Chapter 5
Economic Analysis of Systems Under a Monopoly Based on a Reliability-Quality Index

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ABSTRACT
The aim of this chapter is to present methods for conducting economic analysis on the reliability-quality level of systems as associated techniques for systems economic forecasting. System reliability has been a prominent research topic in the research field of reliability theory, and a sizeable amount of literature has proposed methods for economic analysis of systems. Most of the methods only look at mathematical aspects from the manufacturer’s point of view; that is, mathematical maximization of reliability-quality has been emphasized under a cost constraint. Under real circumstances, however, the economic analysis needs to include the aspect of consumer behavior, so that profitability of the systems can, a priori, be examined, since the goal of manufacturer’s activities is to maximize profit. The authors here introduce methods for economic analysis of systems under a monopoly based on a Stackelberg game formulation considering both the consumer’s viewpoint and the manufacturer’s. The methods are fundamental techniques for system planning which includes the long-term forecasting of the system economy in order to deal with long-term changes in consumer’s characteristics. The research findings from this chapter will assist top-level managers of business organizations in their decision making.

1. INTRODUCTION
The goal of corporate activities is to make a profit, and it is prudent for companies to estimate the profitability of products they provide. For securement of sustainable profit, it is important to forecast long-term changes to variables which affect a system planning, such as customer’s characteristics, economic indicators and social conditions, as well as technical advancement. It is also necessary to
analyze the long-term change in the economy of products estimated by the forecasted variables in order to release appropriate products for customers in the future.

This chapter presents methods for conducting long-term system planning through the economic analysis of systems’ quality in terms of reliability, reliability-quality in short. In the research field of reliability theory, mathematical analysis of a variety of systems is a common theme within the literature. Most studies treated economic analysis of systems as an optimization problem which took into account factors regarding system development, such as reliability-quality level and so-called cost. The studies, however, failed to consider important factors in merchandising of the systems, such as selling prices and consumer behaviors to the systems. Even if a manufacturer developed a system with high reliability-quality level at a low cost, consumers would never purchase a system which did not meet their needs. It is, therefore, fundamental to evaluate system development projects from the consumer’s point of view as well as from the standpoint of the manufacturer. Particularly, the manufacturer needs to give consideration to the consumer’s purchasing behaviors in respect to the selling price and the reliability-quality of the objective systems.

This chapter introduces methods for economic analysis of systems in relation to the reliability-quality within a Stackelberg game framework under a monopoly. The Stackelberg formulation derives an optimal system planning strategy to maximize manufacturer’s profit with also considering consumer’s behaviors. We especially feature economic analysis of a parallel redundant system, which is a well-known system in reliability theory. Most of the introduced methods in this chapter are versatile and applicable in a variety of product planning scenarios with quality indices. The approach will especially be of great help to top-level managers of business organizations who need to make decisions based on forecasts relating to the changing of consumer characteristics and the social economy.

The remaining part of the chapter is organized as follows. Section 2 describes the role of economic analysis in system planning and the relationship among economic analysis, forecasting and optimization techniques in system planning. From Section 3, we introduce methods for economic analysis of systems, in which consumers make decisions based on two kinds of indices: selling prices and the degree of reliability-quality of the provided systems. Section 3 presents a fundamental framework for the introduced method. Subsection 3.1 describes a procedure to compare systems on the basis of the two indices while considering consumer’s reaction to the indices. Subsection 3.2 compares two types of systems, one of which the manufacturer can control the two indices to improve profit. The method described in Subsection 3.2 targets a situation where a newly developed system will be released into an existing market. In Section 4, we confine ourselves to economic analysis of parallel redundant systems against a single unit system. This section evaluates a newly released parallel redundant system against an existing single unit system and focuses on a method for judging whether or not a parallel redundant system should be developed compared to a single unit system in the sense of profitability. Section 5 compares multiple types of systems, including a single unit system and a parallel redundant system, to derive their optimal pricings and optimal levels of reliability-quality for manufacturer’s maximum profit in a more general framework. Section 6 concludes this chapter and considers the applicability of the introduced methods to economic analysis of other kinds of products as well as extensions of the methods discussed.

2. BACKGROUND

2.1. System Planning Process and Economic Analysis

In our rapidly changing environment, the importance of system planning is paramount. When a
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