11-9-2020

An Open Online Product Marketplace to Overcome Supply and Demand Chain Inefficiencies in Times of Crisis

Karl R. Haapala
Oregon State University

Kyoung-Yun Kim
Wayne State University

Gül E. Okudan Kremer
Iowa State University, gkremer@iastate.edu

Rony Kubat
Tulip Interfaces, Inc.

Roy Shilkrot
Tulip Interfaces, Inc.

See next page for additional authors

An Open Online Product Marketplace to Overcome Supply and Demand Chain Inefficiencies in Times of Crisis

Abstract

Digital tools for design and manufacturing have led to a new revolution in how products are conceptualized and made. These advancements have led to the democratization of ideation and creation of personalized products, as well as many other innovations. However, the coronavirus disease 2019 (COVID-19) pandemic has exposed a critical flaw in the digital thread: the manufacturing systems of today remain inflexible to rapid changes brought on by emergency and crisis responses. The inefficiencies of this inflexibility caused by disconnects in supply and demand chains have become especially evident. We present a vision for a digital system—an open online product marketplace—that would enable product designers to rapidly connect with capable producers in meeting urgent customer demands. As such, this digital system would facilitate ordering, orchestration, and fulfillment, as well as continuous improvement of manufacturing-as-a-service systems. It would support flexible, sustainable, and resilient supply and demand chains beyond the COVID-19 period by enabling rapid specification matching for tailored or customized products to existing available manufacturing capabilities.

Keywords

COVID-19, Emergency and crisis response, Manufacturing-as-a-service, Online marketplace, Supply chain optimization

Disciplines

Emergency and Disaster Management | Industrial Engineering | Manufacturing | Systems Engineering

Comments

This is a manuscript of an article published as K. Haapala, K. Kim, G. Kremer, R. Kubat, R. Shilkrot, and F. Sciammarella, "An Open Online Product Marketplace to Overcome Supply and Demand Chain Inefficiencies in Times of Crisis," *Smart and Sustainable Manufacturing Systems* 4, no. 3 (2020): 299-302. DOI: 10.1520/SSMS20200055. Posted with permission.

Authors

Karl R. Haapala, Kyoung-Yun Kim, Gül E. Okudan Kremer, Rony Kubat, Roy Shilkrot, and Federico M. Sciammarella

An Open Online Product Marketplace to Overcome Supply and Demand Chain Inefficiencies in Times of Crisis

Karl R. Haapala[1], Kyoung-Yun Kim[2], Gül E. Okudan Kremer[3], Rony Kubat[4], Roy Shilkrot[5], Federico M. Sciammarella[6]

ABSTRACT

Digital tools for design and manufacturing have led to a new revolution in how products are conceptualized and made. These advancements have led to the democratization of ideation and creation of personalized products, as well as many other innovations. However, the COVID-19 pandemic has exposed a vital flaw in the digital thread – manufacturing systems of today remain inflexible to rapid changes brought on by emergency and crisis response. The inefficiencies of this inflexibility caused by disconnects in supply and demand chains were especially evident. Herein, we present the vision for a digital system – an open online product marketplace – that would enable product designers to rapidly connect with capable producers in meeting urgent customer demands. As such, this digital system would facilitate ordering, orchestration and fulfillment, and continuous improvement of manufacturing-as-a-service systems. It would support flexible, sustainable, and resilient supply and demand chains beyond the COVID-19 era by enabling specification matching for myriad tailored or customized products to existing available manufacturing capabilities.

[1] School of Mechanical, Industrial, and Manufacturing Engineering, Oregon State University, Corvallis, OR, 97333, USA; 0000-0002-9100-4001
[2] Department of Industrial & Systems Engineering, Wayne State University, Detroit, MI, 48202, USA; 0000-0002-9440-5978
[3] Department of Industrial & Manufacturing Systems Engineering, Iowa State University, Ames, IA, 50011, USA; 0000-0001-8070-825X
[4] Tulip Interfaces, Inc., Somerville, MA, 02143, USA; 0000-0003-1809-1302
5 Tulip Interfaces, Inc., Somerville, MA, 02143, USA; 0000-0001-9154-4254
6 MxD, Chicago, IL 60642, USA; 0000-0002-9128-2917

Keywords

COVID-19, Emergency and crisis response, Manufacturing-as-a-service, Online marketplace, Supply chain optimization

Introduction

The COVID-19 pandemic exposed a vital flaw in US personal protective equipment (PPE) and medical device supply chains[1]. At the onset of the pandemic, consumers were urged not to purchase face masks, hospital workers struggled to adapt to PPE made from materials from home or office supplies, and the government compelled consumer product manufacturers to transition their factory spaces to produce ventilators. Future emergencies will pose similar supply chain challenges as production turnaround speed and centralized demand management are jeopardized by lockdowns and a strained workforce. Unfortunately, in times of such rapid change, free market demand management leads to inefficiencies and inequalities in supply, even under policy tools such as the Defense Production Act, which cannot overcome the will of the market.

