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Review

Integrating performance indicator analysis and comparisons in NPD process re-engineering

Chee-Cheng Chen

Department of Business Administration, National Pingtung University of Science and Technology, Taiwan. Department of Management Science and Engineering, School of Management, Shanghai University, China. E-mail: carl2004@mail.npust.edu.tw

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The purpose of the present study is to develop a strategy that integrates all output and feedback from customers (internal and external) with a view to enhancing the new product development (NPD) performance of a manufacturing company. This study combines theory and practice to develop a framework using three analytical dimensions that can be used to identify and solve the problems that arise in NPD strategy implementation. The applicability of the model is demonstrated in a case study. This model can be utilized to investigate the effectiveness of the work procedures, focus on routine jobs, value creation, and self-drive of NPD department members. The proposed analysis of process re-engineering strategy is potentially of benefit for quality improvements and NPD performance in manufacturing firms.

Key words: Process re-engineering, new product development, six sigma, customer orientation, value chain.

INTRODUCTION

A new product development (NPD) strategy is an important activity that helps enterprises to survive and make continuous improvements (Liu et al., 2005). If managers are to increase the success rate of their efforts to introduce new products, they need to master the techniques required in the planning, development, deployment, evaluation, and control of the entire 'NPD' process. This involves the acquisition of competencies from the generation of the new idea to the launch of the product in the marketplace. It also involves an alignment of their new product strategy with their overall corporate strategy if the focus of NPD processes is to be in accordance with the strategic imperatives of the firm (Tzokas et al., 2004).

The concept of 'functional integration' is a critical aspect of success in contemporary NPD activities. In a Traditional function-based organization, various operational duties are the province of particular departments at each stage, and every department tends to treat its particular task from a narrow departmental perspective. This lack of functional integration can have an adverse effect on the overall NPD process. In some cases, a company can even find itself having to spend extra money to modify new products that provide little or no benefits to customers. Since a successful new product must satisfy diverse market as well as technological requirements, the NPD process in general involves various functions in the organization. As a result, coordination between those functions is considered as essential to ensuring successful new product innovation. In particular, an NPD team must be able to integrate diverse expertise from people with varied functional backgrounds as well as experiences: proposed two conditions for effective NPD, (i) the requisite diversity of viewpoints, disciplines, and functional specialties is represented in a team, and (ii) the team's ability to span organizational boundaries and integrate the functional expertise represented by team members (Kim and Kim, 2009). Successful integration depends upon effective communication and cooperation among NPD project

Abbreviations: NPD, New product development; **BPR,** business process reengineering; **DMAIC,** 'define', 'measure', 'analyze', 'improve, and 'control'; **ROI,** return on investment; **IPI,** integrated performance index; **VCA,** value chain analysis; **CVCI,** customer value-chain involvement.

participants, and these aspects may be enhanced by organization structural adaptations, problem solving routines, and information technologies (Swink and Song, 2007).

Given this background, it is clear that it is in the interests of companies to make accurate new product evaluations at the earliest stage. The present study addresses two propositions: That if a greater proportion of a company's total value chain is encompassed by the NPD process; more value will be created by the NPD department.

That if more requirements of customers (both internal and external) are encompassed by the NPD process, the degree of customer orientation and cost-effectiveness of the NPD process will be enhanced.

In addressing these propositions, the study establishes three analytical dimensions: (i) performance indicators (which are used as a fundamental basis for analysis and comparison); (ii) the proportion of the total value chain encompassed by the NPD process; and (iii) the degree of customer-orientation. The study applies these three dimensions to propose a strategy for integrating all output and feedback from customers (internal and external) with a view to promoting the performance of a company's NPD department. The applicability of the proposed framework is demonstrated in a case study.

LITERATURE REVIEW AND RESEARCH OBJECTIVE

Process management and re-engineering

The central theme of operations management is process management (Parast, 2011). A 'business process' can be understood as an organized group of related activities that work together to create value for customers. To achieve these aims of working together, all activities in a business process must be organized and guided by a design that specifies which activities are to be done, when, and by whom. In this regard, an appropriate process design ensures repeatability and consistency (Hammer, 2002).

