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Editorial

Sustainable Product Lifecycle: The Role of ICT

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Abstract: In this paper, we introduce the themes addressed and the approaches used in the Special Issue entitled "Sustainable Product Lifecycle: The Role of ICT". Specifically, by offering multiple perspectives of analysis, this work increases our comprehension and understanding of the role of information and communications technologies (ICTs) in enhancing sustainable product lifecycle.

Keywords: sustainable product lifecycle; product lifecycle management; ICT; green supply chain; new product development

1. Brief Background of the Special Issue

Several definitions of sustainable development have been proposed over time [1], characterizing a process of change in which the exploitation of resources, the direction of investments, and the orientation of technological development are made consistent with future as well as present needs. Sustainability became one of the most important challenges for managers and scholars, given the great impact of its outcomes on the quality of life and the wide variety of fields in which the concept has been applied [2,3].

Markets are increasingly demanding sustainable products and services, as well as additional information about the environmental qualities of the products and services that consumers use [4–6]. To meet such expectations, modern management requires sophisticated tools that can improve the monitoring of the environmental traits of products and services in order to understand how these products and services can be made more sustainable. According to several authors (e.g., [7–9]), the optimization of environmental impacts of products and services along their lifecycles, from design to disposal stages, represents the main issue of sustainability. Considering the entire lifetime of products, it can be observed that the environmental impact of products is caused not only by industrial processes or product usage, but also by natural traits of raw materials and other inputs, such as extraction methods, transportation modes, and storage processes, as well as final disposal [1].

A common key factor of the variety of methods and frameworks designed for a successful sustainability strategy concerns the availability and sharing of relevant data and knowledge, which must be integrated and managed [10,11]. Creating an integrated product information environment is an important determinant of a company's capacity to manage the lifecycle of their products [12]. Despite the pressure for environmental issue incorporation and the consequent growing demand for information, most firms still know very little about the potential environmental and social impacts of their production networks. Therefore, better data and decision-support tools are needed to predict and prevent unsustainable practices [13]. Consequently, information and communications technologies

(ICTs) have become essential as accurate and reliable sources of information to support decision-making and information flow management (e.g., [14–17]).

Several studies have emphasized the role of ICTs, stressing their crucial supporting role for the following:

- sustainable supply chain management practices (e.g., [13,18,19]);
- sustainable new product development (NPD) processes (e.g., [20,21]);
- (more general) sustainable lifecycle management (e.g., [1,10,22]), with a particular reference to product lifecycle management (PLM) solutions [23].

While the importance of ICT for the sustainability of products and supply chains is clear, several unaddressed or poorly addressed research questions remain [13,24,25]:

- What is the set of ICTs that could support the individual firms and the entire supply chain towards energy-efficient and environmental objectives?
- What are the trade-offs in integrating sustainability in NPD or PLM?
- How can the use of ICT support environmental practice in the service sector?
- How can ICT support each one of the green supply chain management practices?
- How can the use of ICT in sustainable supply chain management affect the social performance of organizations?
- How do we mine customer requirements in terms of sustainability and then incorporate the results into product design through PLM solutions?
- How can big data analytics architectures for cleaner manufacturing be developed and implemented?

Based on such points, this Special Issue is aimed at gathering theoretical and practical contributions on the role of ICT in enhancing supply chain, product development, and product lifecycle sustainability, thus contributing to the extension of previous knowledge from both a managerial and an academic point of view.

2. Form and Contents of the Thematic Issue

Based on these premises, this Special Issue adds new knowledge to the existing body of literature on the role of ICT in enhancing sustainable product lifecycle. Due to the multiple potential topics and perspectives related to the role of firm size, papers addressing different research questions and adopting different theoretical lenses and methodologies were developed.

The Special Issue opens with a paper by Shi et al. [26], who discussed a simplified model for assembly precision information (API) of complex products based on tolerance semantic relations. Assembly precision analysis (APA) is considered crucial for the entire lifecycle of complex product design, manufacturing, assembly, and even remanufacturing. Furthermore, the assembly precision information model (APIM) is frequently complex, being affected by many issues, such as design tolerance of parts, assembly process scheme, assembly sequence planning, and tolerance of positioning tooling, among others. Consequently, it is of practical significance for APA to reduce the workload of API modeling. The authors proposed a semantic simplification approach for APIM, grounded on semantic relations between APIM and design tolerance of parts. They started from an ontology of structure knowledge of APIM, created according to a tolerance standard. Then, simplification rules were established and, by utilizing the ontology reasoning function, the simplified semantic APIM was generated. Finally, the authors proved the effectiveness of the proposed method using a practical example of engine front auxiliary drive equipment. Their work could lay the foundation for APA of complex products based on actual measured data.

