

A Value Proposition Analysis of Emerging Circular Economy Business Models in the WEEE Sector

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Abstract: Due to the rapid economic growth, growing demand for high-tech products, and decreasing service life of products, global waste generation from the electrical and electronic equipment sector is increasing. From the environmental and economic perspective, the circular economy (CE) emphasizes e-waste prevention as it is one of the fastest-growing waste streams having both valuable and rare materials as well as toxic substances. It is common to manage electrical products at their end-of-life through circular practices however, knowledge and implementation of CE in the waste electrical and electronic equipment (WEEE) sector still need to be improved. End-of-life practices center on recycling, and the percentage of valuable resources recovered is low. There is a missing insight into the business opportunities for alternative end-of-life options such as reusing, repairing, and re-manufacturing that hold stakeholders from implementing circular strategies. To fill the gaps identified, we developed a research question for investigating and analyzing the services offered and the electrical products adaptable to CE business models (CEBMs) of young companies operating in the WEEE. This study aims to explore the business models (BMs) of circular practice-based business options such as buyers and sellers of used and refurbished electronic devices, information technology asset dispositions (ITADs) companies, and e-waste recyclers to enhance other researchers with a better understanding of business options toward end-of-life e-waste handling and emerging issues in this industry. We conduct a literature review on CEBMs in the WEEE and conduct a multiple-case analysis of 412 emerging circular companies in the WEEE selected from the Crunchbase database to explore their BMs. Key findings show that most young WEEE companies focus on IT and telecom equipment and consumer electronics. Emerging WEEE companies mostly involve asset management and e-waste Recycling service, followed by ITAD services, trade-in/buyback, and reselling of preowned and refurbished electrical devices service, and e-waste collection, recycling, and disposal service. These companies provide unique offerings such as information security, compliance, trustworthiness, convenience, quality, social responsibility, and charitable purpose. Studies in the future may explore other dimensions of these BMs to gain a comprehensive picture and support the design of CEBMs.

Keywords: circular economy (CE), WEEE, e-waste, business model, value proposition, waste electrical and electronic equipment

1. Introduction

The electrical and electronic equipment (EEE) sector generates several types of electronic waste, which contain precious and base metals (Gold, Silver, Copper, Cobalt, Palladium, Lithium, etc.) as well as hazardous materials (Lead, Cadmium, Mercury, Arsenic, Beryllium, etc.) (Bressanelli et al., 2020). The amount of electronic waste or waste electrical and electronic equipment (WEEE) is growing by 3-5% per year, making it one of the fastest-growing waste streams (Cucchiella et al. 2015). The Global E-Waste Monitor also indicates that the global WEEE production was 53.6 Mt in 2019 and is expected to reach 74.7 Mt by 2030 (Forti et al., 2020). WEEE has become a global priority waste stream due to various pressing concerns such as the significant quantity of WEEE is astonishing, with potential health and environmental impacts, as highlighted in studies by Ongondo & Williams in 2011a and 2011b. Furthermore, resource depletion is emphasized by Kumar et al. (2017) and ethical concerns are also raised regarding the improper disposal and management of WEEE (Ongondo & Williams, 2011a). However, despite the growing rate of WEEE generated, the recycling rate is still low, with only 17.4% being collected and properly recycled (Forti et al., 2020). The rest, a large 44.3 Mt, ends up untreated or in landfills, posing a grave threat to the environment and human health. Given these concerning statistics, effective strategies for managing and safely disposing of e-waste are urgently needed to tackle this growing crisis. The linear economy model, which promotes a "take, make, waste" approach, has been increasingly recognized as unsustainable. In response, the circular economy (CE) model has appeared as a practical alternative in recent years, with increasing support from the European Union and other organizations. The CE aims to reduce resource depletion and promote economic benefits by increasing the product lifecycle by prioritizing reuse and remanufacturing over recycling for improved resource recovery.

The circular economy also encourages the closure of the loop of products, components, and materials, leading to serviced leasing and sharing business models (BMs) (Rosa et al., 2019; Urbinati et al., 2017). Applying CE strategies to the WEEE industry in general can promote sustainable development in both the environment and

the economy. However, the implementation of CE in the WEEE industry is still a challenge for companies, organizations, and governments. Literature shows that end-of-life practices in the WEEE focus on recycling, and the percentage of valuable resources recovered is low. There is a missing insight into the business potential for alternative end-of-life strategies such as reusing, repairing, and re-manufacturing that hold stakeholders from implementing circular strategies. With the projected increase in global e-waste generation to 74.7 Mt by 2030 (Forti et al., 2020), it is now more important than ever to examine the development of CE practices in the WEEE industry. Our study focuses on analyzing how CE practices are incorporated into the BMs of young companies using the "6R" CE strategies as the scope of the research shown in Figure 1 since their BMs are more receptive to change and improvement. To achieve this goal, the research question of the study is formulated as follows "What are the value propositions offered by the CEBMs of young companies in the WEEE sector?". The paper is organized into different sections, starting with a literature review in section 2 that discusses the CE in the WEEE industry, and the value propositions offered by BMs in the sector. Section 3 outlines the research method used to identify and analyze the value propositions offered by young companies in the WEEE industry. The results of the exploratory multiple-case analysis are presented in section 4, and section 5 presents a discussion of the findings and conclusions of the study.

