Towards the next generation of Manufacturing: Implications of Big Data and Digitalization in the context of Industry 4.0

Editorial

1. Introduction

Industry 4.0 has come as a consecutive and predicted outcome of the previous industrial periods, recently dubbed Industry 1.0, 2.0 and 3.0 (Pereira and Romero, 2017). As an expected outcome, companies were proactively prepared for the transformational potential of this opportunity by defining in advance the most suitable manufacturing models, operational processes and targets – coming prepared for the associated challenges (Almada-Lobo, 2016; Pereira and Romero, 2017). From a technical perspective, the context of Industry 4.0 can be described as 'increased digitisation and automation in addition to increased communication enabled by the creation of a digital value chain' (Oesterreich and Teuteberg, 2016, p. 122). While not a fully agreed term, 'Industry 4.0' is still a 'slippery' concept (Pereira and Romero, 2017), however undoubtedly the term 'Industry 4.0' is an evolving trend and attracted increasing interest from both practitioner and academic communities (Liao et al., 2017; Fatorachian and Kazemi, 2018). Industry 4.0 primarily includes the internet of things (IoT), cloud and cognitive computing, and digital manufacturing and cyber-physical systems that collect, transfer and make sense of Big Data (Zhou *et al.*, 2015) in order to develop smart industries and respond to fluctuations in the markets' demands for high-quality products. Industry 4.0 has been used in manufacturing and in the car industry by companies such as BMW and Jaguar Land Rover, and also in the food industry by companies such as Mondelez and Nestlé to enhance their overall operational efficiency.

While literature has acknowledged the power of Big Data and the implied disruption in the product and service models (Baines et al., 2017; Papadopoulos et al., 2017; Spanaki et al., 2018; Yoo et al., 2012), Industry 4.0 implies a wave of innovation. There are potential opportunities for organizations and supply chains to innovate, to create strategic advantage and to generate new business value from the data (Gandomi and Haider, 2015), but a rigorous approach of the associated disruption is still missing (Fatorachian and Kazemi, 2018; Santos et al., 2017). The aim of this Special Issue is to facilitate an ongoing discussion for researchers or practitioners, to showcase their findings, and to explore the implementation of advanced and emerging technologies in the next generation of manufacturing and the wider implications of Industry 4.0 in production planning and operations management.

2. Contributions to the special issue

The response to our call for papers for this SI was tremendous. There were exceptional papers, but some were out of scope and therefore had to be rejected. The rest of the manuscripts underwent review by two reviewers at least. Based on the reviewers' comments and our own reading of the manuscripts, authors were invited to revise and resubmit their papers. After two or three rounds of reviews, we selected twelve papers out of eighty in the SI. These were grouped in four themes:

2.1 The disruptive potential of Industry 4.0 in production processes, planning and control.

These papers discuss the disruptive potential of Industry 4.0 in turbulent contexts and highlight the importance of Industry 4.0 for sustainability in turbulent times.

In the first paper Barlette and Baillette discuss the capabilities that result from the use of Big Data Analytics (BDA) which are critical in turbulent environments, in the context of the Industry 4.0 revolution, especially with regards to agility and performance. From a managerial point of view, the paper highlights the role of top management in achieving organizational changes required to embrace BDA.

Ogbuke et al. review the literature on Industry 4.0 with a focus on big data in supply chain management and discuss the benefits of BDA for organisations and society. Furthermore, they discuss the ethical, security, privacy and operational challenges of big data techniques as well as the dark side of big data that may bring potential dis-benefits to businesses. Four facets of big data were identified and analysed based on a review of the literature, that is, big data analytics, applications, ethics and privacy issues, as well as the role of big data in predicting the future of businesses and move resources and capabilities to the required direction. The authors argued for the importance of big data to transform businesses in an increasingly challenging and uncertain environment.

