Variation Reduction in Product Quality and Organisational Performance: A System Dynamics Approach

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Abstract

The paper provides a modelling framework to understand and reduce variation in product quality through the use of system thinking and statistical methods. It brings together a number of techniques and methods to address total value delivery system of customer needs identification, product design and production process control, distribution and services. The model looks at the causal relationships among the methods and their impact on organisational performance. Performance is measured in terms of time to market, number of design changes, product quality as reject rates/ first-pass yield, throughput time and inventory turnover. Currently the model is being validated using data from the Australian manufacturing companies.

Introduction

The development process of a product follows the sequence of idea generation and design formulation (product and process), product production and after-production packaging, storing and distribution and service. All these functions can be represented using a value delivery system

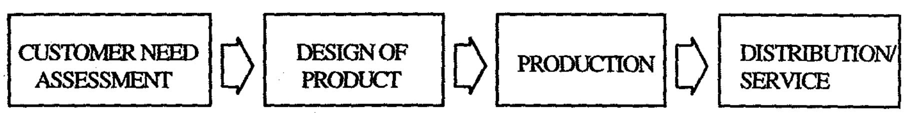

Figure 1: Production development value chain

(Figure 1). These functions are the building blocks by which an organisation creates products valuable to its customers and enhances its competitive advantage (Porter, 1985). Since the process of transformation from one building block to another add value to products and therefore to the potential customers, any variation around products' target specifications incurs loss to the customers, the farther from target, the greater the loss (Taguchi and Clausing, 1990). An emphasis on gradually minimising errors from the target makes the value delivery system in line with the principle of continuous improvement. The variations between required quality and actual quality at every stage of the value chain are referred here as 'quality variation' (QV) (Figure 2). The QVs can be expresses as following:

◊ Quality Variation 1 (*QV 1*) = The gap between customer needs and management understanding of these needs.

◊ Quality Variation 2 ($QV\,2$) = The gap between management perceptions of customer needs and design specifications.

◊ Quality Variation 3 ($QV\,3$) = The gap between design specifications and actual products.

◊ Quality Variation 4 ($QV\,4$) = The gap between actual products and customer perception about products.

◊ Total Variation in Quality = $f(QV1, QV2, QV3, QV4)$.

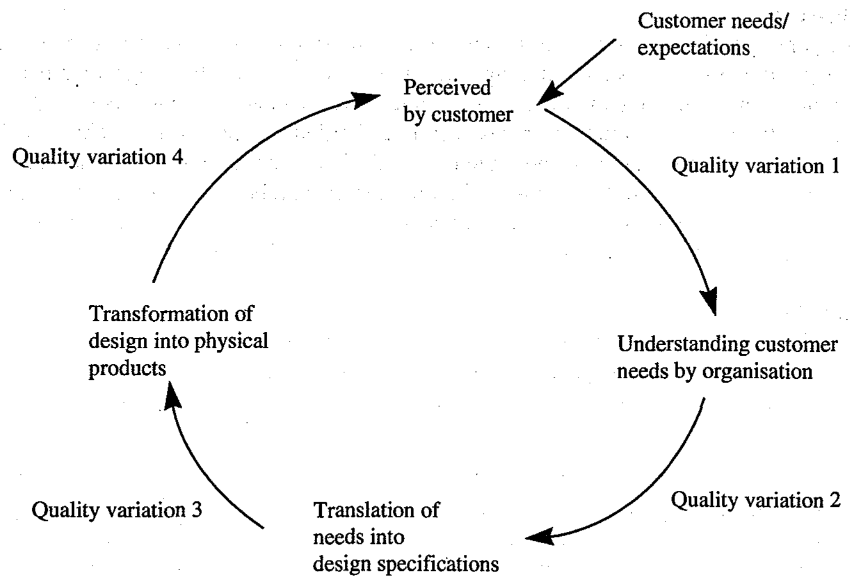

Figure 2: Another quality circle

Every function in a value delivery system is supported by two broad categories of support systems: human resources system and technical system (Porter, 1985). Human resources system consists of activities involved in creating vision, empowering and motivating human resources. Technical system provides technical support in terms of know-how, procedures and methods. In this paper an attempt has been made to identify the causal relationships among various methods of the technical system. These relationships can be exploited to reduce variations and improve organisational performance in each stage of the value delivery system

Performance Measures

The *APICS Dictionary* (1992) defines nine performance measures on which world-class organisations can compete. In this study we considered some of these indicators to measure organisational performance which include time to market, number of design changes, product quality as rejection rates/first-pass yield, throughput time and inventory turnover.

The Model

The concept of quality variations developed in Figure 2 has been expanded in Figure 3. Figure 3 narrates the activities carried out in an entire value delivery system and provides an overview of their interactions.

