AI-readiness for circular economy: Prospects and challenges

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In this essay, the prospects and challenges of applying artificial intelligence (AI) for implementing the principles of circular economy (CE) will be discussed. In the most general sense, AI is an attempt to solve the problem of understanding, modeling intelligence and cognitive process using principles from computation, mathematics, logic, mechanics, and even biology (Frankish & Ramsey, 2014). Driven by the big data revolution and the decline of computing cost, AI has ceased to be the far-fetched topic of dreamers and experts, to become much more entrenched in our daily life: the application of AI carries a promise to find optimal solutions for any given problems. One can see that AI would be our natural ally in realizing the aim of circular economy: the most efficient and comprehensive use of resources.

Researchers have looked into the application of AI for various aspects of circular economy such as smart waste management (Sarc et al., 2019), energy distribution system in industrial parks (Devanand, Zhoue, Karimi, & Kraft, 2019), chemical process simulation and optimization (Zhou et al., 2017), automated dismantling of End-of-Life (EOL) products (Cong, Zhao, & Sutherland, 2017). These papers have shown the application of AI in these cases resulted in much more optimal use of resources and energy. For example, J-Park Simulator (JPS), an ontology-based AI system, is shown to capable of producing efficient information query, process simulation, and process optimization for the chemical manufacturing processes in Jurong Industrial Park, Singapore. It demonstrates the potential to support human decision-making by finding the maximal profit under varying market conditions (Zhou et al., 2017). JPS is also tested to help designing an optimal standalone power system in Jurong Industrial Park, and the results were positive (Devanand, Zhoue, Karimi, & Kraft, 2019). Cong, Zhao, and Sutherland (2017) showed that using an AI-powered dismantling transition matrix for the case of EOL hard disk drive, the semi-automated operations

were able to reduce more costs compared to the traditional scenarios. However, as noted by the authors of these case studies, the challenge is how to scale up these successful experiments beyond the piecemeal processes.

Suggestions have been made to realize the principles of industrial symbiosis the level of the industrial park. For example, Zhou et al. (2017) argue that to fully model eco-industrial parks, further applications of AI to electricity, transportation network, supply chains, and further integration of sensor model are important. In the case of waste management, Sarc et al. (2019) suggested that collaboration among companies are necessary to realize the potential of waste digitalization. Several review articles in the field have looked at the role of emergent advanced technologies in the implementation of CE (de Sousa Jabbour, Jabbour, Godinho Filho, & Roubaud, 2018; Tseng, Tan, Chiu, Chien, & Kuo, 2018; Nobre & Tavares, 2017). Although these pioneering studies have not looked at AI-applications in CE exclusively, their general discussions on the potential of Industry 4.0, and big-data offer great insights for research on AI-powered CE. The researchers have identified several challenges. First, although each company might be aware of the profits of utilizing AI and data-driven approaches, there is a lack of concerted effort to do so. Hence, it is important to invent better governance approaches that help corporates to collaborate in sharing data and best practices. Second, a cross-industry dialogue is much needed to find solutions for data-driven industrial symbiosis (Tseng et al., 2018). Third, the amount of research studies in this area is minuscule compared to its important implications for solving the great environmental and economic problems in the 21st century. Especially, there are not many studies from developing countries, who need the AI-powered industrial symbiosis the most (Nobre & Tavares, 2017). Indeed, one can make a case for more investment to be directed into this field of research, as the potential benefits of utilizing AI to realize CE and IE are enormous. Society can benefit greatly from wise investment in science (Vuong, 2018; Vuong, 2019). Fifth, Nobre and Tavares (2017) also found there is a disconnection between research and practice: the researchers in the field of CE have not studied some important industry initiatives. It is also important to note that the cost dimensions of AI applications in many cases are not thoroughly discussed.

Clearly, the rate of application of AI is much slower than needed to solve the urgent environmental and economic problems of our time. One can compare this problem to the unexpectedly slow rate of AI adoption in the health-care sector. As pointed out in many review

articles about AI-powered medicine, the application of AI suffers not only from the lack of a coherence and consistent data infrastructure, but also, political, social, and cultural barriers (Vuong, et al., 2019). Vuong et al., (2019), in studying AI-readiness for the medical sector in Vietnam, have proposed adequate technical expertise, financial sustainability, and socio-political commitment are necessary for a full-blown AI-powered healthcare sector. As one would expect that peculiarities in a psycho-cultural setting can greatly influence major decisions of individuals and organizations (Vuong, et al., 2018), the authors show the psycho-cultural factors such as the public's incorrect views on AI or the inflexible structure of organizations and institutions can hinder the prospects of a fully AI-powered medical sector. One can argue that both policy-makers and researchers in CE and industrial ecology can learn from medicine for a more successful application of AI. The policy-makers can adapt their investment strategy to minimize the technical problems that occur in medicine, while the researchers can build on the existing frameworks to speed up the progress in finding theoretical and practical solutions for AI-powered CE and industrial ecology.

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