Role of economics in reliability engineering: An overview

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Abstract

The necessity for engineering economy originates from the fact that engineers do not work in an economic vacuum but are under strong impact from the processes that managers use to allocate limited resources to produce and distribute various products. Because engineers are basically trained as physical scientists, it is necessary repetitively to stress that economics, which studies these processes, is an empirical social science that provides us with the conceptual framework known as a theory of choice. This paper presents the overview of role of economics in reliability.

1.Introduction

Positive economics, as opposed to normative economics is concerned with questions of facts to which assumptions relating theoretical constructs to real objects are added. Economic models then represent the purely logical aspects of these theories and serve as tools for decision making, behaviour or consequence predictions, and testing or refutation of underlying assumptions and propositions based upon economic rather than physical consequence.

1.1 Reliability and Value

The task of economic science is to plan best ways of assigning rare resources among contending suggestions for their use. The wealth of data about client behaviour, ideals, principles, and attitudes frequently checks reliability as the most significant product quality attribute, and by that, its influence on the value in exchange. Most of the purchase decisions in the area of consumer electronics consider product price much more important than reliability because of small impact of failures, protection by a warranty period, seller's goodwill.

1.2 Reliability as a Capital Investment

The product can be analysed for its attractiveness as a capital investment convenient measure of this attractiveness is return on investment. The ROI without consideration of the time value of money is an approximation that assumes indefinite life of the project, and the payback method ignores the desired profit or "interest" on the investment. These approximations can be used for "quick-and-dirty" analysis of proposed investments in reliability programs to prevent or reduce the number of costly failures of the products. Where the required rate of return on the investment is high (to compensate for the uncertainties of the future), these correct methods, as illustrated in the example below, can make great differences in the ROI and the payback period.

• *Payback period* is simply the reciprocal of the simple ROI and is a quick test that, however, ignores total cash flow over time and the time value of money.

• *Benefit/cost ratio* is the ROI multiplied by the expected years of useful life.

• The *net return* is calculated by multiplying the benefit/cost ratio by the investment cost, in our case the cost of a reliability improvement program, and subtracting from it again the investment cost.

The figure 1 represents the comparison of price, performance and reliability parameters of two cases.

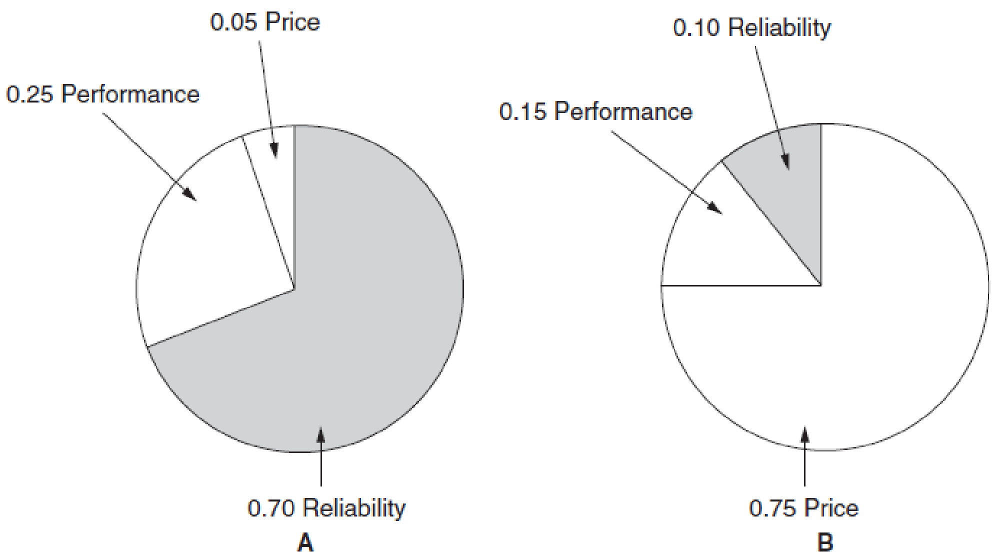

Figure 1. Comparison of price, performance and reliability

2. Reliability and Cost

The concept of *cost of reliability* (COR) represents the cost which manufacturer incurs during manufacturing of a product having given reliability. The classic categorization of COQ applied to COR expresses as unique the costs associated with the following elements:

• External failure. Cost of unreliability during the warranty period, cost of spare parts inventories, cost of failure analysis.

• Internal failure. Yield losses caused by reliability screens and tests, cost of failure-caused manufacturing equipment downtime, cost of redesign for reliability.

• Reliability appraisal. Life testing, environmental ruggedness evaluation, abuse testing, failure data reporting and analysis, reliability modeling.

• Prevention. Design for reliability, reliability standards and guidelines development, customer requirements research, product qualification, design reviews, reliability training, fault-tree analysis, failure modes, effects, and criticality analysis.