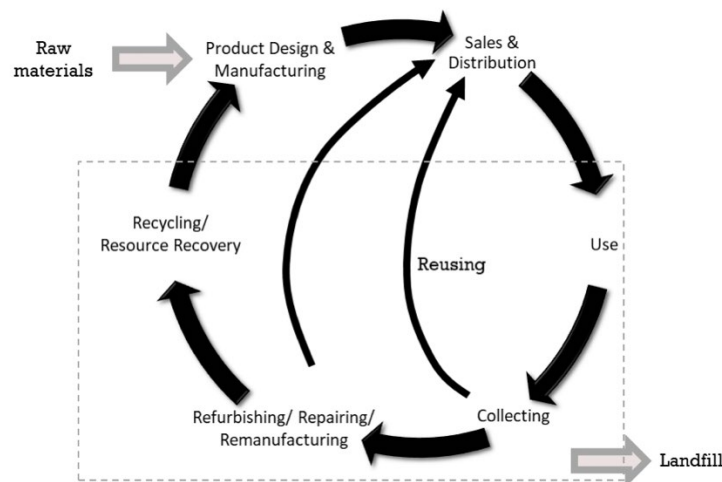


Figure 1: Circular economy approach and scope of the research.

2. Literature Review

2.1 Circular Economy in the WEEE

Although the concept of circular economy (CE) is still an emerging concept (Velenturf et al., 2019), with no established theoretical framework or academic consensus on its definition (Kirchherr et al., 2017), it is widely acknowledged that the current linear business production model is resource intensive. As per Kirchherr et al. (2017), the primary emphasis of CE is on achieving economic benefits, followed by environmental quality and social equity. Circular Economy prioritizes the principles of reuse, recycling, and recovery to reduce resource depletion, increase economic benefits, and extend the product lifecycle. Although recycling is a core principle of CE, it prioritizes the reuse and remanufacturing of electronic devices over recycling to improve resource recovery (Ghisellini et al., 2016). The adoption of CEBMs by individual organizations is crucial for the transition from a linear economy to a CE (Lewandowski 2016). The goal of CEBMs, as described by Lahi et al. (2018), is to minimize resource usage, increase durability, and maximize value retention. Simply put, CEBMs strive to keep products, components, and materials at their maximum value throughout their entire life cycle (Korhonen et al., 2018). Therefore, the EEE sector is one area that could benefit from the greater adoption of CEBMs, and there is a need for new BMs to facilitate the transition from a linear economy to a CE.

Circular models have been widely proposed for the lifecycle management of electronic products (Macarthur, 2013). Such models prioritize the reuse and repair of products over recycling after the first use cycle. However, despite the significant, mostly conceptual, research in this area, there is still a lack of substantial insight and evidence into the technological and business potential for alternative end-of-life options based on reuse, repair, and remanufacturing. This lack of insight keeps the relevant stakeholders from implementing circular strategies (Parajuly & Wenzel, 2017). When it comes to WEEE, the principles of the CE are applied through a focus on, the

reuse, resale, repair, refurbishment, remanufacture, and recycling of products, with the aim of extending their useful lifetimes and recovering raw materials from their waste (Cordova-Pizarro et al., 2019). This study aims to present a comprehensive view of the development of CE practices in the WEEE industry by examining the value proposition offered by young companies. Specifically, the study focuses on analyzing the BMs of these companies and their use of the "6R" CE strategies, which include reuse, resale, repair, refurbish, remanufacture, and recycling (Potting et al., 2017). The circular strategies discussed in Potting et al.'s (2017) work are depicted in Figure 2.

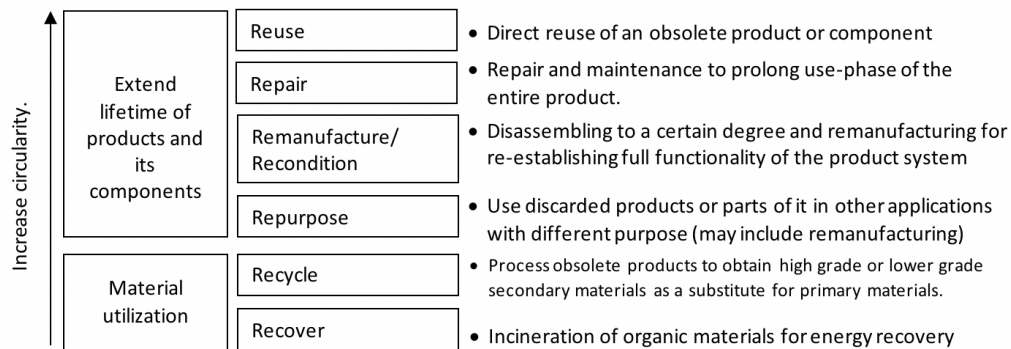


Figure 2: "6R" strategies of circular economy (Potting et al., 2017)

2.2 Value Propositions Offered by WEEE Companies

A company's value proposition encompasses the unique offerings and products/services it offers to its customers (Lüdeke-Freund et al., 2019; Osterwalder et al., 2005). In the WEEE industry, companies provide services approaching CE practices including the 6R strategies. To examine the products offered by young companies in the WEEE sector, this study refers to the categories of products identified by the WEEE directive (European Parliament Directive, 2012) which includes large household appliances, small household appliances, IT and telecommunications equipment, consumer equipment, lighting equipment, electrical and electronic tool, toys, leisure, and sports equipment, medical device, monitoring and controlling equipment and automatic dispensers. The unique offerings provided by businesses in the WEEE sector are discussed as follows.

Unique offerings provided by WEEE companies: A strong value proposition in this industry entails the ability to provide unique offerings such as information/data security, convenience, compliance, and environmentally responsible solutions for managing electronic waste.

