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Digital manufacturing and supply chain: creating benefits through operations research and artificial intelligence

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With Industry 4.0, a transition from automated and intelligent to digital has been coined. This transition covers both network and plant levels. At the plant level, digital manufacturing is based on the collaboration of machines, machines with products, and humans with machines. From the application perspective, these features have materialized through additive manufacturing, robotics, digital twins, virtual and augmented reality, and collaboration tools in creating products and services. At the network level, the digital supply chain has been created utilizing Blockchain, the Internet of Things, e-commerce platforms, and collaborative supplier portals to achieve seamless end-to-end visibility. From the solution methodology perspective, innovative approaches have been developed combining interdis-

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ciplinary methods from operations research (OR), machine learning (ML), and artificial intelligence (AI).

The special issue “Digital Manufacturing and Supply Chain: Creating Benefits Through Operations Research and Artificial Intelligence” is targeted towards, but not restricted to the 10th IFAC Conference MIM 2022 that took place on June 22–24, 2022, in Nantes (France) and attracted 767 participants from 59 countries: <https://hub.imt-atlantique.fr/mim2022/>.

The special issue features papers demonstrating how Automation Technology (Additive Manufacturing, Drones, AGVs), Collaboration Technology (Digital Platforms), Identification and Communication Technology (Blockchain, Sensors, Smart Products), and Data Processing Technology (Big Data Analytics) can generate benefits for manufacturing and supply chains.

This special issue of ANOR reports on recent developments, building upon methods and applications of OR and analytics to digital, resilient, and sustainable manufacturing and supply chains 4.0. It contains 17 papers which are detailed below.

Reza Lotfi, Mohsen Rajabzadeh, Abolfazl Zamani, and Mohammad Sadra Rajabi propose in their paper “Viable supply chain with vendor-managed inventory approach by considering blockchain, risk and robustness” a case study-based model to compare issues in and excluding Blockchain Technology (BCT) using Mixed-Integer Linear Programming and GAMS-Bonmin in the Pharmacy Industry. The results indicate a 0.61% greater cost function of the core problem without using BCT compared to the identical problem with the usage of BCT. The authors state that decreasing the resiliency coefficient and increasing the conservative coefficient will increase the cost function. In addition, the analysis examines an increasing confidence level that results in a reduction of the cost function. As the authors conclude, an expansion in the scale of the problem leads to a longer problem-solving time (Lotfi et al., 2022).

Bin Shen, Jianing Zhang, Ming Cheng, Shu Guo, and Renlong He explore in their paper “Supply chain integration in mass customization” the influence of waiting time and self-design entertainment from the acquisition of mass customization (MC) products on supply chain integration. The study uses a supply chain containing one manufacturer, one retailer, and one customizer. Standardized products are produced and sold by the manufacturer through the retailer. The customizer is able to choose to sell their products between a manufacturer–customizer integration or retailer–customizer integration. Firstly, the authors identify that a win-win-win outcome is created for all supply chain participants whenever the waiting time for MC is within an average range and a high customer satisfaction rate with the product quality in manufacturer–customizer integration. Secondly, they state a different outcome for retailer–customizer integration in case the manufacturer is not engaging in the integration. The authors conclude the competition mitigation effect can compensate for a low level of self-design entertainment in the supply chain integration and the achievability of a win-win-win effect for every supply chain member in the manufacturer–customizer integration is unchanged with endogenized self-design entertainment (Shen et al., 2023).

Jing Peng, Jianghua Zhang, and Tengfei Nie investigate in their paper “Social influence and channel competition in the live-streaming market” the effect on stakeholders in the live-streaming market by making use of a one-to-two channel in which two diverse influencers compete for sales of a popular producer. By implementing a multiunit bilateral bargaining framework, the authors focus on determining an equilibrium with rational expectations by analyzing parallel negotiations with the influencers and the fabricator. The authors conclude

that, since the Matthew effect is observed, the manufacturer should focus on using the most successful influencer and that live streaming increases consumer surplus (Peng et al., 2023).

Ping Xie, Ruixia Shi, and Di Xu identify the optimal live stream plan for retailers that provide complimentary rides between the retailer's store brand and a manufacturer's national brand using a game-theoretic framework in their paper "Retailer service strategy on livestreaming platforms considering free riding behavior". In case there are limited resources on the live streaming channel, the retailer should either not promote products with low demand or offer the service to a national brand themselves. If not, assign it to the manufacturer. Correspondingly, in case there are unlimited assets, promoting both brands may not be mandatory if the store brand has a high demand (Xie et al., 2023).

