Modeling Additive Manufacturing Supply Chain considering Customer Product Choices

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Abstract

This study proposed a utility-driven two-stage stochastic mixed-integer linear programming model to understand how the patient preferences impact the additive manufacturing (AM) supply chain design decisions. The goal of the mathematical model is to maximize the utilities derived from the customer preferences by appropriately allocating the AM facilities in the targeted region under customer decision and demand uncertainty. The mathematical model is visualized and validated by developing a real-life case study that utilizes the biomedical implants data for Mississippi. Several sensitivity analyses are conducted to understand how the patients' behavioral decisions (e.g., price-centric versus time- or quality-centric customers) to purchase biomedical implants impact the AM supply chain design decisions. Experimental results reveal that AM supply chain is sensitive to the utility of the patients. For instance, it is observed that in addition to opening a facility in Lamar County, an additional AM facility is opened in Washington County to serve the rural patients in our test region Mississippi. The results revealed vital managerial insights that healthcare service providers and interested stakeholders could utilize to provide quality healthcare services by managing patient-centric AM facility siting decisions.

Keywords

Additive manufacturing, stochastic optimization, choice-model, biomedical implants, patient preferences.

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Biographies

Julekha H. Ranta is currently a PhD student in the Computational Engineering program at Mississippi State University (MSU). She completed her masters degree in the General Engineering department under the Bagley College of Engineering at MSU. Her research interests include applied optimization and machine learning applications in security, transportation, and supply chain management. Her publications appeared in several prestigious journals, such as IEEE Systems Engineering and IEEE Engineering Management.

Dr. Raed Jaradat is an Associate Professor of Industrial and Systems Engineering Department at Mississippi State University and a scholar working with the Institute for Systems Engineering Research/MSU/U.S. Army Corps of Engineers. Dr. Jaradat received a Ph.D. in Engineering Management and Systems Engineering from Old Dominion University in 2014. His main research interests include systems engineering and management systems, systems thinking and complex system exploration, system of systems, virtual reality and complex systems, systems simulation, risk, reliability, and vulnerability in critical infrastructures with applications to diverse fields ranging from the military to industry. His publications appeared in several ranking journals including the IEEE Systems Journal, and the Computers & Industrial Engineering Journal. His total awarded projects exceed $ 9.2 M, including National Science Foundation (NSF), Department of Defense (DOD), Industry, and other Research Laboratories. Dr. Jaradat's work has been recognized in the IISE professional communities.

Terril C. Falls serves as the Associate Director, Software Design and Development for the Institute for Systems Engineering Research (ISER). Mr. Falls previously served as a Research Civil Engineer for the Mobility Systems Branch, Geotechnical and Structures Laboratory, US Army Engineer Research and Development Center (ERDC). He has over 30 years of experience conducting research and designing and developing software in the R&D fields of Vehicle Mobility Modeling, Modeling and Simulation, Command and Control, Terrain Analysis, and Military Logistics. As the Associate Director, Software Design and Development, Mr. Falls provides technical leadership of software design, development, architecture, implementation and integration and is also responsible for developing and enhancing relationships with federal, state, local governmental and private sector partners. Mr. Falls has a B.S. in civil engineering from Mississippi State University.