Special Issue in the *Journal of Operations Management*: Call for Papers

The Digitization of Manufacturing

1. Motivation

'Digitization of manufacturing' refers to the salient and evolving role of digital tools and artifacts in the design, sourcing, manufacturing, configuration, delivery, and eventually, repair, refurbishment, or renewing of products. Examples of the technologies associated with *digital manufacturing* (DM) include: object-oriented and three-dimensional CAD which is now universally used for product design in aerospace and automotive industries, and widely applied in other sectors; additive manufacturing (also known as '3D printing') used in rapid prototyping and increasingly, manufacturing and after-market parts; shop-floor connectivity and technologies that enable connected sourcing, order flows, and production planning and control in real time. Real opportunities emerge when these technologies converge and interact. For example, digital design along with additive manufacturing enables the production of parts without the intermediate role of production engineering, tooling, batching, or scheduling issues associated with traditional manufacturing. In combination with other emerging practices like web-based services, real-time sensors, and connected material flows (also referred to as 'industry 4.0' or the 'internet of things'), digital manufacturing is poised to fundamentally challenge established theories and practices of the manufacturing firm. Beyond transforming how products are designed and manufactured, it can deliver new approaches to managing the supply chain, and facilitate new value propositions with the customer (de Jong and de Brujin, 2013; Anderson, 2013; D'Aveni, 2015; Baur and Wee, 2015; Porter and Heppelmann, 2015). The impetus for this special issue is the rapidly expanding role that digital technologies play across many industry sectors (Bloomberg, 2013; Shinal, 2013; Economist, 2012, 2013; Wohlers, 2015), and the challenges and opportunities these changes present for theory.

A widespread adoption of DM has the potential to drive structural shifts in the supply chain, with important implications for Operations and Supply Chain Management (OSM) research. It offers great promise in manufacturing through enhanced product customization, the circumvention of tooling, the rationalization of multi-step manufacturing processes, and the potential for relocation and redistribution of manufacturing operations. DM alters the role of customers in the value chain, with companies like Shapeways, Materialise and others increasing opportunities for consumers to upload their own design requirements, consumer-to-consumer transfer of product designs, and real-time customization of both product architectures and design materials (Boston Consulting Group, 2015).

Our theoretical understanding of the implications of the digitization of manufacturing lags behind its rate of adoption in practice. Current research has focused largely on describing the evolution in the DM technologies and their applications. However, the theoretical implications of the combination of digitalization of design and direct manufacturing of parts for the OSM field are not well understood. DM has the potential to alter how firms think about traditional OSM practices, including inventory management, production scheduling, routing, and batch sizing. Functionality (rather than manufacturing process constraints) may drive design processes, opening up significant opportunities to extend existing theoretical work on optimal firm strategy and supply chain design. For example, for supply chain theory, the design-build-deliver model and related approaches (cf. Petrick and Simpson, 2013) will need to incorporate the role of DM in the sourcing and testing of product designs, contract manufacturing, and localization of production and suppliers. As another example, DM will require a recasting of the product-process matrix (Skinner, 1969; Safizadeh et al., 1996), as DM enables the rapid iteration between virtual and physical concepts.

In addition to presenting opportunities and challenges to broadly used OSM theories, DM also opens up more significant roles for theories that have traditionally played but minor roles in our field. Examples include societal-technical changes with localized and democratized design and production, as well as demand-driven and customized product design and on-demand logistics supply. From a technology standpoint itself, we see the emergence of a new industrial eco-system that will be critical for DM to have an impact. This special issue is focused on understanding the theoretical implications brought about by the recent evolution in DM. Given the potentially transformative role of its core technologies the issue will have a particular emphasis on theoretical implications that these changes will bring to all levels of OSM theory and practice.

2. Scope

The potential for DM's impact on manufacturing operations and its supply chains in general has been recognized (see Hopkinson et al., 2006, and others), but there is as of yet little mid-level theory on its introduction in specific OSM domains. Novel insights related to DM are likely to force a recasting of existing intermediate and mature theory in manufacturing and supply chain management (Edmondson and McManus, 2007). The main objective of this special issue is to identify novel theoretical insights for the OSM field related to the digitization of manufacturing.

