 |
| | F_VC | -0.467 | -0.347 | -0.290 | -0.064 | -0.384 | 0.098 | -0.453 | -0.213 | -0.293 | -0.122 | -0.438 |
| | F_MC | -0.046 | 0.588 | 0.031 | 0.469 | -0.025 | -0.326 | -0.068 | -0.399 | -0.252 | -0.599 | -0.264 |
| | F_BP | -0.562 | -0.253 | -0.626 | -0.299 | -0.693* | -0.024 | -0.421 | -0.552 | -0.328 | -0.189 | -0.370 |

**Appendix Table G1** (Continued)

| Correlations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | C_LC | C_VA | C_QC | C_AM | C_CI | CF_AS | CF_PC | CF_PS | CF_CI | CF_MS | CF_DP |
| K_KM | 0.098 | 0.354 | 0.105 | 0.464 | 0.469 | 0.145 | 0.279 | 0.388 | 0.444 | 0.118 | 0.037 |
| K_CT | 0.033 | 0.469 | 0.052 | 0.503 | 0.281 | -0.067 | 0.267 | -0.043 | 0.199 | -0.227 | 0.079 |
| K_CL | 0.201 | 0.644* | 0.430 | 0.248 | 0.341 | -0.052 | 0.419 | 0.067 | 0.128 | -0.245 | 0.043 |
| K_PS | -0.162 | 0.062 | -0.323 | -0.058 | 0.067 | -0.186 | 0.367 | 0.043 | 0.329 | -0.193 | 0.237 |
| K_TE | -0.137 | 0.088 | -0.222 | 0.025 | 0.135 | -0.006 | 0.216 | 0.522 | 0.554 | 0.043 | 0.067 |
| K_RD | 0.104 | 0.669* | -0.134 | 0.511 | -0.091 | -0.235 | -0.055 | -0.462 | -0.082 | -0.294 | 0.055 |

| | Q_LD | Q_PP | Q_R | Q_EA | Q_CT | D_FD | D_OT | D_RQ | D_DP | D_RA |
|---|---|---|---|---|---|---|---|---|---|---|
| C_LC | -0.226 | 0.071 | 0.239 | -0.494 | -0.356 | -0.187 | -0.436 | -0.524 | -0.524 | -0.579 |
| C_VA | -0.401 | -0.482 | -0.099 | -0.075 | -0.445 | 0.204 | -0.062 | -0.105 | -0.358 | -0.183 |
| C_QC | -0.328 | 0.006 | 0.480 | -0.443 | -0.067 | -0.140 | -0.297 | -0.711* | -0.784** | -0.578 |
| C_AM | -0.701* | -0.622 | 0.037 | -0.411 | -0.287 | -0.122 | -0.469 | -0.384 | -0.610 | -0.460 |
| C_CI | -0.274 | -0.012 | 0.310 | -0.761* | -0.219 | -0.234 | -0.471 | -0.632* | -0.681* | -0.685* |
| CF_AS | -0.529 | 0.207 | 0.571 | -0.162 | 0.359 | -0.261 | -0.107 | 0.097 | -0.377 | 0.306 |
| CF_PC | -0.311 | 0.018 | 0.165 | -0.549 | -0.171 | 0.232 | 0.190 | 0.024 | -0.402 | 0.043 |
| CF_PS | -0.067 | 0.309 | 0.515 | -0.128 | 0.430 | -0.309 | -0.207 | -0.455 | -0.527 | -0.299 |
| CF_CI | -0.067 | 0.213 | 0.389 | -0.028 | 0.310 | -0.170 | 0.037 | 0.061 | -0.249 | 0.125 |
| CF_MS | -0.335 | 0.506 | 0.646* | -0.245 | 0.280 | -0.488 | -0.344 | -0.018 | -0.335 | 0.110 |
| CF_DP | 0.624 | 0.491 | 0.370 | 0.061 | 0.091 | -0.309 | -0.006 | -0.042 | 0.103 | -0.122 |
| Q_LD | 1.000 | 0.527 | -0.103 | 0.262 | -0.018 | 0.006 | 0.250 | 0.055 | 0.576 | -0.049 |
| Q_PP | 0.527 | 1.000 | 0.321 | 0.152 | 0.224 | -0.297 | -0.018 | 0.139 | 0.358 | 0.220 |
| Q_R | -0.103 | 0.321 | 1.000 | 0.244 | 0.745* | -0.697* | -0.311 | -0.406 | -0.576 | -0.159 |
| Q_EA | 0.262 | 0.152 | 0.244 | 1.000 | 0.604 | -0.098 | -0.301 | 0.238 | 0.232 | 0.429 |
| Q_CT | -0.018 | 0.224 | 0.745* | 0.604 | 1.000 | -0.515 | -0.037 | -0.139 | -0.285 | 0.152 |

