Stakeholder collaboration for circular economy in WEEE industry: A sociotechnical theory perspective

Jinou Xu (*jinou.xu@polimi.it*)
School of Management, Politecnico di Milano, Milan, Italy

Meng Jia
School of Business, University of Leicester, Leicester, UK

Abstract

Waste electrical and electronic equipment (WEEE) poses significant environmental and economic challenges. Research, along with regional regulations, underscores the importance of effective circular transition in mitigating these issues. The complexity of products, processes, and supply networks advocate for enhanced collaboration among established and emerging stakeholders in WEEE management for circular economy (CE). Drawing on multiple case studies involving diverse actors engaged in the WEEE industry, this study explores the current sociotechnical landscape and discusses several directions to foster stakeholder collaboration from a sociotechnical standpoint. Findings show that achieving the circular transition of WEEE necessitates an approach that seamlessly integrates the social and technical contexts where the social dynamics need to fit with the technological capabilities of involved actors.

Keywords: Circular economy, WEEE, sociotechnical theory

Introduction

With the increasingly diffused use of personal electronic devices, electrification and the progress in industrial digitalisation, the market size for electrical and electronic equipment (EEE) is substantial and is expected to grow significantly in the coming years across various sectors. As of 2024, the electrical and electronics market is projected to be valued at approximately $4,031.77 billion, with a projected forecast to reach around $5,194.42 billion by 2028 (Research and Markets, 2024).

The disposal of EEE is of critical concern. According to statistics, less than one-fifth of waste of electric and electronic equipment (WEEE) is recycled appropriately worldwide (Guzzo et al., 2021). Meanwhile, driven by the shortened lifespan of electronic devices and advancements in technology that encourage consumers to upgrade their electronics more frequently, the Global e-waste Monitor foresees the volume of WEEE reaching 62 billion kg in 2022 (Baldé et al., 2024). Consumer electronics, including smartphones, tablets, and laptops, constitute a significant portion of the WEEE generated, due to their rapid replacement cycles and high consumption rates (Islam & Huda, 2018).

WEEE has significant environmental and economic impacts if not properly managed (Bressanelli et al., 2021). It generates a waste stream that contains both hazardous and valuable materials that require careful monitoring and management in the collection and recycling stage (Baldé et al., 2024). Various government bodies have released formal schemes and directives to guide WEEE management, including the EU WEEE Directive and the producer responsibility laws in the UK. Meanwhile, to prevent valuable materials from being wasted or end up in landfill, the development of a system following the circular economy (CE) principles to create more secure and sustainable value chains is strongly promoted for WEEE management (Baldé et al., 2024; Bressanelli et al., 2020; Cucchiella et al., 2015; Kumar et al., 2020). Yet, the management of WEEE is substantially complex, involving technical challenges, regulatory requirements, environmental concerns, and logistical issues. Diverse composition, combined with hazardous substances, requires precise and careful treatment processes. Meanwhile, the national and international regulations also pose significant challenges to WEEE management.

Therefore, this paper aims to investigate the current implementation of CE in WEEE industry from a sociotechnical perspective. The following research questions guide the study: *RQ1: What is the social and technical context for current WEEE industry?* And *RQ2: How collaboration between traditional and non-traditional supply chain actors in WEEE industry can be facilitated?*

Literature review and conceptual background

The WEEE industry

WEEE has gained increasing attention over the past decade because it has now become one of the fastest-growing waste streams around the world. On one hand, literature has discussed the attempts and progress so far in managing WEEE. For example, scholars have explored the role of technology and innovation in enhancing WEEE management, proposing solutions such as product redesign for easier disassembly, development of advanced recycling technologies, and implementation of traceability systems to track electronic waste throughout its lifecycle (Chen et al., 2018). The research by Garrido-Hidalgo et al. (2020) proposed that the deployment of an Internet of Things oriented technologies in waste management domain can significantly enhance the efficiency, sustainability, and cost-effectiveness of waste collection, sorting, and disposal processes. The importance of regulatory frameworks in shaping WEEE management practices, with stringent legislation driving organizations to adopt sustainable disposal methods and promote product recovery and recycling has also been acknowledged (Bressanelli et al., 2021).