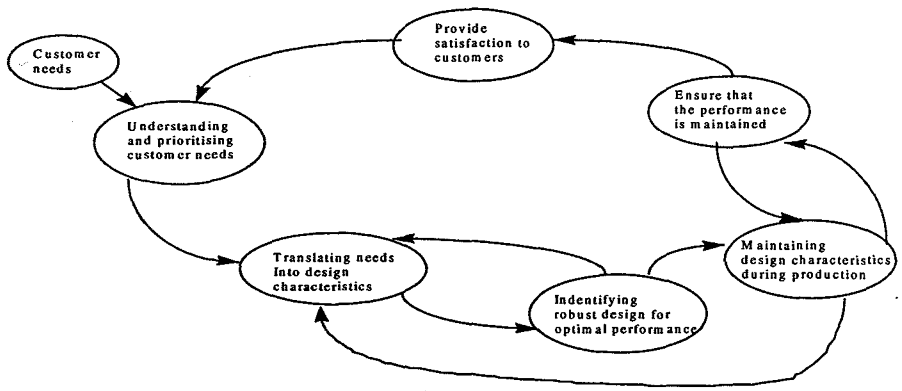

Figure 3: An overview of variation reduction process

Integrating the methods and tools appropriate in each stage of the value system a conceptual model has been developed (Figure 4). This model can be used to understand and reduce variation

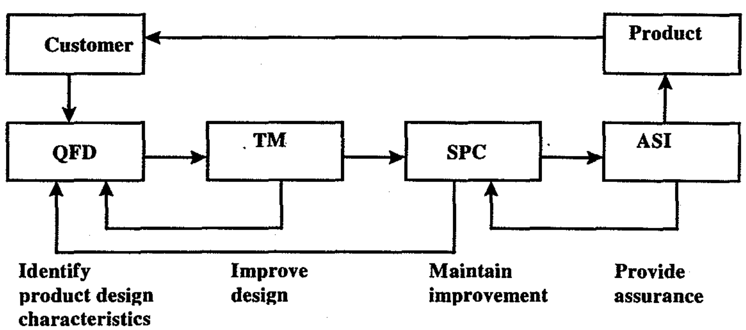

Figure 4: Variation reduction and performance improvement model

and improve performance. In this model, variation reduction hence, improvement in quality begins with identifying and understanding customer needs. QFD (Quality Function Deployment) process allows the design/innovation team to translate customer needs into appropriate product and process characteristics. TM (Taguchi Methods) enables to make the product robust to input and environmental factors, whereas SPC (Statistical Process Control) helps to maintain what has been achieved in the design stage. The process of ASI (Acceptance Sampling Inspection) provides an assurance about the quality of the product. The feedback loops provide a mechanism for continuous improvement. Figure 5 provides the causal loop diagram of the model.

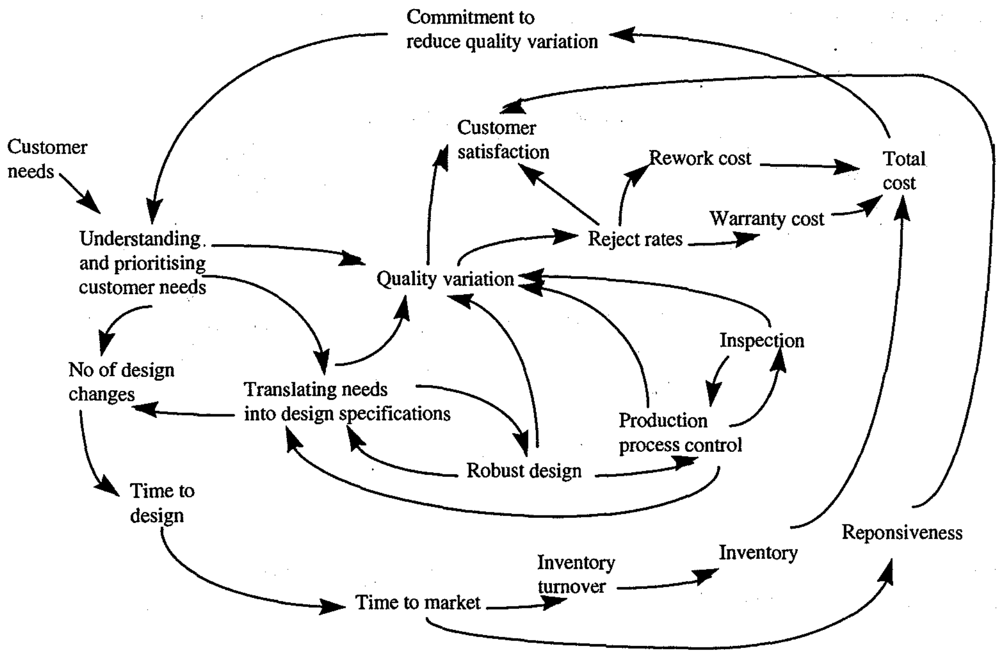

Figure 5: Causal loop diagram of variation reduction and performance improvement model

Application of the Model

Data has been collected for five large manufacturing companies in Australia. All these companies claim to have sound quality management procedures in place. Four companies have formally certified to ISO 9001 quality assurance standard. All companies are involved in design & development, installation, and servicing functions. At this stage data is being used to validate the model and test the policy issues regarding market need assessment, investment in technical system.

References

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