Process management has strategic and operational implication which interacts with all levels within the organization. At the strategic level, research shows that process management programs positively impact business result and enhance profitability. At the operational level, the transformation of input (for example, raw material, labour) to the output (for example, products and/or services) has been the primary focus of operations management, where it is responsible for evaluation, integration and coordination of activities that transform inputs to outputs (Silver, 2004). An important issue in process management is the alignment between the firm's operation strategy and its process management trade-off (that is, cost vs. quality). It has been argued that the ability of the firm to respond to changes in a highly dynamic and evolving market will be at risk if process management maintains a narrow and tight scope on operations. For example, if a firm focuses entirely on inventory in material handling systems while facing a highly evolving market, its ability to respond to customer demands and market changes will be threatened. In fact, strategic alignment between market and process management is the key in process management decisions (Klassen and Menor, 2007). Effective process management in markets where customer preferences are changing rapidly and the rate or product/service innovation is high cannot be sustained with emphasis on efficiency and variance reduction. Rather, it requires flexibility and adaptability (Parast, 2011). Although Business process reengineering (BPR) has received sharp criticism from some quarters over the past 15 years, it remains on the agenda of many organizations because it continues to represent one of the most effective means of boosting business performance and enhancing customer satisfaction (Mansar and Reijers, 2005). The degree of performance excellence that an enterprise can achieve greatly depends on the business flow that the enterprise adopts, where the more efficient and effective the business process flow, the greater the degree of performance excellence the enterprise can achieve (Lam et al., 2009).

Six Sigma and customer orientation

Six Sigma has attracted academic research in recent years. It has been identified as a process improvement approach that dramatically improves performance, enhances process capability, and produces bottom line results for organizations (Parast, 2011). The Six Sigma program provides guidance for continuous process improvement by developing projects from concept to completion through five project-management steps: 'define', 'measure', 'analyze', 'improve, and 'control' (DMAIC). A successful Six Sigma infrastructure requires an ongoing process to infuse an awareness of quality into the way that all employees approach they everyday work. The basic philosophy of Six Sigma is that: "if you can measure it, you can improve it". This approach entails creation of quantitative metrics for processes, which itself can lead to ambiguities in the computation of quality metrics (Goel and Chen, 2008). A key step in any Six Sigma improvement effort is determining exactly what the customer requires and then defining defects in terms of their "critical to quality" parameters (Linderman et al., 2003). According to Hammer (2002) Six Sigma employs a project-based methodology to solve a specific performance problem recognized by an organization. The focus of Six Sigma is on the customer rather than the product (Parast, 2011). Customer orientation is based on customer-driven value creation (Singh and Koshy, 2011). Effective customer orientation is a closed loop, which begins with customer requirements and ends with

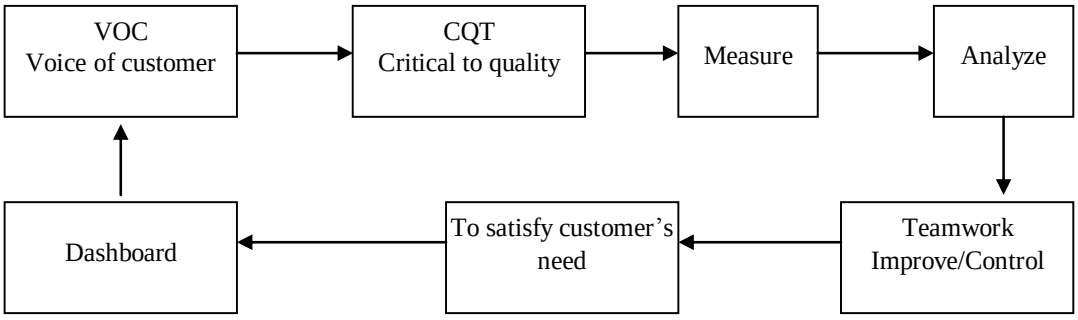

Figure 1. Customer orientation closed loop.

customer satisfaction (Figure 1). Due to fierce competition in the marketplace, globalization and an explosion of technology in recent years, innovation and differentiation are considered as a necessity for every company. At the same time, to achieve market success and sustain a competitive advantage, businesses need to exploit new opportunities, develop new products and /or services and markets as well as place customer orientation at the heart of the firm's competitiveness. An enhanced sense of customer-orientation within the firm is a key element leading to successful external marketing, enhanced customer satisfaction, and increased overall performance of the firm and the organization (Tajeddini, 2010). Chakravorty and Hales (2004) found that the first step in implementing an improvement plan was to perform a customer and market driven strategic analysis. The purpose of this analysis was to direct the operational improvement effort to gain a competitive position in the market. Schonberger (2008) points out that the objective of Six Sigma programs is to create a higher perceived value of the company's products and services in the eyes of the customer (Chakravorty, 2009).