- **Information Security:** effective management of electronic waste must prioritize data security or information security, as protecting user data and ensuring original equipment manufacturer (OEM) brand protection are crucial concerns (Kissling et al., 2013). Consumers are concerned about data security issues relating to the disposal of personal consumer electronics. Moreover, information security is a major factor that influences users' decision to recycle IT and telecommunication equipment (Bai et al., 2018; Cole et al., 2019; Zhang et al., 2019). Proper destruction of data is necessary to safeguard customer privacy (Koga et al., 2013), and this should be done in compliance with relevant data destruction standards and regulations, including on-site and off-site data destruction options. End-of-life electronic recycling businesses need to provide proper documentation to ensure that data is completely wiped from the discarded devices, which helps to set up appropriate data destruction processes and demonstrate their compliance with proper standards and regulations.

- **Incentives** are a crucial factor in encouraging consumers to recycle unwanted electronic devices. Research has shown that providing incentives can significantly impact consumers' willingness to recycle (Bai et al., 2018; Ongondo & Williams, 2011a). Ongondo's (2011a) study found that incentives were necessary to spur cell phone recycling in the UK. Various types of incentives that can be offered, including financial return in exchange for the device (Chi et al., 2014; Kwarteng et al., 2018; B. Wang et al., 2019), store credit, gift cards, courier coupons or vouchers, prize draw entry or discount on a new device (Li et al., 2012; Zhang et al., 2019), competitive pricing or providing the appropriate price for products/services delivered (Cole et al., 2019; Kwarteng et al., 2018; Nasiri & Shokouhyar, 2021), free shipping (envelopes, bags, boxes), environmental incentive, and more. Different incentives elicit different levels of willingness to recycle, as stated by Ongondo (2011a). Financial incentives have been found to have significant effects on the desire to recycle electronic devices as shown by studies conducted by (Wang et al., 2011) and (Dwivedy & Mittal, 2013).

- **Convenience:** it is a system established by companies to facilitate the ‘easy’ or ‘less effort’ return of end-of-life products for repair, reuse, and recycling. This factor is critical for consumers in the WEEE sector which affects their decisions toward end-of-life electronics recycling (Zhang et al., 2019). Proximity and easy-to-find drop-off points, as well as access to the collection spot, are key elements in motivating consumers to recycle their old electronic devices (Bai et al., 2018; Chi et al., 2014; Zhang et al., 2019). To achieve convenience, door-to-door pick-up services are also popular collection modes due to their ease of use (Bai et al., 2018; Yin et al., 2014; Zhang et al., 2019). Other important factors include ease of the process (Wagner, 2013), timely payment (Bai et al., 2018; Wagner, 2013), or courier collection (Kwarteng et al., 2018; Zhang et al., 2019), and providing all services at a single point of contact, which offers suppliers a one-stop solution for collection, preparation for reuse, and recycling of used products (Kissling et al., 2013) are discussed as the main value propositions customers need towards convenience.

- **Compliance:** Recycling, transportation, and disposal of electrical equipment need a company’s compliance with a variety of state, federal, and even international environmental regulations. For instance, IT asset disposition needs to be performed in compliance with data security, environmental, and industry regulations. Compliance with regulations is crucial to the asset management and disposition services to ensure the proper handling of the proprietary and private data as well as the toxic components in retired IT assets. In general, compliance with legal and environmental regulations on electronic waste disposal is a significant concern for companies engaged in e-waste management (Schiller et al., 2016). The handling of electronic waste must comply with legal requirements (e.g., general data protection regulations (GDPR), NIST cyber security, health insurance portability, and accountability act (HIPAA)), environmental standards (responsible recycling (R2), e-steward, ISO 14001...) and other standards (quality management system, occupational health, and safety (OHS)).

- **Social responsibility:** WEEE contains hazardous materials that pose significant threats to both human health and the environment, making it essential to dispose of such waste with utmost care. To promote social responsibility regarding the management of end-of-life electrical devices, businesses adopt various sustainable practices such as zero-landfill policies and engaging the marginalized members of the community. The proper recycling of electronic equipment, done in a responsible, safe, and ethical manner, is crucial for businesses to distribute products for reuse (Nasiri et al. 2021; Kissling et al. 2013). Thus, securing a reliable recycling solution that prioritizes environmental sustainability and safety is a significant concern for businesses.

- **Quality:** In the current refurbished and secondhand electrical devices market, access to high-quality, used, or refurbished electronic devices is becoming increasingly important (Kissling et al., 2013). By offering these devices at a lower cost than the new ones, consumers can save money while still enjoying the peace of mind that comes with a guarantee or warranty. Appropriate warranty plans can eliminate any potential risk of purchasing a refurbished device, making them a more attractive option for consumers (Nasiri & Shokouhyar, 2021).

- **Trustworthiness:** is about establishing credibility and trust with customers and stakeholders from collection to preparation for reuse to redistribution (and to recycling and disposal if relevant) of used products (Chi et al., 2014; Kissling et al., 2013; Ongondo & Williams, 2011a). It also incorporates the transparent processes with complete chain of custody documentation such as by providing a certificate of data destruction and recycling S. Shokouhyar (2021) H. Bai et al. 2018, M.S. Nasiri and S. Shokouhyar 2021

- **Charitable purpose:** it is a practice of businesses providing customers with the option of donation or charity within their e-waste recycling programs. The donated devices can then be refurbished or repurposed and given to individuals or communities in need, such as schools, non-profit organizations, or underserved areas (Koga et al., 2013; Kwarteng et al., 2018; Li et al., 2012).

Table 1: Unique offerings provided by businesses managing EEE at their end-of-life from literature.