The following list provides a few examples of potential research areas that may capture the effect of DM on key areas of OSM theory:

- Theoretical implications of DM for the changing role of economies of scale and scope in manufacturing: For example, as the adoption of additive manufacturing increases in a sector, what are the implications for the role of learning curves, optimal scale, or the balance of forecast and order-driven production?
- Encapsulating design and manufacturing instructions into one digital file: This allows for the rapid transfer of design and manufacturing information. What are the implications of this change for theory? Examples might include new ways of thinking about volume flexibility, new approaches to managing product architectures, and new supply chain dimensions.
- Comparisons of additive manufacturing with the adoption and emergent role of earlier manufacturing technologies and approaches (e.g. machine tools, lean production) to develop novel theory regarding the adoption, acceptance, and performance implication of new OSM techniques at the firm level or the supply chain.
- The integration of additive manufacturing into traditional manufacturing processes: So far additive manufacturing has predominantly resided within the product development department. As its role in the manufacturing and customization process increases, what are the theoretical implications for the product/ process translation or intra- and inter-firm power dynamics?
- Implications of DM on core OSM concepts such as inventory management, lot sizing and routing problems, and production planning and control concepts at the interface between DM and non-DM flows: For example, what are the implications of real-time sensor data and connectivity for theories associated with domains like production planning and control, and inventory management?
- The influence of DM on firm boundary decisions, in terms of location decisions, shifts in supply chain structures and power constellations within buyer-supplier relations (BSRs): What are the theoretical implications of combining additive manufacturing with traditional multi-echelon

supply chains? How could additive manufacturing alter the traditional location logic in manufacturing?

- DM enables increased involvement of the customer in the design process, rapid prototyping, and the ability to update products on a near-continuous basis. What theoretical insights may be derived from more fluid boundaries between the customer and the product design process?
- DM enables novel business models associated with among others, on-demand supply, capacity pooling, contract manufacturing, and aftermarket logistics. How do these new models inform existing theory in this space?

The guest editors are open to a variety of methodological approaches including case studies, industry studies, real-world experiments, and novel approaches such as design science (see Holmström and Ketokivi, 2009). A core requirement for all papers is to contribute to the development and extension of OSM theory; conceptual papers, case studies that only discuss the application or implementation of DM without offering clear theoretical insights, or modeling papers without empirical validation, will not be considered.

Authors interested in submitting their paper to this special issue are strongly encouraged to revisit JOM's mission statement at http://www.journals.elsevier.com/journal-of-operations-management, as well as recent editorials on methodological criteria (see for example Guide and Ketokivi, 2015) at http://www.journals.elsevier.com/journal-of-operations-management/news/notes-from-the-editors, prior to submission.

3. Submission and review process

Authors are requested to submit their full paper via the journal's online submission system at http://ees.elsevier.com/opeman, clearly indicating in their cover letter that they wish to submit to this special issue. The deadline for submission is **May 15, 2017.** All manuscripts will be subject to the regular review process of JOM.

4. Guest editors

Jan Holmström is Professor of Operations Management at the Department of Industrial Engineering and Management at Aalto University, Finland. Jan's main research interest is on the impact of technology on operations management concepts and practices.

Matthias Holweg is Professor of Operations Management at Saïd Business School at the University of Oxford, UK. Matthias is interested in the evolution and adaptation of process improvement methodologies, and the enabling role that DM technologies can play in this context.

Benn Lawson is Associate Professor in Operations Management at Judge Business School at the University of Cambridge, UK. Benn's research focuses on supply chain strategy, and managing the product design-supply chain management interface.

Frits Pil is Professor of Business Administration at Katz Graduate School of Business at the University of Pittsburgh, USA. Frits' research focuses on value creation and knowledge management.

Stephan Wagner is Professor of Logistics Management at the Department of Management, Technology, and Economics at ETH Zürich, Switzerland. Stephan's recent research is centered on risk and innovation in supply chains and buyer-supplier relationships.

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