New product development performance

Various evaluation criteria have been suggested for assessing the performance of NPD. Product competitive advantage is an appropriate facet of NPD performance on which to focus because it captures both a product's desirability to customers (a marketing concern) and its quality, in terms of performance, conformance, and reliability (a manufacturing concern). Many researchers have studied potential drivers of new product time-to-market, as it is considered to be an important determinant of a product's success in the marketplace. The return on investment (ROI) has been investigated as the effects of product competitive advantage (Langerak and Hultink, 2005; Swink and Song, 2007). Manufacturability is a quality of new product development that ensures the product can be produced efficiently and reliably in the manufacturing process. It is measured by the time required to ramp-up production to desired volume levels, by production yields, or by product cost and quality levels (Kim and Kim, 2009).

Pillai et al. (2002) proposed a model that indicated the overall performance through an integrated performance index (IPI). The IPI can be applied in all phases of the project lifecycle: (i) project selection (3 key factors); (ii) project execution (2 key factors); and (iii) implementation (3 key factors). In this model, the major measures of success in the overall project lifecycle were defined by: (i) the customers' delight and goodwill; (ii) return on investment; and (iii) maximization of profit and other intangible benefits from the project.

Tzokas et al. (2004) adopted 20 evaluative criteria for NPD. They included 15 core project-level criteria as used by previous researchers of NPD (Balachandra, 1984; Griffin and Page, 1993, 1996). Because their study was focused on the evaluation of performance throughout the NPD process, Tzokas et al. (2004) included an additional set of five criteria that had been used by researchers in earlier stages of the NPD process (Craig and Hart, 1992; Hart, 1993; Ronkainen, 1985). Overall, these 20 evaluative criteria were grouped under five dimensions: (i) market; (ii) financial; (iii) product; (iv) process; and (v) intuition (Table 1).

Value chain

According to Porter (1985), all value chains have certain "primary activity" components that occur in any business setting: (i) inbound logistics; (ii) operations; (iii) outbound logistics; (iv) marketing and sales, and (v) after-sales service. Porter (1985) also suggested that such a generic chain consists of four "support activities" that overlay the primary links: (i) Procurement process; (ii) Technology development; (iii) Human resources management, and (iv) Infrastructure. Value chain analysis (VCA) describes activities that are required to bring a product or service from conception or design, through different phases of production, to delivery to final consumers and disposal after use. The competitiveness of an individual firm depends upon the competitiveness of its value chain

Table 1. Dimensions and evaluation criteria of NPD.

Dimensions	Evaluation criteria
Market-based	*Customer acceptance* *Customer satisfaction* Sale objective Sale growth *Market share* Sale in units *Market potential*
Financial-based	Break-even time Profit objective IRR/ROI Margin
Product-based	Product performance *Quality* Product uniqueness *Technical feasibility*
Process-based	*Stay within budget* *Introduced in time* Time-to-market
Intuition-based	Marketing chance Intuition

Source: Tzokas et al. (2004).

(Schmitz, 2005; Purnomo et al., 2009). The value chain approach not only involves the process-interlinked material and information flows as well as their spatial distribution, but also relationships between actors related to control and power. Those essentially influence the decision-making process (Altenburg, 2007; Geibler et al., 2010).

Michel et al. (2008) argue that shifting the focus of the offering from an output to a process of value creation makes the customer perceive the supplier as an organizer of this process, in which the customer is a co-producer, rather than a receiver of value (Singh and Koshy, 2011). In terms of NPD, a new product has value if it serves customers' needs, wants, and desires, that is, if it provides benefits to the customer for the price charged. Through customer value-chain involvement (CVCI), customers can be closely involved in the choice of form, technology, and benefits. Examples of such CVCI include (Mascarenhas et al., 2004):

Whirpools' customers being closely involved with its employees and with its new design development;Dell's customers being actively involved in designing personalized computer configurations; Microsoft's regular testing of its software with its target customers and its incorporation of their suggestions into its final versions; and Harley-Davidson's annual customer rally at which top executives discuss new designs with current and potential customers before including the new designs among the following year's models.