Category of Offerings	Description	Subcategories of Offerings	Literature support
Information Security	Assurance of data protection during e-waste disposal and recycling processes.	Data Wiping	H. Bai et al. (2018), C. Cole et al. (2019), R. Kissling et al. (2013), Koga et al., (2013), Y. Zhang et al. (2019)
		Secure Transport	
		Data Destruction	
Incentives		Economic Incentives: - Cash payment	H. Bai et al. (2018), X. Chi et al. (2014), C. Cole et al. (2019), R.

Category of Offerings	Description	Subcategories of Offerings	Literature support
	Providing economic and environmental benefits to encourage e-waste recycling.	- Store credit, gift cards, courier coupons, or vouchers - Discount on a new device - Competitive Pricing	Kissling et al. (2013), Koga et al., (2013), Bo Li et al. (2012), M.S. Nasiri and S. Shokouhyar (2021), Ongondo FO & Williams ID (2011a), J. Yin et al. (2014), Y. Zhang et al. (2019), Y. Zhang et al. (2019), Louise Canning (2006), B. Wang et al. (2019), Z. Sharifi and S. Shokouhyar (2021)
		Free shipping	
		Environmental Incentive	
Convenience	Providing easy and hassle-free options for e-waste disposal and recycling.	Convenient Drop-off Locations	H. Bai et al. (2018), X. Chi et al. (2014), C. Cole et al. (2019), Kissling et al. (2013), Koga et al., (2013), Ongondo FO & Williams ID (2011a), J. Yin et al. (2014), Y. Zhang et al. (2019), T.P. Wagner (2013), Louise Canning (2006), B. Wang et al. (2019)
		Door-to-Door Pick-up Service	
		Mail-back Programs/Courier Collection	
		One-Stop Recycling Solution	
		Ease of process	
		Timely Payment	
Compliance	Ensuring adherence to relevant laws, regulations, and standards in e-waste management.	Legal Compliance (GDPR, NIST, HIPAA...)	Kissling et al. (2013), Ongondo and Williams, (2011b)
		Environmental Standards (R2, e-steward, ISO 14001...)	
		Other standards (QMS, OHS)	
Social responsibility	Demonstrating commitment to social and environmental well-being through e-waste initiatives.	Community Engagement	Kissling et al. (2013)
		Sustainable Practices	
Quality	Offering high-quality, certified, and reliable used equipment with warranties/guarantees.	Certified Refurbished Products	C. Cole et al. (2019), R. Kissling et al. (2013), M.S. Nasiri and S. Shokouhyar (2021), Z. Sharifi and S. Shokouhyar (2021)
		Warranty/Guarantee	
Trustworthiness	Establishing credibility and trust with customers and stakeholders.	Transparent Processes (certificate of data destruction and recycling)	H. Bai et al. 2018, M.S. Nasiri and S. Shokouhyar 2021, Sharifi and S. Shokouhyar (2021)
		Track-and-Trace Capability	
Charitable Purpose	Incorporating charitable contributions or donations into e-waste recycling programs.	Donation Options	H. Bai et al. (2018), Koga et al., (2013), Bo Li et al. (2012), Ongondo FO & Williams ID (2011a)

3. Research Methodology

To explore business model innovation for the CE, we employed a literature review and multiple case study strategies. To conduct our literature review, we searched for publications related to CEBMs in managing electrical and electronic equipment at the end of life. We focused on the Scopus and Web of Science (WoS) core collection databases, using a Boolean conjunction of keywords. ("circular economy" OR "closed\$loop" OR "reverse logistic*" OR "recycl*" OR "end of life" OR "reus*" OR "refurbish*" OR "Repair" OR "maintain*" OR "recover*") AND ("E-waste*" OR "electronic-waste*" OR "electr* waste*" OR "electr* scrap*" OR "electr* garbage" OR "electr* rubbish" OR "WEEE" OR "waste* electr*" OR "obsolete electr*") AND ("Business model*" OR "value proposition*" OR "value creation*" OR "value delivery*"). We found 93 articles, of which we assessed the titles and abstracts for relevance to the value proposition study. We excluded publications focusing on technical recycling practices or research with no connection to BMs in the WEEE sector. The final dataset includes 15 articles that met the study's objective and are used to identify value propositions from the literature.

We analyzed 412 young companies selected from Crunchbase. To identify a wide range of circularity-based firms, we conducted a thorough search on Crunchbase, one of the most comprehensive tech-startup databases. Our search strategy involved using the keyword "Sustainability" which we combined with the industry group "Sustainability," "Consumer Electronics and Hardware," "Information Technology," and "Commerce & Shopping" resulted in 25,884 companies. After applying a filter to select companies with an active operating status, we conducted a detailed analysis of each company's website and the short and long descriptions of the companies' profiles on Crunchbase. Subsequently, we specifically included companies belonging to the EEE sector, which focuses on the end of a product life cycle. Furthermore, we excluded companies without a functional website, resulting in a total of 412 companies.

