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A Novel Decision-Making Framework for Robust-Reliable Aggregate Production Planning Problem

Abstract

In the dynamic and complex landscape of Aggregate Production Planning (APP), achieving a balance between cost efficiency, reliability, and workforce well-being is critical for sustainable operations. This thesis develops a novel decision-making framework for robust and reliable APP, with a particular focus on integrating human factors into the optimisation process. By leveraging advanced methodologies, including Multivariate Adaptive Regression Splines (MARS), Weighted Goal Programming (WGP), and Fuzzy Programming, the research addresses the challenges of uncertainty, multi-objective optimisation, and workforce dynamics. The framework is applied to a real-world case study in the automotive industry, a sector characterised by multi-product manufacturing, fluctuating demand, and stringent just-in-time (JIT) requirements. Two key objectives - minimizing total costs and maximizing system reliability - are explored using a bi-objective Mixed-Integer Non-Linear Programming (MINLP) model. Human factors, such as learning and forgetting rates, fatigue dynamics, and workforce reliability, are systematically integrated into the model, providing a comprehensive approach to enhance both operational efficiency and employee reliability. The study's findings emphasise the critical role of workforce-related variables in achieving reliable and sustainable APP. Practical tools, such as the Matrix Questionnaires (MQ1 and MQ2), are developed to evaluate and incorporate human-centric criteria into production planning. Sensitivity analyses further validate the robustness of the proposed model, offering actionable insights for managers to navigate the complexities of demand uncertainty and workforce variability. This research contributes to the growing field of sustainable production planning by bridging the gap between operational objectives and human-centric considerations. It provides a scalable and adaptable framework for the automotive industry and beyond, paving the way for future advancements in integrating human factors, advanced analytics, and sustainability into decision-making processes.