CONCEPTUAL FRAMEWORK

The research methodology of the present study utilizes theoretical analysis and a case study to address the two research propositions noted previously:

1. That if a greater proportion of a company's total value chain is encompassed by the NPD process, more value will be created by the NPD department; and
2. That if more requirements of customers (both internal and external) are encompassed by the NPD process, the degree of customer orientation and cost-effectiveness of the NPD process will be enhanced.

The generic value chain to be examined in addressing these questions is illustrated in Figure 2.

The analysis used in addressing these questions can be utilized to investigate the effectiveness of work procedures in the NPD department, the focus on routine jobs, the capability for value creation, and the self-drive of members of the NPD department. The main purpose is to develop a strategy that integrates all output and feedback from customers (internal and external) to promote better NPD department performance.

Performance indicators

The inputs and outputs for the performance indicators can be treated as the starting point (S) and the end point (E) in the routine handling of the NPD process in the company's value-chain activities. In some cases, these starting-points and end-points will be located in one department; in other cases they will be located in different departments. For example, taking 'controlling expenses within budget' as an example, the input could be 'expected (limited) expense' whereas the output would be 'actual expense'. The starting-point' and 'end-point in this case are both within the NPD department. To take 'technical feasibility' as another example, the input could be 'expected yield' and the output would be 'actual yield'. The starting-point' for this performance indicator would be in the NPD department whereas the end-point would be in the production department (Figure 2).

Proportion of total value chain

The distance between a starting-point and an end-point (described above) can be understood as a certain proportion of the total 'length' of the company's value chain. This value chain contains eight departments (Figure 2).

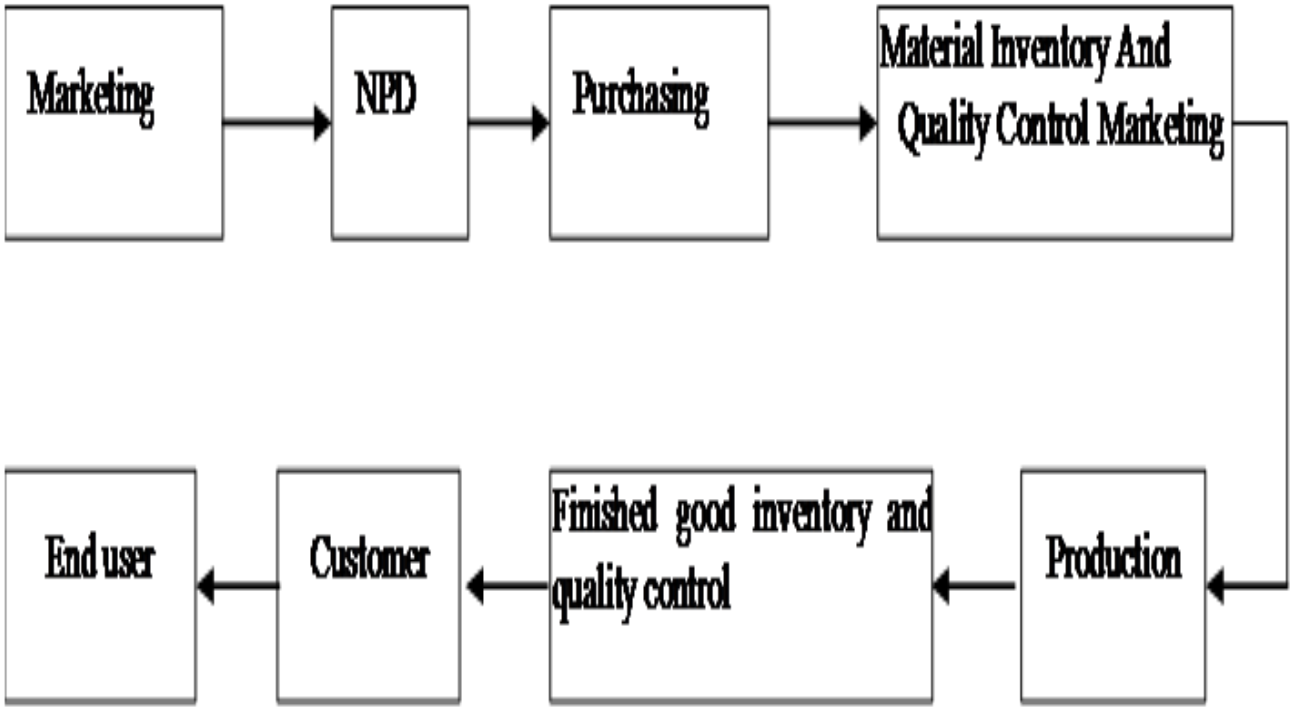

Figure 2. Generic value chain.