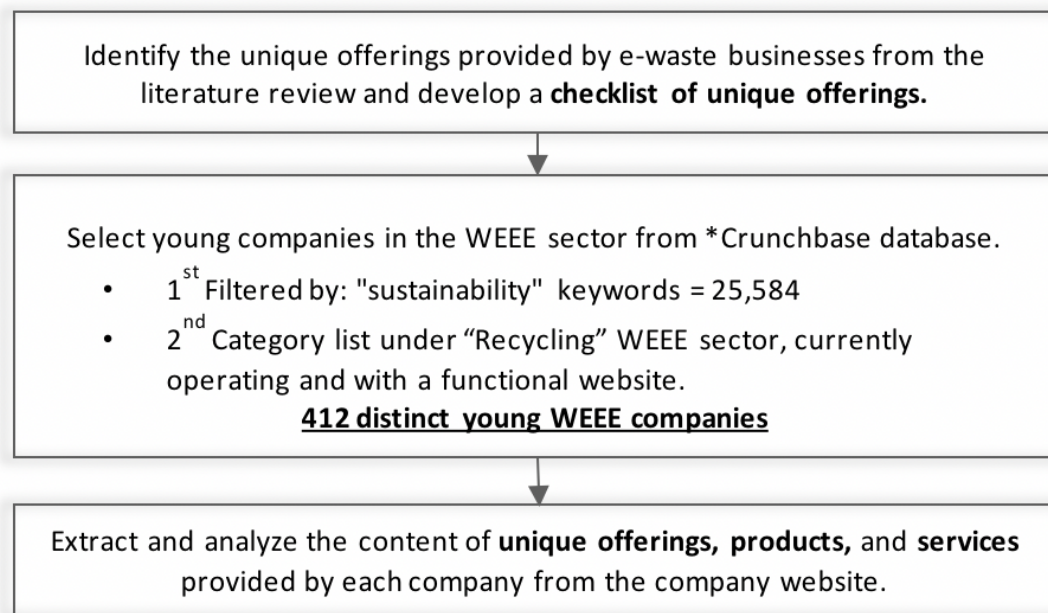


Figure 3: Research Method

4. Result and discussion

4.1 Unique Offerings Provided by Young Companies in the WEEE

Using a checklist developed from our literature review, our analysis of young companies in the WEEE sector finds several unique offerings provided by different BMs. These offerings include information security, compliance, trustworthiness, quality, social responsibility, incentives, and charitable purposes. Companies prioritize information security by offering data wiping and physical destruction through on-site or in-house service. Conveniences such as door-to-door pick-up, and drop-off options, customized solutions that are easy to use, and fast services are also other offerings. In addition, companies offer financial and environmental incentives, competitive pricing, high-quality refurbished products, compliance, and environmentally friendly processing as their main value propositions. Companies predominantly offer their customers a strong emphasis on Information Security (45.9%), Compliance with legal regulations and environmental standards (42.1%), and Trustworthiness (24.5%). In addition, companies primarily focus on Secure Data Wiping (69.4%) and Data Destruction (57.5%) as their key offerings. They also prioritize legal compliance related to Data security (56.6%) to ensure a robust and trustworthy service for their customers.