Nail Tahirov, Najmaddin Akhundov, Simon Emde, and Christoph H. Glock propose in their paper "Configuration of last-mile distribution networks for an encroaching manufacturer" an integrated optimization model aimed at examining various distribution approaches for a manufacturer retailing both standard and customized products to diverse customer sections with changing preferences. By resolving a location-routing problem, a wide-ranging evaluation of the effects on the total logistics costs and customer approachability is generated. The authors conclude that for serving a variety of customer divisions while reducing handling costs at the same time, an omnichannel distribution system is a viable method (Tahirov et al., 2024).

In their paper "Contracting under information superiority in a supply chain of subscription-based apps: a comparative analysis", Tal Avinadav and Priel Levy use a game-theoretic approach to analyze a supply chain of subscription-based apps that contain a platform and a designer. Two scenarios concerning the platform's data status for each static fee and commission rate are evaluated. The study concludes that it is beneficial for the platform to make fixed-fee contracts which result in higher quality and price of the subscription. Lastly, estimated revenues of the platform and designer are higher with bigger demand volatility (Avinadav & Levy, 2023).

Kuo-Ching Ying, Pourya Pourhejazy, and Po-Jui Fu explore production planning of a three-stage distributed manufacturing system including the production of subcomponents, assembling components in Original Equipment Manufacturer (OEM) factories as well as fabricating products at the product manufacturer's facility. In their paper "N-list-enhanced heuristic for distributed three-stage assembly permutation flow shop scheduling" using Distributed Three Stage Assembly Permutation Flowshop Scheduling Problems (DTrSAPFSP) models, the authors argue that a significantly better algorithm performance can be created by using an N-list-enhanced Constructive Heuristic algorithm (Ying et al., 2023).

Longfei He, Xiao Zhang, Baofeng Huo, and Yang Zhang analyze the influence of cross-network externality as well as supply risk of the two-sided market on the Acceptance Decisions of Pricing and Blockchain by volume distribution platforms in their paper "Platform pricing and blockchain adoption for capacity sharing with cross-network externality and supply risk". By using the mean-variance model and blockchain technology, the authors state that platforms prefer using blockchain technology whenever fixed costs for implementation are lower than the expected profit, adding more value to the blockchain technology. To conclude, the authors provide a theoretical foundation for pricing policies of platforms and managerial insights for utilizing blockchain technology (He et al., 2024).

Feng Liu, Mingjie Fang, Shufeng Xiao, and Yangyan Shi explore the effect of the digital revolution on the bullwhip effect at the firm level and the relationship to customer concen-

tration using the organizational processing theory in their paper “Mitigating bullwhip effect in supply chains by engaging in digital transformation: the moderating role of customer concentration”. Hierarchical linear modeling with 2,159 Chinese manufacturing firms from 2016 to 2020 is used for hypothesis testing. The authors conclude that a severe mitigation of the bullwhip effect in firms when using digital transformation and a less diffuse customer base (Liu et al., 2024).

Samira Ebrahimi, Mohammad Fathian, and Seyyed-Mahdi Hosseini-Motlagh analyze in their paper “Dynamic effects of parallel selling channels on the electronic marketplace reputation and performance” the dynamic effect of the parallel selling channels on the cost-effectiveness and standing of the electronic marketplace. Using a dynamic game theory approach, price markdown and delivery lead time decisions are computed. Price discounts and delivery time choices can be contemplated as simultaneous dynamic results for enhancing market share. Furthermore, commission fees can influence the service level and time leads to improving the marketplace reputation over time. To conclude, the authors state that the performance of retailers and the market increases significantly with coordination contracts (Ebrahimi et al., 2024).

In the paper “A queueing-inventory system with a repeated-orbit policy during the service”, Gabi Hanukov investigates a service system where customers are not required to be present during the processing of their order. Using the matrix geometric method, analysis of the queueing-inventory-repeated-orbit (QIRO) is executed in case customers need to leave again before their service is completed. For optimal sendoff time calculation, a maximization of the customer’s anticipated efficacy is considered. Correspondingly, the author states for an increased demand and maximization of the profit an optimal finished service storage capacity and investment in preservation technologies are required (Hanukov, 2023).