Table 2 shows the eight departments in the company's value chain in the first column. Alongside this, certain performance indicators are illustrated as a proportion of the total value chain. For example, the performance indicator 'controlling expenses within budget' has a starting-point and an end-point both within the NPD department. This represents one-eighth of the total length of the value chain (which equals a proportion of 12.5%). Another performance indicator, 'technical feasibility', has a 'starting-point' in the NPD department and an end-point in the production department. This represents four-eighths of the total length of the value chain (which equals a proportion of 50%).

If the proportion of the total value chain is small, the contribution value of the NPD department is relatively less. Conversely, if the proportion of the total value chain is greater, the contribution value of the NPD department is larger.

Degree of customer orientation

As shown in Table 2, if the proportion of the total value chain is large, the degree of customer-orientation will be relatively high.

Another measure of customer orientation is proximity to the end user. If the end-point is closer to the end user, the degree of customer-orientation is higher.

Classification categories

All performance indicators can be divided into three levels:

Level I refer to the starting-point and the end-point both being within the NPD department.
Level II refers to the starting-point being in the NPD department and the end-point being in one of the internal customer departments.
Level III refers to the starting-point being in the NPD department and the end-point reaching an external customer (end user).

As can be seen in Table 2, certain performance indicators have been chosen from Table 1 for illustration in the proposed framework. For each of these indicators, the starting-point (S) and the end-point (E) are indicated, as are the 'proportion of total value chain' and the 'degree of customer-orientation'.

Case study

The NPD performance of a power-supply manufacturing company ('D company') was assessed as an example of the application of the conceptual framework described above. 'D company', a listed company, had received certification under ISO 9001 and ISO 14001.
At the time of the case study, the prevailing NPD process at 'D company' was organized as shown in

Table 2. Performance indicator, proportion of total value chain and degree of customer-orientation.