The second contribution is represented by the paper of Johansson et al. [27], dealing with smart and sustainable e-maintenance, with a specific focus on the development of capabilities for the digitalization of maintenance. The authors started by claiming that, in the current digital era, researchers have begun

to more thoroughly examine digital maintenance, that is, eMaintenance. Researchers do so because, within all types of maintenance work, it must be possible to quickly discover the reasons for errors, the remedies, and the improvements for future products. eMaintenance is particularly of interest when considering long-life components such as those used in transport industries, as it helps to identify the appropriate type of maintenance to be implemented and the frequency for device maintenance can be reduced through real-time diagnosis. This leads firms to reduce costs and resource utilization as well as providing environmental benefits. In their paper (2019), and based on an exploratory case study of a digital railway maintenance development company and its main customer, Johansson et al. developed a framework illustrating the required capabilities, how to implement eMaintenance in organizations, and how to identify the outcomes of the transition to eMaintenance.

Finally, the third contribution is represented by the study of Bottani et al. [28], which provided a quantitative assessment of the role of ICT in supporting the collection and valorization of spent coffee grounds. They stressed that, as never before, there is the need to consider alternative energy sources from renewable and waste materials so as to preserve the planet. They observed that one of the possible elements suitable for this purpose is represented by spent coffee grounds. While many studies have addressed its potential exploitation, recent works are pointing out its possible thermal valorization for industrial processes. In light of this, the authors of the paper proposed a new sustainable use of spent coffee grounds, namely to convert them into combustible pellets. In this form, they can be a source not only for industrial heaters, but also for public or private buildings. Bottani et al. developed a feasibility study of a pellet production plant fed by waste collected by vending companies operating in the northern part of Italy. Their evaluation was focused on a logistic model supported by an ICT system to help gather spent coffee grounds from the different companies and collect them into the pellet production facility. Their results highlighted the impact of adopting an ICT tool (in the form of a transportation management system) for the optimal management of collection and transport activities. They showed that the adoption of an ITC tool brings significant savings in terms of costs and scheduling activities.

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References

1. Belkadi, F.; Bernard, A.; Laroche, F. Knowledge based and PLM facilities for sustainability perspective in manufacturing: A global approach. *Procedia CIRP* **2015**, *29*, 203–208. [CrossRef]
2. Rosen, M.A.; Kishawy, H.A. Sustainable manufacturing and design: Concepts, practices and needs. *Sustainability* **2012**, *4*, 154–174. [CrossRef]
3. Ma, W.; Cheng, Z.; Xu, S. A Game Theoretic Approach for Improving Environmental and Economic Performance in a Dual-Channel Green Supply Chain. *Sustainability* **2018**, *10*, 1918. [CrossRef]
4. Buxel, H.; Esenduran, G.; Griffin, S. Strategic sustainability: Creating business value with life cycle analysis. *Bus. Horiz.* **2015**, *58*, 109–122. [CrossRef]
5. Kim, M.K.; Sheu, C.; Yoon, J. Environmental Sustainability as a Source of Product Innovation: The Role of Governance Mechanisms in Manufacturing Firms. *Sustainability* **2018**, *10*, 2238. [CrossRef]
6. Petroni, G.; Bigliardi, B.; Galati, F. Rethinking the Porter Hypothesis: The Underappreciated Importance of Value Appropriation and Pollution Intensity. *Rev. Policy Res.* **2019**, *36*, 121–140. [CrossRef]
7. Hauschild, M.; Jeswiet, J.; Alting, L. From life cycle assessment to sustainable production: Status and perspectives. *CIRP Ann.-Manuf. Technol.* **2005**, *54*, 1–21. [CrossRef]
8. Accorsi, R.; Versari, L.; Manzini, R. Glass vs. plastic: Life cycle assessment of extra-virgin olive oil bottles across global supply chains. *Sustainability* **2015**, *7*, 2818–2840. [CrossRef]

