

Digital Twin Enabled Multi Supplier Coordination and Production Planning under Dynamic Reliability

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Abstract

Supplier delivery performance can deteriorate or recover over time, so plans built on static reliability assumptions often lead to material shortages, costly expediting, and persistent backlog. This paper studies an integrated multi supplier procurement and production inventory planning problem where supplier reliability is modeled as a time varying state updated from observed delivery outcomes, including on time delivery, lateness, and partial fulfillment. We propose a digital twin enabled closed loop framework in which the digital twin consolidates system state information, tracks outstanding pipeline orders, updates supplier reliability states from delivery observations, and provides material availability signals to procurement and production decisions on a rolling horizon. The planning model represents supplier activation and selection, order allocation under lead times, MOQ constraints, and supplier capacity limits, with optional expediting or supplier support actions. Production is constrained by shared capacity that may be reduced by machine breakdown events. Demand is stochastic and unmet demand is fully backlogged. Simulation experiments compare reliability aware policies against static reliability and myopic benchmarks under disruption scenarios. Results are evaluated using total cost and service indicators, demonstrating the benefit of delivery performance feedback for more robust coordination.

Keywords

Digital twin, supplier reliability, multi sourcing, production inventory planning, simulation optimization

Biographies

Erickson Liang is a Ph.D. candidate in the Department of Industrial Engineering and Engineering Management at National Tsing Hua University. He received his master's degree from Yuan Ze University and is currently pursuing research on digital twin-enabled decision-making for production and supply systems. His research interests include digital twins, simulation-based optimization, reinforcement learning for planning and scheduling, and supplier reliability modeling. His current work focuses on integrated multi-supplier procurement and production-inventory planning under dynamically evolving delivery reliability, with rolling-horizon evaluation in stochastic manufacturing environments.

Kuo-Hao Chang is a Professor of Industrial Engineering and Engineering of National Tsing Hua University. He received his PhD in Industrial Engineering from Purdue University in 2008. Professor Chang's research interests include data analytics, applied probability and statistics, and simulation optimization. He was the winner of the 2012 Bonder Scholar Research Award from INFORMS, 2015 IIE Transactions Best Application Paper Award, 2015 K.D. Tocher Medal from The OR Society, 2015 Ta-You Wu Memorial Award from the Ministry of Science and Technology and 2016 Junior Investigators Research Award from the Academia Sinica and 2017 IEEE Transactions on Semiconductor Manufacturing Best Paper Award. He is currently the Associate Editor of several prestigious international journals, including the IEEE Transactions on Automation Science and Engineering, the Asia-Pacific Journal of Operational Research, and the International Journal of Simulation and Process Modeling. Professor Chang and his team has successfully carried out many projects in collaboration with companies, including TSMC, LiteOn, UMC, VisEra, YOMURA, ITRI, III etc. Professor Chang is an active member of INFORMS, IIE and a senior member of IEEE.