Seyd Amin Seyfi, İhsan Yanıkoğlu, and Görkem Yılmaz analyze a combined lot sizing and workforce scheduling issue under demand insecurity using a multi-stage stochastic manufacture planning method as a case study at Vestel in their paper “Multi-stage scenario-based stochastic programming for managing lot sizing and workforce scheduling at Vestel”. For modeling uncertainty in demand, scenario trees are used, and a multi-stage scenario-based stochastic linear program is established to enhance the total efficacy of production planning and to regulate production quantities accordingly. To conclude, the authors state that almost ideal solutions in feasible computation times are generated through a meta-heuristic for large-sized cases, and a noteworthy enhancement in costs as well as CPU time performance for benchmark methods is observed (Seyfi et al., 2023).

Xue Yan, Ting Wang, and Xuefei Shi explore the usage of the combinatorial auction in technician obligation and subcontracting amenity procurement using software enterprises for reducing the overall expenses for software development in their paper “Optimal scheduling on unrelated parallel machines with combinatorial auction”. The authors propose using an unrelated parallel machine scheduling problem incorporating combinatorial auction (UPMSCA) to investigate whether to plan works on parallel machines or select the offer with the lowest rate. An arc-flow model and a set-partitioning formulation with column-based constraints are suggested to resolve the issue. The algorithm’s performance is validated by outcomes from widespread computational tests on 100 series of randomly created examples (Yan et al., 2024).

Na Liu and Shuyun Ren analyze production disruption risks by investigating the effects on the consumer, supply chain agents, and society in their paper “Production disruption in

supply chain systems: impacts on consumers, supply chain agents and the society”. A variety of parameters are used to explore the influence on the ideal decisions of selling price and the revenue of supply chain agents as well as the profit alteration. The authors highlight that wholesale price is irrelevant for unbiased supply chain agents but becomes important for risk-seeking supply chain agents (Liu & Ren, 2024).

Amina Antit, Amel Jaoua, Safa Bhar Layeb, and Chefi Triki propose a new mechanism for handling the range of common customers for a logistics company in their paper “Pre-auction optimization for the selection of shared customers in the last-mile delivery”. The novel approach uses the auction as an instrument to handle the assortment of common clients through the coalition pool which outsources entirely nonprofit shared customers to other cooperating carriers. Firstly, to explain the deterministic form of the issue, a mixed integer linear programming model is used. Secondly, a simulation-based optimization model is established to efficiently resolve the stochastic form of the issue and is aimed at solving a case study of a parcel delivery company. To conclude, the authors state that the study discovered an increase of 22.65% in revenues for the delivery company using an auction approach for handling the common customers (Antit et al., 2023).

Wenping Liu, Bangyi Li, Guoqing Zhang, Zhe Wang, and Yongbo Cheng suggest in their paper “Quality disclosure pattern options for competing refurbishers: blockchain vs online platform”, a duopoly model to analyze the execution circumstances of various quality disclosure designs for refurbishers and equilibrium disclosure patterns in the rival market using game theory. Online retailer sales or direct blockchain adoption are measured as quality patterns with competing refurbishers with heterogeneous levels of quality. The authors conclude that the counterparty’s pattern is crucial for the refurbishers’ will for diverse disclosure patterns and the product quality gap affects the high-grade refurbisher (Liu et al., 2023).

Huini Zhou, Guo Li, Yong Tan, and Xu Guan propose an approach for dynamic investment tactics of online advertising for multi-oligopoly businesses by contemplating the spillover effect of online promotion in their paper “Dynamic investment in online advertising of multi-oligopoly competitive enterprises with spillover effect”. For examination, the authors use the Hamilton-Jacobi-Bellman function to identify the Nash equilibrium solutions of the online promotion quantity and revenues accomplished in symmetrical, semisymmetric, and asymmetric events for analyzing market share and spreading the model to n -dimensional space. Firstly, to conclude, the authors state that investment in fixed-location online marketing is inversely proportional to the spillover effect although pay-per-click is directly proportional. Additionally, leading companies are touched by the spillover effect in semisymmetric and asymmetric events. Secondly, the total investment in online advertising is contrary to external restriction aspects, and negative revenue in the case of more than three companies in the market (Zhou et al., 2023).

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