On the other hand, challenges such as lack of infrastructure, awareness, and financial incentives persist, highlighting the need for further research and collaborative efforts to address the complex issues surrounding WEEE management and pave the way for a sustainable future (Kumar et al., 2020). For example, literature has primarily discussed the enabling role of government intervention and the need for stringent legislation (e.g. Bressanelli et al., 2021), while overlooking whether and how these regulatory measures could support or fit with the rapidly developed and various technology tools required in managing WEEE alongside the supply chains.

Moreover, CE urges systemic changes in existing supply chain systems, highlighting the necessity to establish a broad alliance of stakeholders, including supply chain actors (e.g. producers, consumers) and beyond (e.g. policymakers, technology providers) (Kirchherr et al., 2023). For example, Garg et al. (2023) found that NGOs (Non-Governmental Organizations) serve as a conduit between waste pickers and electronic manufacturers under pressure to collect and recycle what they sell. However, the collaboration between non-supply chain factors including NGOs and environmental campaigns is not well aligned due to goal congruences, geographical limitations, etc. Prior literature presents little finding on how collaboration between a broad alliance of traditional and non-traditional supply chain actors can be developed and eventually facilitate the CE transition for WEEE industry.

Sociotechnical theory

Sociotechnical theory, rooted in the works of researchers such as Eric Trist and Fred Emery (1962), offers a holistic framework for understanding the intricate interplay between social and technical elements within organizational contexts (Sarker et al., 2019). At its core, sociotechnical theory posits that effective organizational performance hinges not only on optimizing technical systems but also on attending to the social dynamics inherent in those systems (Oesterreich et al., 2022; Sony & Naik, 2020).

Traditional approaches to addressing sustainability issues often focus solely on optimizing technical aspects of tasks, such as knowledge, techniques, and procedures. However, the sociotechnical theory emphasizes the importance of considering socio-psychological factors, such as attitudes, relationships, cultures, norms, etc (Shan et al., 2022). Sociotechnical theory has recently gained attention in the supply chain management and sustainability subjects. More specifically, researchers have applied the sociotechnical lens to understand lean production, sustainability practices in supply chains, and the operation of organ transplant supply chains (Akenroye et al., 2023). Research has shown that social dynamics and the technical systems of organisations interact and jointly affect the practices and performances of organisations. For example, Shan et al. (2022) found that social and technical integration have an enhancing synergistic effect on sustainable production and sourcing in high-uncertainty supply chains.

As previously stated, research has shown that multiple actors and stages are involved in the management of WEEE (Bressanelli et al., 2020). Traditional supply chain actors such as manufacturers and retailers of EEE and non-traditional actors such as recycling service providers are all relevant actors in the WEEE management system. Meanwhile, various new technologies are widely adopted in WEEE industry. It is shown that proper management of WEEE is likely to generate wider social benefits beyond just economic benefits for a broad alliance of stakeholders. Therefore, it is necessary to take a holistic view that is able to take all related factors into consideration when investigating the circular transition of WEEE. To this end, the sociotechnical theory offers a comprehensive framework for understanding and managing the complex interdependencies between social and technical elements within the management of WEEE.

Methodology

Owing to the explorative and explanatory nature of the research questions, this research employs a multiple case study approach to collect contextual rich data on the focused phenomenon (Barratt et al., 2011). We started compiling an initial list of potential companies involved in the management and value chain of WEEE. After a careful filtering process based on publicly accessible information (e.g. website, news, reports) and a consultation with their interest in participating in this research, we arrived at a pool of actors with active business units in Europe and conducted data collection through interviews. The resulting sample covers multiple traditional and emerging actors in the field of WEEE, including producers, retailers, PROs (Producer Responsibility Organisations), recyclers and start-ups that were funded to fill in the market gap with innovative business models to extend product lifecycles (also known as gap exploiters) (Hollander & Bakker, 2016). The adopted criteria allow to capture different perspectives from supply chain actors and stakeholders in the management of WEEE, assuring heterogeneity in terms of company size and across the various R-imperatives (i.e. reduce, reuse, recycle and recover). Due to space restrictions, the final sample is presented together with the results in the next section.

The interviews are carried out following semi-structured protocols, with on average one-hour duration. The conversations typically start with a discussion on the firm's endeavour in CE, the encountered issues in CE implementation, as well as the current and planned collaborations set around these initiatives. All interviews are recorded, transcribed and stored in shared databases, complemented by other additional information about the cases.

