ABSTRACT

This dissertation addresses the enhancement of production planning resilience under variability and disruptions through a predictive–adaptive approach. The research focuses on a high-mix, low-volume production environment characterized by multilevel bills of materials, complex process routings, and shared resources. In such an environment, the effects of local disruptions may propagate through production dependencies and compromise the timely completion of finished products.

The aim of the study was to develop and validate a solution for mitigating disruption impacts by combining production order predictions, risk assessment, and the selection of feasible adaptive actions. The proposed approach integrates data, predictive, decision-making, and execution layers. The predictive layer employs XGBoost-based machine learning models to predict order completion dates, start delays, and completion delays. Risk assessment combines material requirements balancing and the allocation of available supply with the representation of dependencies leading to finished products. Action selection considers the disruption type, feasibility constraints, expected effects on delivery performance, and the extent of changes to the production plan.

Validation was conducted through experiments involving production flow disruptions, material shortages, and quality disruptions at different intensity levels. A baseline scenario without adaptation was compared with a scenario employing the proposed solution. The results showed reductions in median production order delays and finished product delays across the analyzed experiments. The effectiveness of individual actions varied depending on the nature of the disruption and the state of the production system.

This dissertation develops and experimentally evaluates an integrated approach that combines predictive information with the assessment of risks to finished product completion and the selection of feasible adaptive actions. The findings indicate that the proposed approach can support production planning resilience under the conditions studied, while its operational effects require further validation through industrial implementation.

The proposed approach can serve as a component in developing dual-use solutions aimed at creating production systems that are resilient to random disruptions.

Keywords:

1. production planning resilience
2. predictive–adaptive planning
3. production disruptions
4. machine learning
5. material dependencies
6. disruption propagation