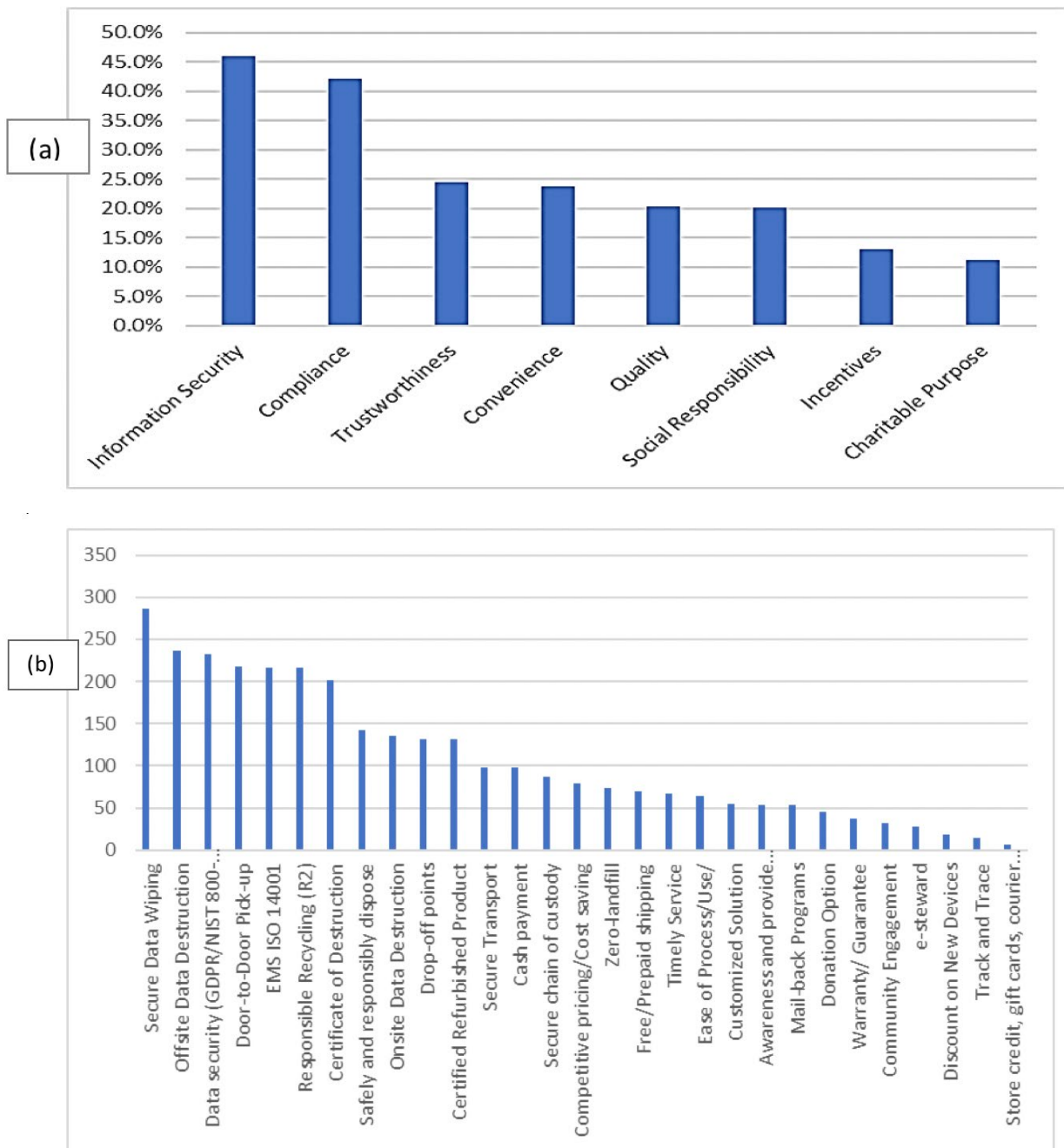


Figure 4: Unique Offerings of Young WEEE Companies (a) by Main Category and (b) by Subcategories

4.2 Products Processed by Companies in the WEEE

After analyzing 412 young companies based on the product categories outlined in the WEEE Directive 2002/96/EC, we found that most companies (67.9%) focus on IT and Telecommunications Equipment, which includes smartphones (77.3%), computers (71%), laptops (69.5%), and tablets (57.2%). In addition to ITT, companies in the WEEE sector also prioritize Consumer Equipment and PV (14.9%), which mostly VCR/DVD/Blu-Ray players (27%) and audio-visual equipment (25.3%), as well as Small Household Appliances (6.3), such as toasters (12.4%), vacuum cleaners (12.4%), blenders (11.8%), and microwaves (11.8%). These product categories are prominent in the BMs of young companies in the WEEE sector.

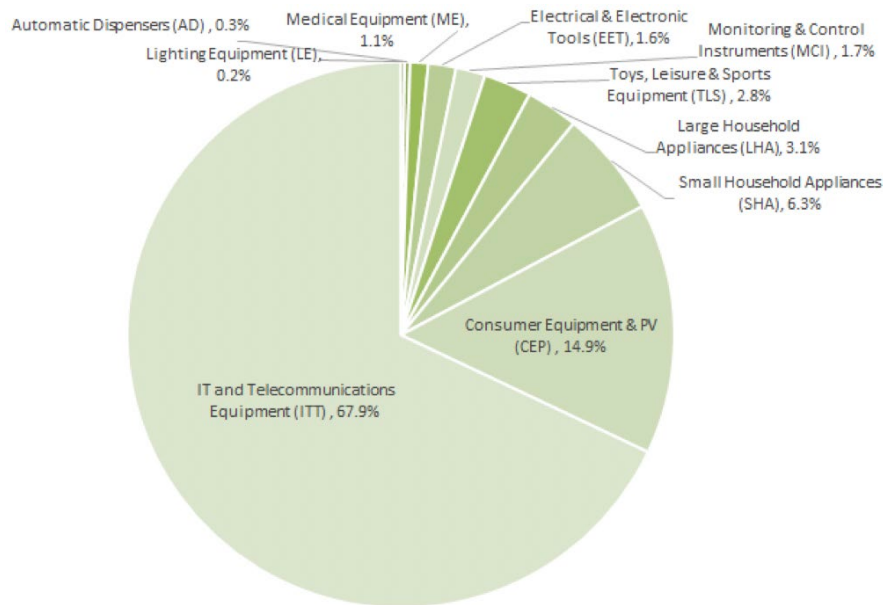


Figure 5: Product categories processed and delivered by WEEE young companies.