The consequent data analysis followed an abductive approach (Dubois & Gadde, 2002) starting from the preliminary conceptual framework drawing on the sociotechnical perspective (Sarker et al., 2019), with the technical system focusing on the WEEE management objectives, tasks, infrastructure and process technologies, and the social system encompassing the actors, responsibilities, culture, and norms. Coding of the R-imperative follows the 4 categories in the framework of Kirchherr (2023), namely, reduce, reuse, recycle, and recover, since a more granular classification would lead to empty clusters resulted from impracticality in the WEEE sector. The following Figure 1 depicts the conceptual framework of this study.

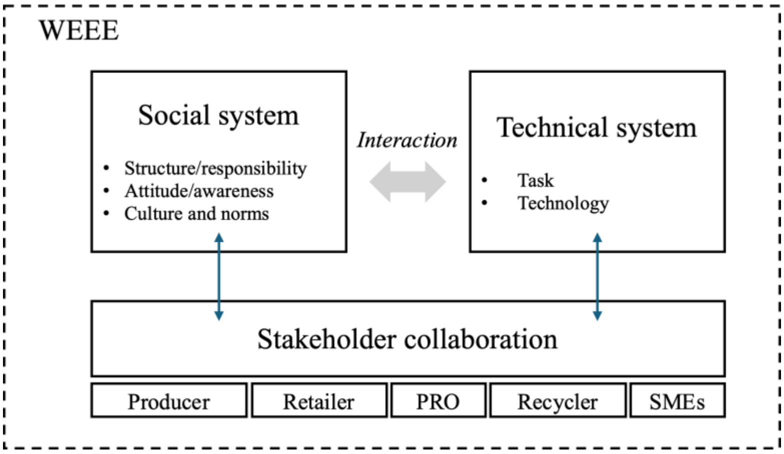

Figure 1 Preliminary conceptual framework

At this moment, the data analysis and interpretation are yet to be concluded. This working paper is developed based on some early results and insight aiming to collect some feedback to guide the ongoing analysis, and underline the potential need for further data collection.

Findings

An overview of the sampled cases is drawn in Table 1, reporting the type of actors, EEE categories and the implemented R-imperatives. The firm size has significant variation owing to the nature of the companies. In general, producers and retailers are typically large, established companies who traditionally operate in the EEE sector for decades. Meanwhile, gap exploiters – businesses established around the idea of extending the lifetime of products from other firms – are typically start-ups with very limited size. In terms of EEE category, small household appliances are clearly the category receives the most interest among the involved actors. Instead, ICT and heavy industrial equipment are the least addressed WEEE category among the actors involved in this study. For what concerns the R-imperative, the case studies tend to concentrate on the one of *reuse* – note that this also encompasses recycling, repair and refurbishing of resources according to Kirchherr (2023) framework. This convergence shows the evident relevance of these practices in the WEEE industry.

Table 1 Case overview and related R-strategy

		Actor type					**EEE Category**							**R-imperative**				
ID case	**Firm size (# employoee)**	Producer	Retailer	Recycler	Producer Responsibility Organisation	Gap exploiter	Large households appliances	Small households appliances	Temperature exchange equipment	TV and monitors	Lighting equipment	Professional equipment	ICT Equipment	Reduce	Reuse	Recycle	Recover	Collection
PRD 1	250-5000	x										x		x				
PRD 2	>10000	x									x			x				
PRD 3	>10000	x					x		x						x	x		
PRD 4	>5000	x					x	x						x	x			
RET 1	>10000		x				x	x	x	x	x							x
RET 2	>10000		x				x	x	x	x	x				x			x
RET 3	>5000		x				x	x	x	x	x				x			x
RET 4	< 50		x					x						x	x			
REC 1	>5000			x			x	x	x	x	x					x		x
REC 2	250-5000			x			x	x	x	x	x					x		x
REC 3	N.A.			x			x	x	x							x		x
REC 4	250-1000			x			x	x	x	x	x			x				x
PRO 1	< 50				x		x	x	x	x	x					x		x
PRO 2	N.A.				x		x	x	x	x	x					x		x
PRO 3	50-250				x		x	x	x	x	x				x	x		
PRO 4	< 50				x		x	x	x	x	x					x		x
PRO 5	< 50				x		x	x	x	x	x			x				x
PRO 6	N.A.				x			x				x						x
GAP 1	50-250					x							x		x			x
GAP 2	< 50					x		x										x
GAP 3	N.A.					x		x							x			
GAP 4	N.A.					x		x							x	x		
GAP 5	< 50					x						x			x			

