Readiness Versus Cost Tradeoffs for Additive Manufacturing in a Spare Parts Supply Chain

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Additive manufacturing (AM) is an emerging technology with disruptive implications in supply chain dynamics that is just starting to be realized. With AM technology, a specific classification of parts can be produced quicker and at lower incremental costs than traditional methods. This technology permits augmenting a spare parts supply chain by allowing downstream locations removed from suppliers to rapidly replace parts that would normally require significant lead times. This research aims to analyze the improvement in readiness and cost that AM could provide for various supply chain designs and for different demand classifications.

The research evaluates the impact of AM in a pilot study with three different parts and a supply chain consisting of one traditional manufacturer, three distribution centers, and two service locations. Part demand is generated for each service location and is filled either by AM machines or from the traditional manufacturer via distribution centers. The model explores a total of 32 different network designs which specify the location and configurations of AM at distribution centers and service locations. Part demand is intermittent and classified using average demand interval (a measure of how often nonzero demand periods occur) and squared coefficient of variation (a measure of variance among nonzero demands) to extract best design insights by demand type. A hybrid procedure uses state-of-the-art demand forecasting and a mixed integer linear program to determine an optimal inventory policy for each demand classification. That policy is then fixed in a Monte Carlo simulation that evaluates many possible demand outcomes over a planning horizon to obtain readiness and cost metrics using a frontier-based approach.

The two main metrics output by the model are total cost—which encompasses overhead, material, and transportation costs—and total backorders, which measures unfilled demand volume over a single time period. Preliminary results lead us to expect AM will increase costs in the short run, but will increase readiness and decrease long run costs for more erratic part demands. The most important demand characteristic proves to be the volatility of nonzero demand periods, which is measured by the squared coefficient of variation. Scenarios with larger variation have increased backorders and therefore, benefit greatly from the introduction of AM. For parts with predictable demand however, AM leads to very little improvement.

The next logical step to employ this model is to utilize it in military logistical situations that have large scale, global implications. In forward deployed scenarios, readiness is essential for all equipment. Additionally, resupplies take even longer and are extremely costly due to the distance from the continental US. The implications of employing AM in these situations would drastically improve the military's warfighting capabilities. After designing realistic deployed scenarios with multiple stage supply chains, the model would be able to answer where most effectively AM can be constructed and its effects on military logistics as a whole.

References:

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