An immediate identified need is for a suite of product design and procurement tools delivered through an open online product marketplace. These tools would support flexible, sustainable, and resilient supply and demand chains beyond the COVID-19 era through an extensible service-oriented cloud platform that enables matching of product specifications with manufacturing capabilities. This approach would enable a consumer (e.g., hospital purchasing agent) to identify producers (e.g., PPE or ventilator parts suppliers) and virtually assemble a supply chain in response to a crisis. Such facilitated connections will require demand orchestration algorithms capable of matching supply and demand specifications extracted from multimedia information (e.g., text and sketches), and provide closed-loop order-fulfillment tracking. While

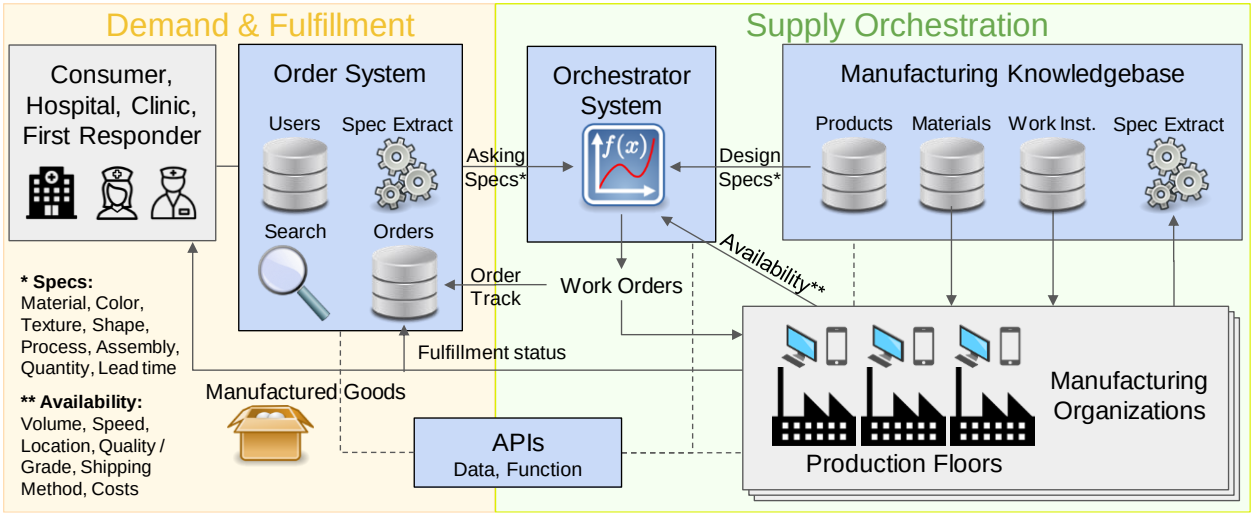
efficiently and equitably meeting the dire needs of consumers during an emergency, such a marketplace would enable manufacturers to benefit from improved accessibility to their products, services, and production resources, even under typical business operations.

Manufacturing-as-a-service has largely failed due to incompatible or limited information architectures and infrastructure to handle manufacturer attributes (specialized equipment, proprietary data, and established supply networks)[2]. Existing approaches are limited by the complexities of integrating supply and demand data, manufacturing capabilities, and product configuration[3]. In fact, no intelligent automated method for matching supply and demand data with information about manufacturing capabilities exists, which has inhibited a distributed rapid response to fulfilling critical product demands.

An open online product marketplace would necessarily include elements to semi-automatically harvest product design and manufacturing information and to perform matchmaking, offering consumers the ability to fulfill their demands from able producers. Algorithms for maintaining a constant, workable strain on producers would ensure capacity utilization and load-balancing between participating manufacturers, as well as knowledge sharing for making the demanded goods. These orchestration algorithms would need to balance the supply-demand market by extracting and matching product specifications, performing manufacturing availability prioritization analysis, and tracking goods distribution.

This envisioned open online product marketplace would encompass 1) a cloud service platform (Fig. 1) using a manufacturing knowledge base constructed from extracted consumer specifications and manufacturing capability information; 2) an orchestration framework for optimizing supply-demand balances based on consumer-and-producer pairings; and 3) an order-fulfillment system for end-to-end engagement.

FIGURE 1. Open Online Product Marketplace Framework.



Developing and integrating these elements within the envisioned framework would require a collaborative effort among academia, industry, standards organizations, and other partners. Once developed, the marketplace would require continuous maintenance, operational management, and oversight to ensure quality and equity of commerce. Realizing this vision would lead to:

- An operational system that will address critical needs by matching of producers and their capabilities with the precise needs of consumers
- Aiding consumers and producers in optimization and decision making
- Swift and easy onboarding of consumers and producers
- Facilitating communities of consumers and producers centered around a variety of product and production domains
- System validation and proofing, as well as bootstrapping of a knowledge base that underpins the matching and optimization algorithms
- Sharing of knowledge accumulated during building the system, knowledge base and algorithms, and scenarios describing uses and benefits.