The technical context of WEEE

The technical framework for managing WEEE is conceptually straightforward. End-of-life products must be reintegrated into the cycle through one of the various *collection* channels. For consumers, two primary pathways exist. Firstly, specialized recyclers, under contracts with municipalities, either utilize collection boxes and schedule transport when these become full, or they conduct door-to-door pickup upon reservation (e.g., REC1). Secondly, retailers who maintain direct contact with consumers can also facilitate the return of end-of-life products, typically small devices, through take-back programs or designated drop-off points (e.g., RET2, RET3). In the case of large-scale waste collection from industries and businesses, while some recyclers handle the collection internally, it is more common for a consortium to serve as a mediator within this process. The role of the consortium is to coordinate the requirement from the point of disposal with the consequent stages including reverse logistics, sorting and processing, and engaging different actors to execute the necessary tasks (e.g., PRO2).

Very often, organizations involved in WEEE management are specialised in a limited range of activities. This is due to the stringent regulations, the need for dedicated infrastructure, high levels of expertise, and the often limited volumes of waste collected. Specialisation ensures the convergence of e-waste resource flows, thus, providing the context for investment. For instance, some retailers are engaged in the *repair* of consumer-oriented EEE products, setting up centralized large repair centres or distributed small stands (e.g. RET2). The repair centres are also capable of offering product care and repair advice to consumers in remote. In this case, the availability of trained staff and robust partnerships with spare part suppliers are crucial to service delivery (e.g., RET3).

Although some retailers are equipped to undertake *refurbishing* activities, a more recent stream of actors has emerged, specialising in the marketing and sales of refurbished products. These entities focus on restoring the original functionality of end-of-use products, whether collected or purchased, through repair, refurbishing or simply maintenance processes (GAP4, GAP5). Some of these practices are delivered in schemes of product-as-a-service or leasing business models, where the focal company possess the expertise necessary to restore the product functionality before it reaches the next owner. However, determining the optimal point – at which it becomes more economically and environmentally prudent to replace rather than refurbish a product – is cited as a complex challenge (i.e. GAP5). Nonetheless, *recycling* WEEE is a particularly delicate R-imperative due to the presence of both valuable and hazardous materials. Chemicals and the processes employed require strict monitoring and control. Therefore, recycling activities necessitate stringent certifications endorsing the reintroduction of output secondary materials into the market. A typical recycler can operate only with a limited range of materials (e.g. metals, plastic), thus, not all recycling activities can be conducted internally. In some cases, this limitation may also stem from a lack of expertise – considering the diverse array of knowledge needed to process the various streams of WEEE, constraints on infrastructure or eventually capacity.

As in the previous discussion, the entry of the gap exploiter – businesses that are found to extend the product life cycle of other companies – primarily works on the *reduce* imperative. The technical side of this process is relatively similar to the ones of repair and refurbishing. Interestingly, there is one case in which the focal company dedicates itself to the development of a digital platform that consolidates information from various channels to small businesses regarding e-waste recycling and treatments (GAP2). Besides owning a limited collection capacity, this company is active in engaging consumers to change their disposal habits through business campaigns and setting up conversations between customers and recyclers to act on the reduction of WEEE generation. This new type of actor views themselves at the intersection between consortium, regulatory bodies and the end-users, as a two-sided platform to channel information and facilitate engagement.

The social context of WEEE

Since a diverse array of stakeholders is involved in the management of WEEE, the social side of WEEE management can be complicated. To a certain extent, all actors are closely bonded due to the possession of complementary skills in the WEEE management process, while each holds clearly defined responsibilities.

Our analysis highlights the presence of both ongoing long-term collaborations and project-based partnerships within this industry. A critical aspect of WEEE management is the interaction with consumers, which is essential for enhancing impact through increased consumer awareness. In this context, recycler REC1 emphasizes the importance of collaborating with PROs and producers to organize consumer education and empowerment campaigns. Furthermore, REC1 also works alongside logistics providers to offer a free-of-charge collection service for bulky e-waste, which significantly enhances the collection rate. Another example is GAP2 who denotes the collaboration with online retailers to facilitate the collection of end-of-life products sold on these platforms, offering incentives to users for product return. In exchange, GAP2 receives higher visibility and brand exposure.