**Appendix Table G1** (Continued)

| Correlations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Q_LD | Q_PP | Q_R | Q_EA | Q_CT | D_FD | D_OT | D_RA | D_RQ | D_DP |
| | D_FQ | 0.006 | -0.297 | -0.697* | -0.098 | -0.515 | 1.000 | 0.805** | 0.341 | 0.382 | 0.236 |
| | D_OT | 0.250 | -0.018 | -0.311 | -0.301 | -0.037 | 0.805** | 1.000 | 0.598 | 0.530 | 0.299 |
| | D_RA | -0.049 | 0.220 | -0.159 | 0.429 | 0.152 | 0.341 | 0.598 | 1.000 | 0.915** | 0.534 |
| | D_RQ | 0.055 | 0.139 | -0.406 | 0.238 | -0.139 | 0.382 | 0.530 | 0.915** | 1.000 | 0.709* |
| | D_DP | 0.576 | 0.358 | -0.576 | 0.232 | -0.285 | 0.236 | 0.299 | 0.534 | 0.709* | 1.000 |
| | F_DA | -0.158 | -0.286 | -0.395 | 0.174 | -0.061 | 0.608 | 0.661* | 0.728* | 0.675* | 0.359 |
| | F_VC | -0.231 | -0.140 | -0.134 | 0.110 | 0.158 | -0.219 | -0.339 | 0.116 | 0.024 | 0.231 |
| | F_MC | -0.264 | -0.877** | -0.411 | -0.136 | -0.436 | 0.325 | 0.122 | -0.296 | -0.178 | -0.166 |
| | F_BP | -0.006 | 0.067 | -0.467 | 0.220 | -0.152 | 0.127 | 0.055 | 0.591 | 0.612 | 0.733* |
| | K_KM | -0.455 | -0.523 | 0.037 | -0.378 | -0.037 | -0.314 | -0.533 | -0.443 | -0.308 | -0.462 |
| | K_CT | -0.293 | -0.787** | -0.043 | -0.264 | -0.140 | 0.030 | -0.064 | -0.325 | -0.159 | -0.415 |
| | K_CL | -0.164 | -0.498 | -0.298 | -0.364 | -0.547 | 0.450 | 0.092 | -0.367 | -0.316 | -0.292 |
| | K_PS | 0.128 | -0.249 | -0.310 | -0.205 | -0.182 | 0.377 | 0.437 | 0.122 | 0.340 | 0.073 |
| | K_TE | -0.178 | -0.178 | -0.031 | 0.012 | 0.215 | -0.031 | -0.012 | -0.037 | 0.031 | -0.227 |
| | K_RD | -0.195 | -0.620 | -0.079 | 0.138 | -0.201 | 0.061 | 0.055 | -0.006 | 0.164 | -0.122 |

| | | F_DA | F_VC | F_MC | F_BP | K_KM | K_CT | K_CL | K_PS | K_TE | K_RD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | C_LC | -0.720* | -0.467 | -0.046 | -0.562 | 0.098 | 0.033 | 0.201 | -0.162 | -0.137 | 0.104 |
| | C_VA | -0.015 | -0.347 | 0.588 | -0.253 | 0.354 | 0.469 | 0.644* | 0.062 | 0.088 | 0.669* |
| | C_QC | -0.463 | -0.290 | 0.031 | -0.626 | 0.105 | 0.052 | 0.430 | -0.323 | -0.222 | -0.134 |
| | C_AM | -0.352 | -0.064 | 0.469 | -0.299 | 0.464 | 0.503 | 0.248 | -0.058 | 0.025 | 0.511 |
| | C_CI | -0.555 | -0.384 | -0.025 | -0.693* | 0.469 | 0.281 | 0.341 | 0.067 | 0.135 | -0.091 |
| | CF_AS | 0.229 | 0.098 | -0.326 | -0.024 | 0.145 | -0.067 | -0.052 | -0.186 | -0.006 | -0.235 |
| | CF_PC | 0.217 | -0.453 | -0.068 | -0.421 | 0.279 | 0.267 | 0.419 | 0.367 | 0.216 | -0.055 |
| | CF_PS | -0.274 | -0.213 | -0.399 | -0.552 | 0.388 | -0.043 | 0.067 | 0.043 | 0.522 | -0.462 |
| | CF_CI | 0.165 | -0.293 | -0.252 | -0.328 | 0.444 | 0.199 | 0.128 | 0.329 | 0.554 | -0.082 |