The potential immediate impact of this envisioned system would be a deployed and working solution with the capacity to handle thousands of concurrent pairings between producers and consumers, all the while tracking the fulfillment of orders and balancing the demand. The system could immediately build upon deployed and tested supply fulfillment mechanisms. With an open online system in place, the greatest impact will come from its widespread use by consumers and producers. Sustained efforts would require engagement of developer and user communities, for example through third-party coordination of university (e.g., through engineering and entrepreneurship courses as well as informal education) and industry (e.g., through incentivizing participation and snowballing or chaining of beneficial membership) partners.

Discussion

An open online product marketplace has the potential to contribute to efficient crisis response, addressing many of the supply and demand challenges witnessed during the COVID-19 pandemic. Currently, significant deficiencies inhibit the linking of existing technologies to facilitate engagement between consumers and manufacturers. A first step that can be taken by the research community is to embark upon production case studies in the B2C (business-to-consumer) context where consumers can provide their own unique specifications for health and medical products, including PPE, ventilators, and other goods. This bootstrapping can lead to an initial database of products and product specifications that can be used to derive and optimize sets of manufacturers that would be capable of meeting these immediate needs. In addition, production gaps (opportunities) can be perceived and met, while designers and engineers can generate product designs that more efficiently and more effectively match with capability sets.

While B2C case studies represent real market needs, ultimately, a robust community would need to assemble around the goal of expanding the database, either manually or automated information gathering (e.g., by crawling manufacturer databases). Use cases will be important to understanding behaviors of individual consumers and manufacturers. For example, examining the highly-relevant PPE product case would allow confirmation of the functionality, performance, and quality of any developed product marketplace environment. Logically, this approach could also be used to identify opportunities for refinement and continuous improvement as listed in Table 1.

TABLE 1. Anticipated Impacts of an Open Online Product Marketplace.

Impact point 1	A highly-available centralized system for dispatching emergency production work orders to distributed manufacturing organizations and consumers throughout the US, tracking the orders and managing their fulfillment in a transparent, timely manner.
Impact point 2	A system that manages supply and demand requirements, with both microscopic inputs (e.g. a hospital that says "We need 10k gowns") and macroscopic (e.g. "NY will need 30k ventilators by…"), while providing an optimized environment for all parties, both manufacturers and consumers. Optimal operation means organizations do not reach critical failure states, maintaining their work procedures based on their capabilities, in terms of volume, speed, location, etc.
Impact point 3	A system that unifies capabilities (specifications) for product and manufacturing mechanics of emergency response goods, such as PPE. The system will provide both "search engine" like interface, as well as automatic matchmaking between consumer and producer based on the unified specifications.
Impact point 4	A system to support and reduce the barrier for manufacturers to change their operations to fill new requirements during an emergency event, and start getting orders without jeopardizing their business. The system is flexible and conforms to the changing state of manufacturing organizations in emergency situations, e.g., changing number of employees or reduced capacity due to safety matters.
Impact point 5	A decentralized manufacturing-data collection system where any organization (consumer or producer) can interface smoothly, and third-party analysis organizations (e.g., government or non-profit) can utilize the data collected in the system for tertiary business impact.

Use cases will also enable prior detailed examination for input products. Further, user studies can observe behaviors and data flow between the parties (consumers, manufacturers, and

mediators) to develop appropriate interfaces and underlying software architectures. Such studies can be supplemented with user interviews (allowing exploration of direct interactions), and can provide requirement definition for facilitating fruitful and "serendipitous" interactions between consumers and manufacturers.

COVID 19, with its ongoing impacts to production, logistics and all surrounding service systems, exposed the multi-faceted vulnerabilities of critical supply chains. Research and technology development investments to respond to these vulnerabilities should allow nimble reconfigurations of supply chains for known, and to be developed products, where each node of the supply chain has well-defined core competencies and flexible interface capabilities.

References

1. M. L. Ranney, V. Griffeth, and A. K. Jha, "Critical Supply Shortages — The Need for Ventilators and Personal Protective Equipment during the Covid-19 Pandemic," New England Journal of Medicine, 382, no. 18 (April 2020): e41. https://doi.org/10.1056/NEJMp2006141.

2. A. James, and J.-Y. Chung, "Business and Industry Specific Cloud: Challenges and Opportunities." Future Generation Computer Systems, Special Section: Business and Industry Specific Cloud, 48 (July 2015): 39–45. https://doi.org/10.1016/j.future.2014.12.006.

3. V. Shapiro, M. Behandish, and D. Crawford. 2017. *Report on the First Cybermanufacturing Workshop on Enabling Composable & Modular Manufacturing through Abstractions: Where Computer Science Meets Manufacturing*, (International Computer Science Institute (ICSI) Berkeley, CA, June 2-3, 2016), October 30, 2017. https://www.icsi.berkeley.edu/icsi/sites/default/files/Cyber%20Manufacturing%20WorkshopReport%20-%20Final%202017-10-30.pdf

Recommended citation:

K. Haapala, K. Kim, G. Kremer, R. Kubat, R. Shilkrot, and F. Sciammarella, "An Open Online Product Marketplace to Overcome Supply and Demand Chain Inefficiencies in Times of Crisis," *Smart and Sustainable Manufacturing Systems* . Published ahead of print, November 09, 2020, https://doi.org/10.1520/SSMS20200055.