Our analysis also indicates that a shift in attitude from organizations is also needed to support the transition into a more circular system. For instance, REC2 comments on the attitude of producers in embracing the use of secondary raw materials "*In many cases, it is preferred to continue using virgin materials as they are easier to manage*". RET1 emphasises that retailers should not be satisfied by merely selling products containing secondary materials as a contribution to CE, but they should assume the role of collecting and delivering e-waste to the right destination.

Unsurprisingly, culture and norms, particularly views on legislation and regulations, are considered the most critical social contexts in waste management. Regulations, often complex and technical, pose significant challenges for enforcement due to a general lack of necessary expertise and knowledge among inspectors. REC4 has highlighted that end-of-use products collected from consumers vary significantly depending on usage. This makes it difficult for inspectors to accurately interpret the legislation, and therefore, take the correct measure. Furthermore, some existing regulations can be counterproductive; for example, regulations governing the take-back procedures for e-waste may inadvertently require similar products to be processed through different channels, complicating the recycling process. WEEE management actors call for the regulation and rules to be streamlined and coherent. However, there is still the positive side. Guidelines on eco-design, design for repair, and design for refurbishment have significantly promoted organizational learning on developing products that support circularity.

Discussion

By examining the social and technical context of WEEE, the findings suggest that in order to facilitate a circular transition of WEEE management, it is necessary to explore a holistic approach that takes the different actors, EEE categories, and R-imperatives into consideration. In this regard, the findings support those in prior studies that research so far lacks a holistic view of how these factors jointly affect the effective management of WEEE (Bressanelli et al., 2021). The study also extends prior research by highlighting the need to work collaboratively with a broad alliance of stakeholders to achieve a fit between the social and technical contexts of WEEE.

To achieve the circular transition of WEEE management, it requires an approach that could facilitate the fit between the social and technical contexts

Our findings show that even though the technological capabilities of supply chain actors have been advanced over the years which offer opportunities for more efficient management of WEEE, the social dynamics between stakeholders as well as the unfit between the social dynamics and the technological capabilities remain major issues that hinder the development of a holistic approach to facilitate circular transition of WEEE management.

On one hand, regulations and legislations across the world have evolved in different ways in order to push supply chain actors to proactively take on their part of responsibilities towards the effective management of WEEE. While this has been found a good start and solid basis, it also poses challenges to supply chain actors as they need to navigate a landscape that is often fragmented and inconsistent across different areas and different levels of regulations and legislation. Meanwhile, the rapid pace of technological advancements introduces additional complexities, as supply chain actors must continually adapt their processes and infrastructure to comply with evolving requirements. The pace of new product introduction and technological innovation also brings significant challenges to WEEE management since products are extremely diverse and fragmented. Consequently, many actors may lack the technological capabilities or resources over time to effectively implement and adhere to regulations, which leads to compliance gaps, inefficiencies, and potential legal risks. In facing the challenge of the social system, technologies could also play an active role. For instance, recent advancements in AI technologies are capable of supporting the sorting in dangerous environments of WEEE treatment (Kelly, 2022).

On the other hand, on top of facilitating supply chain actors to actively participate, government interventions include educating consumers regarding proper recycling practices and good disposal behaviour. However, consumers still face various practical difficulties and challenges. For example, with information coming from various sources, including both authentic ones such as government agencies and nonauthentic sources, consumers often encounter confusion and conflicting advice regarding how they should participate in the proper disposal and recycling practice regarding WEEE. This reinforces the findings from previous research (e.g. Pan et al., 2022) as to consumer knowledge related to proper management of WEEE is crucial to the successful implementation of R-imperatives.

