Building systematic context and physical interoperability for decentralized, human-driven supply chain design and operations

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Engineers have a vibrant history of designing, operating, and improving supply chains, the complex large-scale interconnected networks that ensure the right materials, information, and money are exchanged to fulfill customer requests. However, as we have seen in the face of the COVID-19 pandemic, new engineering advances are needed to support the creation of more resilient supply chains. This is challenging because supply chains are not designed nor operated by a single entity. Instead, supply chains evolve through a set of decentralized, yet interconnected and interdependent decisions. Individual supply chain entities, such as a supplier, manufacturer, distributor, retailer or government entity, must make decisions in dynamic and uncertain environments, where the full systematic, end-to-end impact of their decisions is not fully under their control, and instead is impacted by the actions of others. As we experienced in response to supply chain challenges during COVID-19, decentralized actions, often well intended, were made too often with local, short-term information and relied heavily on people to execute the processes. Without visibility into the systematic context nor scalable processes, even with the best intentions, a single entity alone cannot build a resilient supply chain. And here in lies two central engineering challenges: first, resilient supply chain design requires human decisions makers to be provided with the systematic context of how their local decisions impact interconnected, interdependent supply chains, and second, the physical world must also adapt so that more agile and dynamic decision making can be executed at scale.

Because of their ability to better understand the systematic context of interconnected and interdependent decisions, model-based supply chain design and operations can help with the first engineering challenge. To provide better visibility and predictive capabilities into supply chain actions, much-needed digitally connected, collaborative decision-support solutions, as well as common infrastructure, data models, data engineering and integration are emerging. Optimization-based models can recommend the best systematic decisions when there are finite resources, combinatorically many options, and interrelated decision trade-offs, a task notoriously challenging for human decision makers. While much progress has been made to make data-informed and model-driven decisions, due to a supply chain's decentralized, human-driven, competitive and adaptive nature, it is highly unlikely that individual supply chain decision makers will ever have access to a fully aware, ground truth of knowledge across an entire supply chain. Instead, human decision makers will likely have access to richer local contexts, and entity-specific knowledge and goals, and so it critical that model-based supply chain design advances establish more human-centered approaches that combine the power of analytics and data with human ingenuity and adaptability. Further, the full potential of digital, mathematical and computational advances can only go so far in supply chains if the physical world does not also change. Supply chains, after all, are not solely a virtual enterprise. For supply chains to become more resilience to disruptions, our procurement processes, manufacturing systems, transportation infrastructures, supply chain facilities, logistics and distribution networks, and equipment, as well as the management systems and business models that support resource acquisition, allocation and deployment across the supply chain must also advance to become more connected, interoperable, agile, modular, and reconfigurable.

This presentation will (i) provide an overview of current engineering challenges to supply chain resiliency, (ii) highlight projects supporting future supply chains to be more human-centric, model-based, data-informed, adaptive, and thus more resilient to future disruptions, and (iii) be a call to action to engineers to contribute their expertise. While analytical, data-informed, and model-based approaches are emerging for supply chains, open challenges still exist in how best to create human-centric systems that provide systematic supply chain context to decentralized supply chain decision makers and how to translate the modularity and plug-and-play nature of electronic resources to physical and human-driven supply chains.