3. Life-Cycle Costing (LCC)

LCC has evolved into a costing discipline, a procurement technique, an acquisition consideration, and a design trade-off tool. LCC requires the identification of all potential system costs through all the phases of the product life cycle: conceptual, development, manufacturing, installation, operation, support, and retirement, application of the LCC methodology. This costing and trade-off process, as shown in figure 2 which illustrates its generalized structure, requires a very close customer-vendor interface.

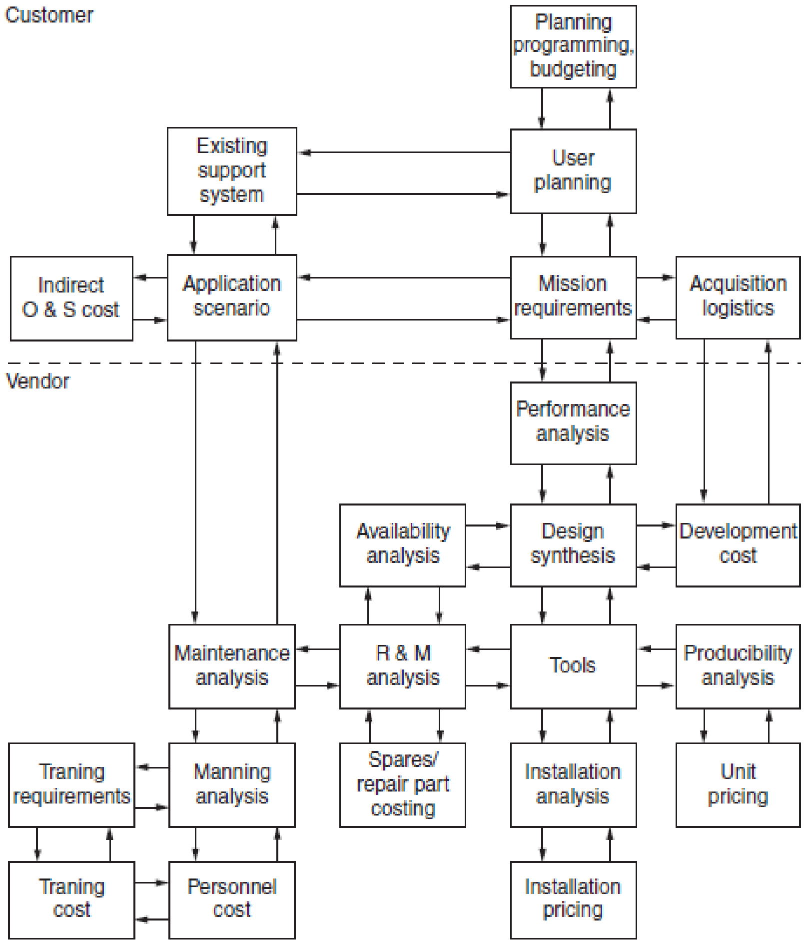

Figure 2. LCC model for reliability

4. Economic Aspects of Product Safety

The close relationship of reliability to issues of product safety is evident from a simple definition of risk: Results obtained by techniques of fault-tree analysis, failure modes and effects analysis, or hazard analysis can be interpreted in terms of negative utility, event probabilities, and severity (criticality), which are standard subjects of cost-benefit studies. The cost factor, strongly dependent on the criticality level, must take into account cost of design for safety, manufacturing for safety, and losses caused by complaints, claims, suits, legal cost, unfavourable publicity, government intervention, and so on. The best investments usually result from the lowest cost-benefit ratio, but implementation alternatives must be selected carefully because cost can significantly increase on both probability extremes:

- Low probability requirements could result in over-design.
- Accepted high probability of occurrence could be simply perceived as negligence.

A cost-benefit analysis can be complemented by a comparison of the cost of different alternatives to achieve a defined acceptable level of safety. Analytical approach to decision making about safety issues usually follow this simple process:

- Identify potential hazards and resulting probable accidents associated with current product design.
- Obtain credible data on accident rates by product over time, for example, from the National
- Emergency Injury Surveillance system or insurance companies.
- Risk = probability of a failure × exposure × consequence

- Provide a set of alternatives for providing additional increments of safety.
- Get cost data or cost assessments for these alternatives.
- Analyse alternatives provided for their effects and cost.

5.Conclusion

Reliability engineering and management can greatly benefit from prudent application of tools from engineering economics and operations research, especially when facing decisions about costly investments, high risks, or complex situations, such as those occurring in high-technology environments. The power of these tools, with their rigorous methods and computational accuracy, must be understood in the context of their dependency on quality and relevance of underlying assumptions, historical data, cost estimates, and known unequal treatment of results from physical versus human sciences. This paper presents the overview of economics of reliability.

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