Facilitating effective collaboration between traditional and non-traditional supply chain actors plays a crucial role in moving towards the goal of circular transition of WEEE

It was found that although actors such as retailers and in the WEEE industry seem to have been equipped with relevant skills to engage with R-imperatives, it is quite common that each actor is only specialised in one or few of the skillsets to carry out R-imperatives. Collaborative planning and capacity building thus become necessary to tackle the issue of dispersed technical capabilities across different actors in the supply chain. This reinforces the findings from prior research that limited attention has been given to how supply chain members can work collaboratively to implement a circular economy in EEE supply chain although it is widely acknowledged that it is quite unlikely that the circular transition can be controlled or done by any individual actor in the supply chain (Bressanelli et al., 2021).

Meanwhile, the findings have shown that a variety of new untraditional supply chain actors emerged which perform quite important roles in closing the technological and information-sharing gaps between supply chain members as well as facilitating positive changes at the customer end. Those non-traditional actors such as Gap exploiters and NGOs can be an effective complementary to traditional supply chain members. More specifically, Gap exploiters, for instance, often operate within informal or secondary markets, where they salvage valuable components or refurbish electronics, thereby extending their lifespan and diverting them from landfills. Our findings thus extend prior research which focuses on the more widely discussed non-traditional actors such as NGOs (Garg et al., 2023). Besides, the role of industry associations is highlighted as they are in charge of defining the production standards regarding the design of the components and products where concerns such as recyclability should be set as compulsory specifications.

Conclusion

Based on the empirical evidence from 23 interviews, our study elucidates the current social and technical context of WEEE management. In particular, this paper presences the task, processes and technologies for the technical context, while commenting on the legislation and norms, awareness and structure from the social side. Our discussion extends to the reflections on the fit (and unfit) between the social and technical context, highlighting the necessity of facilitating effective collaboration between traditional and non-traditional actors in the management of WEEE.

Potential limitations of this study, including the lack of multiple informants from each case and the interpretation of the results, are considered to be addressed in the next stage. We have a plan to run further rounds of data collection for a more in-depth discussion on the social system and to capture the linkages between the case companies. Our objective to address the interaction between the social and technical systems will be further explored, explaining the evolution of the adaptation between the two systems.

Reference

Akenroye, T. O., Oyedijo, A., Rajan, V. C., Zsidisin, G. A., Mkansi, M., & Baz, J. El. (2023). Connecting the dots: uncovering the relationships between challenges confronting Africa's organ transplant supply chain systems. *Supply Chain Management*, *28*(7), 43–61. https://doi.org/10.1108/SCM-12-2022-0457

Baldé, A. C. P., Kuehr, R., Yamamoto, T., Mcdonald, R., Angelo, E. D., Althaf, S., Bel, G., Deubzer, O., Fernandez-cubillo, E., Forti, V., Gray, V., Herat, S., Honda, S., Iattoni, G., Deepali, S., Luda, V., Lobuntsova, Y., Nnorom, I., Pralat, N., … Luda, V. (2024). *The global e-waste monitor 2024*.

Barratt, M., Choi, T. Y., & Li, M. (2011). Qualitative case studies in operations management: Trends, research outcomes, and future research implications. *Journal of Operations Management*, *29*(4), 329–342. https://doi.org/10.1016/j.jom.2010.06.002

Bressanelli, G., Pigosso, D. C. A., Saccani, N., & Perona, M. (2021). Enablers, levers and benefits of Circular Economy in the Electrical and Electronic Equipment supply chain: a literature review. *Journal of Cleaner Production*, *298*, 126819. https://doi.org/10.1016/j.jclepro.2021.126819

Bressanelli, G., Saccani, N., Pigosso, D. C. A., & Perona, M. (2020). Circular Economy in the WEEE industry: a systematic literature review and a research agenda. *Sustainable Production and Consumption*, *23*, 174–188. https://doi.org/10.1016/j.spc.2020.05.007

Chen, Y., Chen, M., Li, Y., Wang, B., Chen, S., & Xu, Z. (2018). Impact of technological innovation and regulation development on e-waste toxicity: a case study of waste mobile phones OPEN. *SciEnTific REpoRTS |*, *8*, 7100. https://doi.org/10.1038/s41598-018-25400-0

Cucchiella, F., D'Adamo, I., Lenny Koh, S. C., & Rosa, P. (2015). Recycling of WEEEs: An economic assessment of present and future e-waste streams. *Renewable and Sustainable Energy Reviews*, *51*, 263–272. https://doi.org/10.1016/j.rser.2015.06.010