Hughes et al. argue that despite the plethora of new technologies, the multi-faceted nature of Industry 4.0 and new technologies needs to be balanced with the aim to remain operationally effective and sustainable. They review the literature on Industry 4.0 in relation to sustainability and contribute to the debate of the links between Industry 4.0 and sustainability by offering and discussing an innovative Industry 4.0 framework and alignment of Industry 4.0 themes with the UN Sustainability Goals.

2.2 The adoption of Industry 4.0 for operational efficiency, productivity and performance

Moradlou et al. examine issues related to the collaboration between buyers and suppliers during the adoption of emerging technologies. They adopt the relational view and study how a high-tech firm from the aerospace sector developed additive manufacturing technology. In contrast to the literature on the collaboration between buyers and suppliers in the supply chain, this paper argues that the regular interaction between buyers and suppliers does not necessarily lead to information and knowledge sharing during the development of emerging technologies. Rather, the freedom of using intellectual property in non-competing industries and guarantees of future business are key to knowledge sharing and exchange and for the success of the adoption.

Davies et al. examine the development of additive manufacturing as a supply chain solution, that allows for the management of complexity and for products and supply chains to adapt efficiently and effectively close to context of use. This is done through a single case study, drawing upon design change data and in-depth interviews with industry experts. The findings of the paper suggest that, in contrast to the view of the literature claiming that tangible products are fixed and intangible service elements adapt to absorb variety, it is that tangible products as well can absorb variety to meet emergent need.

Fosso-Wamba and Queiroz focus on Blockchain diffusion across supply chains. They offer a multi-stage model of adoption (intention, adoption, and routinisation stages) that facilitates the adoption of Blockchain, drawing on diffusion of innovations theory, the resource-based view, dynamic capability, the technology adoption model, and the institutional theory. The model is then validated using PLS-SEM applied in Indian and US organisations. The authors illustrate the different variables and their implications that need to be considered in each of the stages and highlight the role of the context (i.e. country) in the diffusion. For instance, within the intention stage Indian organisations highlighted perceived benefits, top management support, absorptive capacity, and trust as the most critical variables, whereas for US organisations it was only perceived benefits and trust.

Kucukaltan et al. argue towards the importance of Industry 4.0 for logistics service providers (LSPs). With regards to this sector, they conduct a structured survey in the Turkish logistics industry. A follow up then took place through an integrative interview survey, where the probabilities and the impacts of Industry 4.0 were discussed. The contribution of this study lies in demonstrating the role of Industry 4.0 for LSPs but also the possible changes in the logistics industry from the operational, financial, and human resources aspects.

Rahman et al. focus the role of Industry 4.0 in enhancing organizational performance in the cargo logistic business (service sector) in Bangladesh and Canada. They use the Technology-Organization-Environment (TOE) framework, as shaped by the institutional theory. Through purposive sampling a total of 210 (105 each) survey questionnaires, as completed by employees working in logistics companies, were gathered. The paper argues no matter if the two contexts are

totally different, businesses should enact Industry 4.0 to gain benefits both in short-term (day-to-day operations) and long -term strategic planning.

Robert et al. discuss the weaknesses of Industry 3.0 performance management systems with regards to its omission of the human factor when they argue that the inclusion of the human factor is *sine qua non* to understanding Industry 4.0 performance management systems. They used a case study of an organisation that dealt with the issues of Industry 3.0 using a grounded theory approach (Glasser and Strauss, 1967) based on a thorough and comprehensive literature review followed by practical observations of a performance management system within Schneider Electric. The contribution of this paper is twofold: firstly, it presented a model of performance management that was implemented successfully by Schneider Electric to deal with the repercussions of the organizational transition to an Industry 4.0; and secondly, it highlights the importance of human factors which are very important for sustainable Industry 4.0 performance management systems.

Wiech et al. look at the relationship between the implementation of Industry 4.0 related technologies and performance, as well as the role of the organisational structure in this relationship. Following a review of the literature, a set of hypotheses were developed, then tested with 116 participants from German-speaking countries. The findings do highlight the link between technology and performance as these technologies have distinct, partially unexpected, performance effects. Additionally, the authors found that organisational structure does not play a significant role in technology adoption.