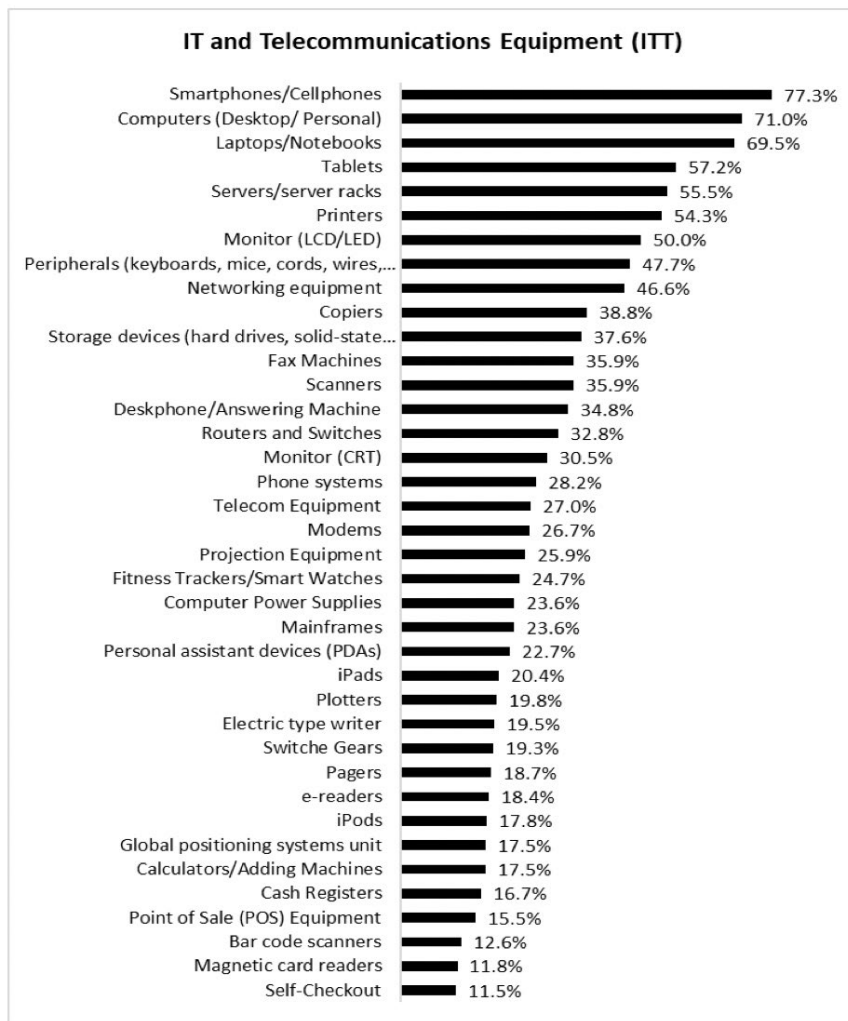


Figure 6: IT and Telecommunication Equipment Processed by Young Companies Operating in WEEE

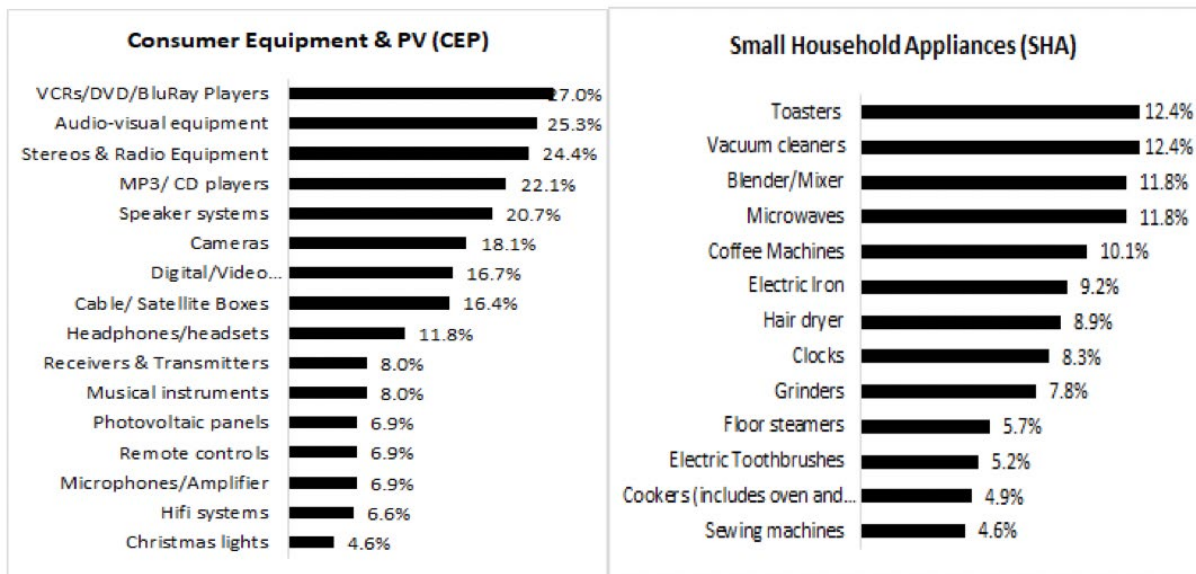


Figure 7: Electrical Devices Processed by Young Companies in the WEEE (a) Consumer Equipment and (b) Small Household Appliances

4.3 Services Offered

In our analysis of the 412 companies' websites, we found six primary service categories offered by the BMs of young companies in the WEEE sector. These service categories include asset management and e-waste Recycling service (38.3%), followed by ITAD Services (25.2%), trade-in/buyback and reselling of preowned and refurbished electrical devices service (18.9%), e-waste collection, recycling, and disposal service (15.8%), platform service for buying and selling of used electrical devices (1%), and IT support services (0.7%). Data destruction services are found common for all the BMs focusing on removing information from IT and telecommunication devices, using a variety of methods such as data destruction software tools, degaussing, and physical destruction. Data wiping is a process used to securely erase data from a storage device, making the original data unreadable. This method involves overwriting the existing data on the device with random or meaningless data, which destroys the original data and makes it impossible to recover using data recovery tools. Specialized software tools are used for data wiping. Another method of secure data destruction is degaussing, which uses electromagnetic fields to disrupt the surface area of the storage device where data is stored. Physical destruction of electronic devices involves shredding or crushing the storage device into small pieces or particles to ensure that data stored on the device is irretrievable and secure. The data destruction services can be delivered on-site or at a specialized facility and typically come with a certificate of data destruction, verifying that the storage device has been securely erased or physically destroyed in compliance with specific data destruction standards. In the following section, we will discuss the identified services offered by these businesses and their related unique offerings in more detail.

Asset management and e-waste Recycling service: Most of the young companies in the WEEE sector provide comprehensive services, from collecting old devices, and preparing for reuse to recovering valuable materials. These companies collect e-waste and repair/remanufacture for reuse or manage it responsibly by dismantling and sorting it. They employ specialized techniques to extract valuable materials from e-waste, contributing to resource conservation. Furthermore, they ensure that the recovered materials are treated and processed for reuse or recycling, promoting sustainability and circular economy principles while minimizing the environmental impact associated with electronic waste disposal.

IT Asset Disposition (ITAD): ITAD companies offer a set of services that involves the secure, compliant, and environmentally responsible disposal of electronic equipment and data. ITAD companies work with businesses and organizations to manage the disposal of assets, which are near or at the end of their lifecycles. These services typically include asset tracking and reporting, secure data destruction, secure transportation, redeployment, refurbishment and resale, environmentally responsible disposal, and recycling to maximize the IT asset value recovered while minimizing the risks associated with retiring active data-bearing equipment and following environmental protocols. ITAD services help businesses and organizations manage the lifecycle of their

electronic equipment and data, from acquisition to disposal, while protecting sensitive data and meeting regulatory requirements.