Dubois, A., & Gadde, L. E. (2002). Systematic combining: An abductive approach to case research. *Journal of Business Research*, *55*(7), 553–560. https://doi.org/10.1016/S0148-2963(00)00195-8

Emery, F. E., & Marek, J. (1962). Some Socio-technical Aspects of Automation. *Human Relations*, *15*(1), 17–25. https://doi.org/10.1177/001872676201500102/ASSET/001872676201500102.FP.PNG_V03

Garg, S., Ahmad, A., Madsen, D. Ø., & Sohail, S. S. (2023). Sustainable Behavior with Respect to Managing E-Wastes: Factors Influencing E-Waste Management among Young Consumers. *International Journal of Environmental Research and Public Health*, *20*(1). https://doi.org/10.3390/ijerph20010801

Garrido-Hidalgo, C., Ramirez, F. J., Olivares, T., & Roda-Sanchez, L. (2020). The adoption of Internet of Things in a Circular Supply Chain framework for the recovery of WEEE: The case of Lithium-ion electric vehicle battery packs. *Waste Management*, *103*, 32–44. https://doi.org/10.1016/j.wasman.2019.09.045

Guzzo, D., Rodrigues, V. P., & Mascarenhas, J. (2021). A systems representation of the Circular Economy: Transition scenarios in the electrical and electronic equipment (EEE) industry. *Technological Forecasting and Social Change*, *163*(March 2020), 120414. https://doi.org/10.1016/j.techfore.2020.120414

Hollander, M. den, & Bakker, C. (2016). *Mind the Gap Exploiter: Circular Business Models for Product Lifetime Extension* (pp. 1–8). Fraunhofer IZM Berlin. https://research.tudelft.nl/en/publications/mind-the-gap-exploiter-circular-business-models-for-product-lifet

Islam, M. T., & Huda, N. (2018). Reverse logistics and closed-loop supply chain of Waste Electrical and Electronic Equipment (WEEE)/E-waste: A comprehensive literature review. *Resources, Conservation and Recycling*, *137*(March), 48–75. https://doi.org/10.1016/j.resconrec.2018.05.026

Kirchherr, J., Yang, N. H. N., Schulze-Spüntrup, F., Heerink, M. J., & Hartley, K. (2023). Conceptualizing the Circular Economy (Revisited): An Analysis of 221 Definitions. *Resources, Conservation and Recycling*, *194*(September 2022), 107001. https://doi.org/10.1016/j.resconrec.2023.107001

Kumar, A., Wasan, P., Luthra, S., & Dixit, G. (2020). Development of a framework for selecting a sustainable location of waste electrical and electronic equipment recycling plant in emerging economies. *Journal of Cleaner Production*, *277*, 122645. https://doi.org/10.1016/j.jclepro.2020.122645

Kelly, A. (2022). *New AI sorting technology to reduce battery fires in WEEE wins pilot funding*. Resource.Co. https://resource.co/article/new-ai-sorting-technology-reduce-battery-fires-weee-wins-pilot-funding

Oesterreich, T. D., Anton, E., Teuteberg, F., & Dwivedi, Y. K. (2022). The role of the social and technical factors in creating business value from big data analytics: A meta-analysis. *Journal of Business Research*, *153*(August), 128–149. https://doi.org/10.1016/j.jbusres.2022.08.028

Research and Markets. (2024). *Electrical and Electronics Global Market Report 2024: Vol. February*. https://www.researchandmarkets.com/reports/5781043/electrical-electronics-global-market-report

Sarker, S., Chatterjee, S., Xiao, X., & Elbanna, A. (2019). The sociotechnical axis of cohesion for the IS discipline: Its historical legacy and its continued relevance. *MIS Quarterly: Management Information Systems*, *43*(3), 695–719. https://doi.org/10.25300/MISQ/2019/13747

Shan, S., Shou, Y., Kang, M., & Park, Y. (2022). The effects of socio-technical integration on sustainability practices: a supply chain perspective. *Industrial Management and Data Systems*, *122*(2), 419–441. https://doi.org/10.1108/IMDS-05-2021-0295

Sony, M., & Naik, S. (2020). Industry 4.0 integration with socio-technical systems theory: A systematic review and proposed theoretical model. *Technology in Society*, *61*(August 2019), 101248. https://doi.org/10.1016/j.techsoc.2020.101248