2.3 Industry 4.0 technologies and sustainability

Felsberger et al. investigate the impact of the implementation of Industry 4.0 on the sustainability dimensions of European manufacturing industries. They propose a framework that combines the firms existing and new dynamic capabilities, competencies and market requirements to achieve sustainable competitive advantage. The authors collected and analysed data from six European Manufacturing industries including aerospace manufacturing (AM) and electronic component and systems (ECS) manufacturing. The contribution of this paper lies in revealing the relationships between Industry 4.0, the dynamic capabilities of the firm, and distinct dimensions of sustainability. The dynamic capabilities mediate the impact Industry 4.0 on economic, environmental, and social aspects.

Finally, the paper by Kayikci et al. completes our SI. This paper focuses on food supply chains and the role of Industry 4.0 in tracing the food across the whole supply chain from the farm through processing until it reaches the customer and, thus, ensure transparency. The study recognises the opportunities and challenges related to the adoption of blockchain technology in the food supply chain, based on qualitative research and semi-structured interviews with stakeholders from the food industry in India and Turkey with an interest in tracking, or who had

used blockchain before. Then a semi-structured questionnaire was developed with twelve major questions which covered aspects of people, process, performance, and technology. Hence, this study contextualizes PPT theory in an emerging economy to show the interaction effect of technology to strengthen the relationship between people, process, and performance.

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References:

Almada-Lobo, Francisco. 2016. "The Industry 4.0 Revolution and the Future of Manufacturing Execution Systems (MES)." *Journal of Innovation Management*.

Baines, T., Bigdeli, A., Bustinza, O.F., Shi, V.G., Baldwin, J., & Ridgway, K. (2017). Servitization: revisiting the state-of-the-art and research priorities. *International Journal of Operations and Production Management* 37, 256–278.

Fatorachian, H. & Kazemi, H. (2018) A critical investigation of Industry 4.0 in manufacturing: theoretical operationalisation framework, *Production Planning & Control*, 29:8, 633-644.

Gandomi, A., & Haider, M. (2015). Beyond the hype: Big data concepts, methods, and analytics. *International Journal of Information Management* 35, 137–144.

Lamba K. & Singh S. P. (2017) Big data in operations and supply chain management: current trends and future perspectives, *Production Planning & Control*, 28:11-12, 877-890.

Liao, Y., Deschamps, F., de Freitas Rocha Loures, E. & Ramos, L.F.P. (2017) Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal. *International Journal of Production Research*, 55:12, 3609-3629.

Oesterreich, T D, and F Teuteberg. 2016. "Understanding the Implications of Digitisation and Automation in the Context of Industry 4.0: A Triangulation Approach and Elements of a Research Agenda for the Construction Industry." *Computers in Industry* 83: 121–39.

Papadopoulos, T., Gunasekaran, A., Dubey, R., & Wamba, S.F., (2017). Big data and analytics in operations and supply chain management: managerial aspects and practical challenges. *Production Planning & Control*, 28: 11-12, 873-876.

Pereira, A. C., and F. Romero. 2017. "A Review of the Meanings and the Implications of the Industry 4.0 Concept." *Procedia Manufacturing*.

Santos, M.Y., Sa, J.O., Andrade, C., Lima, F.V., Costa, E., Costa, C., Martinho, B., & Galvao, J. (2017). A Big Data system supporting Bosch Braga Industry 4.0 strategy. *International Journal of Information Management* 37, 750-760.

Spanaki, K., Gürgüç, Z., Adams, R., Mulligan, C. (2018). Data supply chain (DSC): research synthesis and future directions. *International Journal of Production Research,* 56:13, pp.4447-4466

Yoo, Y., Jr, R.J.B., Lyytinen, K., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization Science* 23, 1398–1408.

Zhou, K., Liu, T., & Zhou, L., (2015) Industry 4.0: Towards Future Industrial Opportunities and Challenges, 12th International Conference on Fuzzy Systems and Knowledge Discovery (FSKD), 2147-2152, 10.1109/FSKD.2015.7382284.