

An Analytical Formulation of the Conformance-Quality Loss Relationship using Probabilistic Process Mean Shifts

Burak Birgören and Salih Tekin

Industrial Engineering Department

TOBB University of Economics and Technology, Ankara, Türkiye

b.birgoren@etu.edu.tr, stekin@etu.edu.tr

Abstract

This study introduces a mathematical framework for modeling Expected Total Quality Loss within a stochastic manufacturing process control environment. It addresses a long-standing gap in the literature where the relationship between conformance rate and quality-related loss, as depicted by the well-known Lundvall-Juran curves, has been primarily conceptual. By integrating Taguchi's Quality Loss Function with a probabilistic model of stochastic process mean shifts, the research develops a nonlinear decreasing function expressing expected loss in terms of conformance rate. This function, which assumes a single quality characteristic, accounts for the probabilistic nature of process drifts and their economic impact. Its versatility is demonstrated by analyzing three representative cases where normal, mixed, and discrete distributions are used to model mean shifts to capture a range of realistic manufacturing scenarios. The effect of inspection is also investigated. While resembling classical conceptual models, the derived function departs from them as the conformance rate approaches 100%, becoming progressively steeper, and thereby indicating an accelerating rate of loss reduction. This analytical framework offers a powerful tool for managers to move beyond heuristic guidelines, enabling a quantitative evaluation of quality improvement initiatives and their return on investment.

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Biographies

Burak Birgören is a Professor of Industrial Engineering at TOBB Economics and Technology University in Ankara, where he also serves as the Director of the Graduate School of Natural and Applied Sciences. He holds B.S. and M.S. degrees in Industrial Engineering from Bogaziçi University in Istanbul and a Ph.D. in Industrial Engineering from Penn State University, specializing in statistical quality control. Upon returning to Turkey, he became a founding member of the Industrial Engineering department at Kirikkale University. Over his career, he has held significant administrative positions for a total of 17 years, including Department Chair, Associate Dean, and Director of the Graduate School of Natural and Applied Sciences. His academic expertise spans various subjects, and he has taught courses such as Quality Control, Probability Theory, Statistics, and Operations Research. His research is extensive, encompassing national and international projects, including a DPT (national State Planning Organization) -funded Advanced University Project, multiple TUBITAK (The Scientific and Technological Research Council of Turkey) 1001 projects, and an EU project for the Ministry of Labor and Social Security. He has strong connections with the industry, notably with MKEK, a major defense company in Turkey, where he has provided technical training and served as a consultant for quality control. His collaborations have led to the successful supervision of eight M.S. and three Ph.D. theses with direct industrial applications. His academic work centers on statistical quality control, reliability engineering, risk management, and stochastic programming.

Salih Tekin is an Assistant Professor at TOBB University of Economics and Technology. He received his B.S. degree in Industrial Engineering from Bilkent University, Ankara, Turkey, in 2002, and M.S. and Ph.D. degrees in Industrial Engineering from Georgia Institute of Technology, GA, USA, in 2006 and 2011, respectively. He also has an M.S degree in statistics from Georgia Institute of Technology, GA, USA, earned in 2004. His current interests include reliability and applied probability models.