**Appendix Table G1** (Continued)

| Correlations | | F_DA | F_VC | F_MC | F_BP | K_KM | K_CT | K_CL | K_PS | K_TE | K_RD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CF_MS | -0.211 | -0.122 | -0.599 | -0.189 | 0.118 | -0.227 | -0.245 | -0.193 | 0.043 | -0.294 |
| | CF_DP | -0.213 | -0.438 | -0.264 | -0.370 | 0.037 | 0.079 | 0.043 | 0.237 | 0.067 | 0.055 |
| | Q_LD | -0.158 | -0.231 | -0.264 | -0.006 | -0.455 | -0.293 | -0.164 | 0.128 | -0.178 | -0.195 |
| | Q_PP | -0.286 | -0.140 | -0.877** | 0.067 | -0.523 | -0.787** | -0.498 | -0.249 | -0.178 | -0.620 |
| | Q_R | -0.395 | -0.134 | -0.411 | -0.467 | 0.037 | -0.043 | -0.298 | -0.310 | -0.031 | -0.079 |
| | Q_EA | 0.174 | 0.110 | -0.136 | 0.220 | -0.378 | -0.264 | -0.364 | -0.205 | 0.012 | 0.138 |
| | Q_CT | -0.061 | 0.158 | -0.436 | -0.152 | -0.037 | -0.140 | -0.547 | -0.182 | 0.215 | -0.201 |
| | D_FQ | 0.608 | -0.219 | 0.325 | 0.127 | -0.314 | 0.030 | 0.450 | 0.377 | -0.031 | 0.061 |
| | D_OT | 0.661* | -0.339 | 0.122 | 0.055 | -0.533 | -0.064 | 0.092 | 0.437 | -0.012 | 0.055 |
| | D_RA | 0.728* | 0.116 | -0.296 | 0.591 | -0.443 | -0.325 | -0.367 | 0.122 | -0.037 | -0.006 |
| | D_RQ | 0.675* | 0.024 | -0.178 | 0.612 | -0.308 | -0.159 | -0.316 | 0.340 | 0.031 | 0.164 |
| | D_DP | 0.359 | 0.231 | -0.166 | 0.733* | -0.462 | -0.415 | -0.292 | 0.073 | -0.227 | -0.122 |
| | F_DA | 1.000 | 0.280 | 0.289 | 0.541 | -0.133 | 0.098 | 0.226 | 0.210 | -0.049 | 0.076 |
| | F_VC | 0.280 | 1.000 | 0.185 | 0.748* | 0.037 | -0.242 | -0.085 | -0.610 | -0.314 | -0.335 |
| | F_MC | 0.289 | 0.185 | 1.000 | 0.055 | 0.393 | 0.679* | 0.738* | 0.062 | -0.106 | 0.585 |
| | F_BP | 0.541 | 0.748* | 0.055 | 1.000 | -0.295 | -0.409 | -0.182 | -0.359 | -0.374 | -0.176 |
| | K_KM | -0.133 | 0.037 | 0.393 | -0.295 | 1.000 | 0.715* | 0.302 | 0.306 | 0.636* | 0.324 |
| | K_CT | 0.098 | -0.242 | 0.679* | -0.409 | 0.715* | 1.000 | 0.422 | 0.566 | 0.377 | 0.743* |
| | K_CL | 0.226 | -0.085 | 0.738* | -0.182 | 0.302 | 0.422 | 1.000 | 0.012 | -0.111 | 0.195 |
| | K_PS | 0.210 | -0.610 | 0.062 | -0.359 | 0.306 | 0.566 | 0.012 | 1.000 | 0.640* | 0.405 |
| | K_TE | -0.049 | -0.314 | -0.106 | -0.374 | 0.636* | 0.377 | -0.111 | 0.640* | 1.000 | 0.148 |
| | K_RD | 0.076 | -0.335 | 0.585 | -0.176 | 0.324 | 0.743* | 0.195 | 0.405 | 0.148 | 1.000 |

**Note:** ** Correlations significant at 0.01 level, * Correlations significant at 0.05 level

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