9. Martin, M.; Røyne, F.; Ekvall, T.; Moberg, Å. Life Cycle Sustainability Evaluations of Bio-based Value Chains: Reviewing the Indicators from A Swedish Perspective. *Sustainability* **2018**, *10*, 547. [CrossRef]
10. Gmelin, H.; Seuring, S. Determinants of a sustainable new product development. *J. Clean. Prod.* **2014**, *69*, 1–9. [CrossRef]
11. Zhang, Y.; Ren, S.; Liu, Y.; Sakao, T.; Huisingh, D. A framework for Big Data driven product lifecycle management. *J. Clean. Prod.* **2017**, *159*, 229–240. [CrossRef]
12. Terzi, S.; Bouras, A.; Dutta, D.; Garetti, M.; Kiritsis, D. Product lifecycle management–from its history to its new role. *Int. J. Prod. Lifecycle Manag.* **2010**, *4*, 360–389. [CrossRef]
13. de Camargo Fiorini, P.; Jabbour, C.J. Information systems and sustainable supply chain management towards a more sustainable society: Where we are and where we are going. *Int. J. Inf. Manag.* **2017**, *37*, 241–249. [CrossRef]
14. Urwin, E.N.; Young RI, M. The reuse of machining knowledge to improve designer awareness through the configuration of knowledge libraries in PLM. *Int. J. Prod. Res.* **2014**, *52*, 595–615. [CrossRef]
15. Arsenyan, J.; Büyüközkan, G. An integrated fuzzy approach for information technology planning in collaborative product development. *Int. J. Prod. Res.* **2016**, *54*, 3149–3169. [CrossRef]
16. Favi, C.; Germani, M.; Mandolini, M.; Marconi, M. Implementation of a software platform to support an eco-design methodology within a manufacturing firm. *Int. J. Sustain. Eng.* **2018**, *11*, 79–96. [CrossRef]
17. Galati, F.; Bigliardi, B. Industry 4.0: Emerging themes and future research avenues using a text mining approach. *Comput. Ind.* **2019**, *109*, 100–113. [CrossRef]
18. Green, K.W., Jr.; Zelbst, P.J.; Meacham, J.; Bhadauria, V.S. Green supply chain management practices: Impact on performance. *Supply Chain Manag.* **2012**, *17*, 290–305. [CrossRef]
19. Lai, R.S.; Hsu, L.L.; Chen, J.C. Green supply chain management systems: A case study in the textile industry. *Hum. Syst. Manag.* **2012**, *31*, 111–121. [CrossRef]
20. Kalish, D.; Burek, S.; Costello, A.; Schwartz, L.; Taylor, J. Integrating Sustainability into New Product Development: Available tools and frameworks can help companies ensure that sustainability is embedded as a fundamental building block of new product development. *Res. Technol. Manag.* **2018**, *61*, 37–46. [CrossRef]
21. Sinclair, M.; Sheldrick, L.; Moreno, M.; Dewberry, E. Consumer Intervention Mapping-A Tool for Designing Future Product Strategies within Circular Product Service Systems. *Sustainability* **2018**, *10*, 2088. [CrossRef]
22. Borsato, M. Bridging the gap between product lifecycle management and sustainability in manufacturing through ontology building. *Comput. Ind.* **2014**, *65*, 258–269. [CrossRef]
23. Pinna, C.; Galati, F.; Rossi, M.; Saidy, C.; Harik, R.; Terzi, S. Effect of product lifecycle management on new product development performances: Evidence from the food industry. *Comput. Ind.* **2018**, *100*, 184–195. [CrossRef]
24. Notarnicola, B.; Sala, S.; Anton, A.; McLaren, S.J.; Saouter, E.; Sonesson, U. The role of life cycle assessment in supporting sustainable agri-food systems: A review of the challenges. *J. Clean. Prod.* **2017**, *140*, 399–409. [CrossRef]
25. Centobelli, P.; Cerchione, R.; Esposito, E. Environmental sustainability and energy-efficient supply chain management: A review of research trends and proposed guidelines. *Energies* **2018**, *11*, 275. [CrossRef]
26. Shi, X.; Tian, X.; Wang, G.; Zhang, M.; Zhao, D. A Simplified Model for Assembly Precision Information of Complex Products Based on Tolerance Semantic Relations. *Sustainability* **2018**, *10*, 4482. [CrossRef]
27. Johansson, N.; Roth, E.; Reim, W. Smart and Sustainable eMaintenance: Capabilities for Digitalization of Maintenance. *Sustainability* **2019**, *11*, 3553. [CrossRef]
28. Bottani, E.; Tebaldi, L.; Volpi, A. The Role of ICT in Supporting Spent Coffee Grounds Collection and Valorization: A Quantitative Assessment. *Sustainability* **2019**, *11*, 6572. [CrossRef]