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# **Integration of Taguchi's Robust Parameter Design Approach in a Mature Lean Manufacturing Environment - The Case of the Apparel Industry**

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## Abstract

It has been documented in the literature that combining overlapping manufacturing practices lead to superior performance. The primary driver of this study is the conceptual overlap the researcher identified between the zero waste proposition in Lean and the zero defects (loss to society) proposition in Taguchi's Quality Philosophy (TQP); TQP provides the backbone of Taguchi's robust parameter design (RPD) approach, a statistically driven experimental method that enables engineers to identify optimum design parameter settings to make the product's functionality robust against the background variables (noise). This study hypothesises that Taguchi's RPD approach complements Lean. This overall hypothesis was examined in two phases.

First, through the literature, the researcher hypothesised the theoretical relationships between TQP and Lean, through the mediating role being played by Continuous Improvement to explain Manufacturing Outcomes. This model was tested through Structural Equation Modelling using data collected from 318 respondents in 31 apparel manufacturing factories belonging to a mature Lean organisation in Sri Lanka. The researcher found that the model was a good fit to data (e.g. RMSEA = 0.047), which suggested that her hypothesised theoretical model is tenable and that TQP is acceptable to Lean practitioners as an avenue to improve manufacturing performance.

Next, the researcher examined the practical compatibility between Taguchi's RPD approach and Lean through extensive fieldwork in one of the factories in the Lean organisation. The work involved conducting RPD experiments to solve a substantial quality problem, (which helped the researcher to identify the merits and demerits of Taguchi methods) and also permitted ethnographic engagement with the factory staff. This enabled the researcher to explore the drivers and restraints of integrating Taguchi's RPD in the setting studied. The merits of Taguchi's RPD were found to be the high degree of standardisation, ease of conducting the experiment and analysing the data, and compatibility with the Lean culture. The researcher identified 5 drivers (also 3 inhibitors) out of which, the most influential drivers were: (a) the experienced ineffectiveness of the existing tools and techniques being used, (b) non-value adding activities associated with machine setting up, and (c) conduciveness to conduct large Taguchi style experiments. Using *Force Field Analysis* as the theoretical framework, the researcher explained how Lean organisation, similar to the one being considered, can move towards using Taguchi's RPD as a tool for process improvement. The study identified several future research directions for practitioners and academics.

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## List of Acronyms

AIAG	American Automotive Industry Action Group
AMOS	Analysis of Moment Structures
ANOVA	Analysis of Variance
AQL	Acceptable Quality Level
CBSEM	Covariance Based Structural Equation Modelling
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CI	Continuous Improvement
DoE	Design of Experiments
LHS	Left Hand Side
LSL	Lower Specification Limit
MSD	Mean Square Deviation
MSE	Mean Square Error
NFI	Normed Fit Index
NPP	Normal Probability Plot
OA	Orthogonal Array
PCA	Principal Component Analysis
PCLOSE	The Closeness of Fit
PDCA	Plan-DO-Check-Act
PLSBSEM	Partial Least Squares Based Structural Equation Modelling Approach
QA	Quality Assurance
QCO	Quick-Change-Over
QI	Quality Improvement
RD	Robust Design
RE	Robust Engineering
RHS	Right Hand Side
RMSEA	Root Mean Square Error of Approximation
RPD	Robust Parameter Design
SD	Standard Deviation
SEM	Structural Equation Modelling
SNR	Signal-to-Noise Ratio
SPI	Stitches Per Inch
TMC	Toyota Motor Corporation
TPS	Toyota Production System
TW	Toyota Way
USL	Upper Specification Limit

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