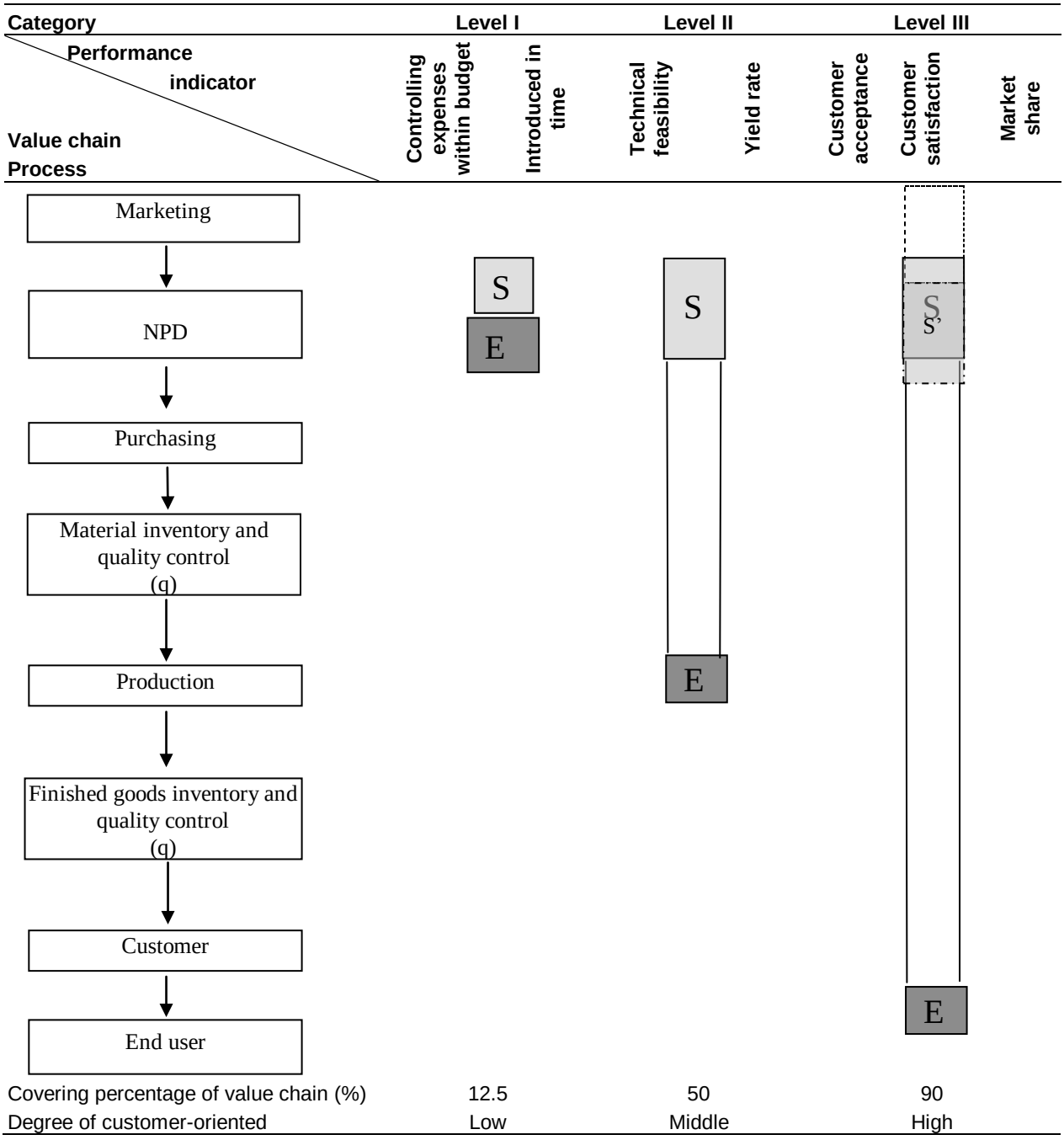

Figure 3 (solid arrows). As can be seen in the portion of the flow chart from 'project evaluation' to 'mass production', the solid arrows formed an open loop.

The performance indicators for the NPD team were defined in this case study as 'completed project numbers', 'budget control', and 'percentage reduction in cost of new product' for NPD team.

Analysis of the prevailing NPD process indicated that the process was not sufficiently customer-oriented. Each department was concerned with its own goals without consideration for the needs of internal and external customers. Moreover, the process was incapable of identifying (and solving) product defects or customer dissatisfaction in a timely and effective manner. More specifically, the following concerns were noted.

The prevailing NPD procedure did not reflect extra costs (reworking of defective products and/or scrapping of unusable products) incurred by internal customers as a

