Editorial: Performance measurement and management in Industry 4.0: Where are we? What next?

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In the last few years, a new industrial revolution has been emerging termed the Fourth Industrial Revolution or Industry 4.0. This is recognized a great challenge for all organisation types and many countries are planning huge investments to increase the adoption of an integrated set of innovative technologies (i.e. big data analytics, cloud services, 3D printing, cyber security, autonomous robots, Internet of things, augmented reality, simulation, horizontal and vertical integration).

The important role of the Industry 4.0 phenomenon of organisations is widely described by scholars and practitioners. However, whilst there is a large consensus concerning the fact that Industry 4.0 investments will significantly affect the way organisations manage the business performance, operations and supply chains, the literature does not provide sufficient insight into the understanding of how Industry 4.0 influences managerial practices.

Performance measurement systems and performance management practices (PMM) are recognised as essential to bring improvements in the form of efficiency and effectiveness to organisations (Neely *et al.*, 1995; Smith and Bititci, 2017; Bourne *et al.*, 2018), and recent research highlight the need to revise PMM to face the new business trends (Garengo *et al.*, 2022; Nudurupati *et al.*, 2021; Sardi *et al.*, 2019). However, there has been little research into how the Industry 4.0 technologies are affecting the way organisations measure and manage performance. In this scenario, we reflect on performance management and measurement in Industry 4.0 to understand where we are and what could be next.

First, the question "What are the theoretical underpinnings of PMM literature?" has been addressed by Demartini and Taticchi. They carry out a bibliometric review of the existing performance measurement and management literature, to investigate the current state of research, looking at popular theories in more detail.

The findings give an overview of the main theory dominating the PMM field with a dive into the most relevant theories for PMM in the Industry 4.0 context. Agency theory, stakeholder theory, resource-based view, contingency theory and institutional theory emerge as the main theory. With particular attention to the design of PMM for Industry 4.0 environments, the study suggests the use of dynamic capability theory as this theory supports the understanding of the firms' ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments.

Second, the question "how does the maturity of SMEs' manufacturing processes interplay with performance measurement system and performance management practices, in the context of Industry 4.0?" has been investigated. The study identifies a maturity model evaluating the link between manufacturing processes and PMM in small and medium-sized enterprises (SMEs). Then, a qualitative empirical investigation on 12 SMEs shows that technical excellence in manufacturing processes is still perceived as the most relevant factor in SMEs and not enough attention is given to managerial processes such as PMM. The delay in the development of the participative and democratic approaches required by digitalisation underlines the need to further exploit performance management practices related to the culture of data, employee knowledge, motivation, empowerment and teamwork etc.

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Third, the question "how information and communication technologies (ICT) can contribute to empowerment in an Industry 4.0 settings" has been investigated by Korsen and Ingvaldsen. The authors studied a leading Norwegian manufacturing organisation that has highly automated production and an integrated ICT platform. Using Smith and Bititci's (2017) framework for PMM, the data analysis shows how advanced ICT reinforced both performance measurement systems and performance measurement practices. Advanced ICT not only favours the maturity of PMS but, at the same time, the development of the ICT platform favours empowerment. The automated collection, analysis and reporting of performance data free up middle managers' time so that they, together with operators, can drive continuous improvement. So in Industry 4.0 context, middle managers play a key role in empowering operators through continuous improvement.

Finally, the question "how do the different groups of ICT and Industry 4.0 technologies affect the firm's knowledge-related performances" has been addressed by Capestro, Bettiol, Di Maria and Micelli. In this study, the authors carried out a survey to investigate how the different groups of ICT and Industry 4.0 technologies affect the firm's knowledge-related performances to show how knowledge can become a measure of successful technology use. As the use of different technologies enhances the creation and monitoring of new knowledge within the operation department and processes, the study highlight that digitalisation of the firm's manufacturing internal processes can improve the development and management of knowledge on multiple levels. Manufacturing ICT are also important technologies for knowledge, with a slight interaction effect of both technologies on the co-creation process. Industry 4.0 technologies affecting production processes require a certain capability of employees to automatically, autonomously add value to new products and new manufacturing solutions. In other words, Industry 4.0 technologies affect the knowledge-related performances in the production domain (improvement of production process, job-related learning and co-creation).

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