Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.
Integration of Taguchi's Robust Parameter Design Approach in a Mature Lean Manufacturing Environment - The Case of the Apparel Industry

A thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Technology at Massey University, Manawatu, New Zealand.

Pramila Gamage

2015
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.
Acknowledgements

If I did not how complex a doctoral research project is four years ago, now I know what it is like to complete a substantial research project. If not for many people who helped me in various ways during the good times and bad times, I would not have been able to achieve my project goals to level of satisfaction that I enjoy now. First, I would like to thank my supervisor Dr. Nihal Jayamaha for his guidance and patience and tracking my academic progress and my general wellbeing. I am grateful to my co-supervisor A/Prof. Nigel Grigg for his guidance, support, encouragement, and humility.

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