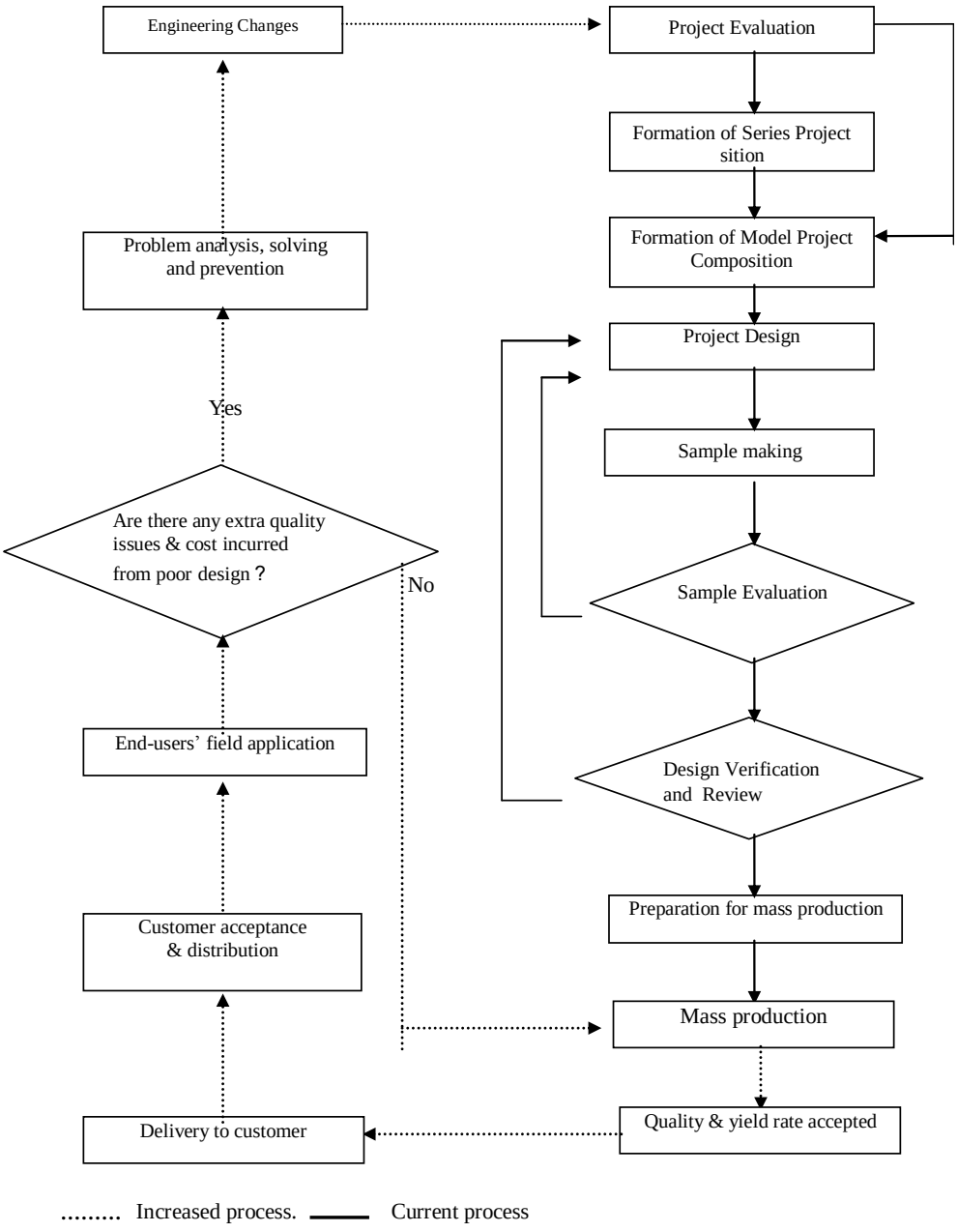

Figure 3. NPD process in D company. ……Increased process; _____current process

result of poor design in the NPD department.

The prevailing process was incapable of providing an effective solution to quality issues caused by poor NPD performance just-in-time or at earlier stage, with consequent loss of an opportunity to implement preventive activities.

The three NPD performance indicators were all at levels I or II (Table 2). The NPD process flow chart did not reach level III because the end-point of the prevailing NPD process was an internal customer, not an external customer.

The external customer's satisfaction was not included in the prevailing NPD process.

It was thus not difficult to find shortcomings in the prevailing NPD process in 'D company'. To modify the process, suggestions were made as shown in the dotted arrows in Figure 3. The starting-point was changed from S to S' (as shown in Table 2), with the end-point (E) now located at the end-user. Team operating and consideration will be enhanced to full range of desired value cycling in the entire process from S' to E. The proportion of the total value chain encompassed by the improve significantly. It was felt that the improvements were likely to induce members of the NPD department to

Table 3. Loss amount caused by poor design in D company.

Quarter	Q4, ’08	Q1, ’09	Q2, ’09	Q3, ’09	Q4, ’09	Q1, ’10	Q2, ’10
Loss amount K US$	215.7	219.5	220.8	203.1	164.2	142.3	115.4

become more customer-oriented in making decisions and taking actions. They were also less likely to focus only on a single department’s tasks and more likely to give proper consideration to the needs of customers (both internal and external). It was expected that the extra costs associated with quality defects in products would decrease significantly in the short term.

The new NPD process was fully implemented in ‘D company’ in the fourth quarter of 2009. Table 3 shows the loss amount (in thousands of US dollars) caused by poor design in the period from the fourth quarter of 2008 until the second quarter of 2010. It is apparent that the overall NPD performance of ‘D company’ improved dramatically.

Conclusion

The main purpose of the present study was to propose a strategy for integrating all output and feedback from customers (internal and external) with a view to enhancing the performance of a company’s NPD department. The study has established three dimensions for the analysis of NPD processes: (i) ‘performance indicators’; (ii) ‘proportion of total value chain’; and (iii) ‘degree of customer-orientation’. The analysis and dimensions proposed here for a process re-engineering strategy can be utilized to enhance quality and NPD performance. The case study of ‘D company’ indicates that performance-indicator analysis is helpful in implementing internal quality improvement and enhancing competitive strength. An effective customer orientation is the most important factor in such an exercise in business re-engineering.

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