**ABSTRACT**

Manufacturers face significant challenges during emergencies, such as pandemics, when surging demand for critical products like personal protective equipment (PPE) or ventilators overwhelms traditional supply chains, leading to disruptions and resource shortages. Rapid reconfigurability of manufacturing supply chains is vital for manufacturers to sustain operations and gain competitive advantages during such crises. However, achieving effective reconfiguration involves addressing two key challenges. First, supply chain reconfiguration requires integrated decision-making across two stages: (1) process planning to determine manufacturing tasks and material flow, and (2) task assignment to suppliers and manufacturers. Traditional approaches handle these decisions sequentially, neglecting their interactions and often resulting in suboptimal outcomes. Second, the lack of detailed reconfiguration cost data, especially in the early stages of production planning during emergencies, limits the applicability of existing models, which often rely on complete data for optimization. This dissertation addresses these challenges by investigating two strategic approaches for supply chain configuration in emergency scenarios: (1) factory-in-a-box manufacturing, which utilizes mobile factory modules to enable on-site production near customer locations, and (2) repurposing existing supply chains to form new configurations for high-demand products, maximizing resource reuse. Furthermore, this research extends the factory-in-a-box concept to healthcare services by developing a "hospital-on-wheels" scheme, where mobile hospital units deliver life-saving services to patients on-site. Different from manufacturing, this approach addresses demand uncertainty across locations by formulating a two-stage robust optimization problem. To overcome the data limitations, this research represents the joint decisions by a supernetwork or assembly hierarchy graph for process planning. Then it introduces a novel graph-based similarity metric to evaluate the similarities among assembly hierarchies or supernetworks, enabling the approximation of reconfiguration costs without requiring detailed data. Similarity metrics customized for each strategy guide the formulation of integrated decision-making problems using nonlinear integer programming, jointly optimizing process planning and supplier/manufacturer selection. All the problem formulations, guided by similarity metrics, involve highly nonlinear integer programming, rendering traditional methods such as branch-and-bound ineffective. To address this challenge, customized metaheuristic algorithms are developed to solve these problems efficiently with computational feasibility. The outcomes of this research provide quantitative tools for integrated process planning and supplier selection, enhancing the adaptability of practitioners in mitigating supply chain disruptions. By addressing emergency production challenges, the proposed solutions can help preserve manufacturing jobs, sustain business continuity, and improve responsiveness to crises.