Trade-in or buyback and re-commerce services: businesses that offer trade-in or buyback and re-commerce services allow their customers (individuals or businesses) to sell their used electronic devices, such as smartphones, tablets, and laptops, in exchange for cash or credit toward a new one. The companies first assess the value of the device based on its condition, age, and other factors. Then provide an offer for the customer, and if customers agree, they can send the device to the company or bring it to a designated location for verification and processing. Finally, the company performs cleaning and data sanitation before reselling the devices online or in retail stores with a high-quality certified product at a lower price than new devices. Other companies even perform refurbishing or upgrade used equipment before reselling it. Furthermore, certain companies may offer warranties or return policies on their used mobile devices to offer customers an extra sense of security.

E-waste collection, recycling, and disposal service: in this business, offer the responsible and environmentally friendly disposal of electronic devices such as computers, laptops, and mobile phones. Recycling companies accept these devices through door-to-door pickup or drop-off points, dismantling, part harvesting shredding/crushing, and finally and extracting valuable materials and components while ensuring that hazardous materials are disposed of properly. These materials can be recycled and repurposed for new electronic devices, which helps to reduce the environmental impact of electronic waste. Many of these companies are certified by environmental organizations and adhere to strict standards such as R2, e-Stewards, and ISO 14001 to ensure environmentally responsible recycling. These companies also provide certificates of destruction and recycling that verify that the devices have been securely erased, physically destroyed, or recycled in compliance with specific standards.

Platform service for buying and selling used electrical devices: Based on the analysis of young WEEE companies, it appears that only a few businesses have been identified as offering an online marketplace for buying and selling used electrical devices. Platform service helps reduce electronic waste by allowing customers to trade in their used electronic devices. However, this segment of the market is relatively underrepresented compared to other areas of WEEE management.

IT support services: a business that specializes in electronic repair and replacement and offers various services to fix electronic devices such as smartphones, tablets, and laptops. They usually employ trained technicians who can diagnose and repair common hardware or software issues, including cracked screens, broken buttons, malfunctioning charging ports, and battery replacements. In addition, they may also provide software-related services such as virus removal, data backup, and software updates. Some repair businesses offer on-site repair services, while others only operate in-store. The main objective of an electronic repair business is to provide quick, easy, and cost-effective solutions to individuals and businesses in need of repair services for their electronic devices.

5. Conclusion

We conducted a literature review on CE-based BMs and analyzed 412 emerging circular companies in the WEEE industry selected from the Crunchbase database to understand their BMs. Based on the analysis of young companies in the WEEE sector, the research concludes that companies predominantly prioritize information security, compliance with legal and environmental standards, and trustworthiness in their BMs. Key offerings of these companies primarily revolve around secure data wiping and physical data destruction, along with legal compliance related to data security. The most prominent product categories in the WEEE sector are IT and telecommunications equipment, including smartphones, computers, laptops, and tablets. Consumer equipment, as well as small household appliances, are also notable in their business models. In terms of service categories, asset management & e-waste recycling hold the highest focus, followed by ITAD services, trade-in/buyback & reselling of used and refurbished electrical devices, and e-waste collection, recycling, and disposal services are key findings. However, platform services for buying and selling used electrical devices and IT support services are less prominent but still present in a few companies business models. Based on these results, recommendations and suggestions are presented as follows.

- Since information security is a top priority for companies in the WEEE sector, strengthening information security measures is essential for businesses to continuously improve and enhance their security practices. This may include investing in secure data erasure technologies, and regular security audits to ensure the protection of sensitive customer data.

- As compliance with legal regulations and environmental standards is a significant focus for these companies, enhancing environmental compliance is crucial to stay up to date with changing regulations and adopting environmentally friendly practices in their operations. Companies can consider obtaining relevant certifications to show their commitment to sustainability and responsible waste management.
- While secure data wiping and data destruction are key offerings, companies can consider diversifying their services to supply a more comprehensive and integrated approach to e-waste management. This could include offering repair and refurbishment services to extend the lifespan of electronic devices, thereby promoting the circular economy principles.
- While IT and telecommunications equipment are prominent, there is potential for young companies to explore opportunities in other product categories such as consumer equipment and PV, and small household appliances. By addressing these fewer dominant categories, companies can tap into new markets and widen their customer base. Targeting Less Dominant Product Categories:
- The low representation of platform services for buying and selling used electrical devices suggests an untapped opportunity in this area. Companies can consider developing user-friendly online platforms that help the trade of used electronics, encouraging customers to participate in the circular economy by giving their used devices a second life.
- As young companies in the WEEE sector, raising awareness among customers about the importance of responsible e-waste management is crucial. Companies can engage in educational initiatives to inform customers about the benefits of recycling, the potential environmental impacts of improper disposal, and the advantages of supporting circular economy practices.

Overall, the research shows valuable insights into the strategies and priorities of young companies in the circular economy business model within the WEEE sector. In general, this study finds that emerging companies in this sector are focused on extending product lifecycles through repairing, remanufacturing, reusing, and remarketing, and have the potential to work towards a CE if an adequate amount of used electronic devices are supplied by users. Therefore, as this sector is highly suitable for implementing CE principles, and young companies are more suitable for BM innovation, future studies should focus on studying the BMs of these companies beyond the value proposition dimension.

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