Exploring Determinants Influencing Consumers' Engagement in E-Waste Recycling Behavior: A Comprehensive Review

Nur Shafeera Mohamad and Ai Chin Thoo

Faculty of Management, Universiti Teknologi Malaysia, 81310 Skudai, Malaysia
Corresponding Author Email: shafeeramohamad@gmail.com

Abstract
The swift proliferation of electronic devices such as mobile phones, televisions, computers, laptops, washing machines and many more contributes significantly to the rapid generation of electronic waste (e-waste). This escalating issue has garnered substantial attention from numerous countries. This is because e-waste, often referred to as a "silent killer," contains a variety of toxic materials that can adversely affect the environment and human health if not properly recycled or managed. Therefore, it is crucial for consumers to recognize and aware the benefits of recycling e-waste. This paper presents an overview of the factors affecting e-waste recycling behavior among consumers by considers papers that has been published in the Scopus, Web of Science (WOS) and Google Scholar that related with e-waste recycling behavior. The findings of this study could be beneficial for the electronics manufacturers, governments, and policymakers to better understand the factors that can facilitate consumers to participate in the e-waste recycling behavior. In addition, this study can contribute to the formation of new laws and regulations that will enhance recycling efforts for a more sustainable ecosystem in the future.
Keywords: Electronic Waste (E-Waste), E-Waste Recycling Behavior, Waste Management, E-Waste Recycling Intention, Recycling Behavior, Pro-Environmental Behavior

Introduction
Over the past two decades, there has been a sharp decline in the average lifespan of electrical and electronic goods, often perceived as challenging or expensive to repair due to rapid technological advancements driving consumer demand (Duman et al., 2019; Ruiz, 2023). Manufacturers have invested substantial sums to stimulate consumer interest in the latest electronic models, rendering older technology obsolete and undesired even if still functional (Ruiz, 2023). Consequently, the proliferation of electronic devices has led to staggering volumes of electronic waste (Haron, 2019; Gill, 2022). Electronic waste (e-waste) has emerged as one of the world's fastest-growing waste categories, increasing by at least 2 million tonnes annually (Bourne, 2022). As a result, the global concern over e-waste has escalated

significantly (Aboelmaged, 2021). Additionally, Ruiz (2023) reported that in 2021, 57.4 million metric tonnes (Mt) of e-waste were generated, with an annual increase of 2 Mt. Previous studies indicate that 53.6 million metric tonnes (Mt) of e-waste were produced in 2019 (Abd-Mutalib et al., 2021a; Knudsen et al., 2021). Notably, nearly half of this substantial volume originates from Asian countries, amounting to 24.9 Mt (ERI, 2022).

Furthermore, according to Figure 1, current reports indicated that by 2030, global electronic waste generation is expected to reach 74.7 million metric tonnes, nearly doubling the amount produced in 2014 (Forti et al., 2020; V. Gill, 2022; Ruiz, 2023; Tiseo, 2023). ERI (2022) also notes that e-waste generation increased by 21 percent between 2014 and 2019. Hence, without significant intervention, this figure is forecasted to rise to 120 million metric tonnes by 2050.

Indeed, recycling is recognized as a cost-effective strategy for poverty alleviation and emission reduction, offering concurrent opportunities for job and economic growth (Whitmarsh, 2009). However, despite these benefits, global e-waste statistics for 2019 reveal a meager recycling rate of only 17.4% (ERI, 2022; Ruiz, 2023; Yun, 2021). The recycling rate in the United States stands at a mere 15% (ERI, 2022), while Asian countries exhibit a recycling and waste disposal rate of only 11.7%, with Africa registering the lowest recycling rate at just 0.9% (Ruiz, 2023). Similarly, in Malaysia, household e-waste recycling hovers below 25%, resulting in the disposal of hundreds of thousands of tonnes of e-waste in landfills annually (Thanam Industry, 2021; The Star, 2022). Additionally, Ruiz (2023) predicts that by 2023, the global stockpile of unrecycled e-waste will exceed 347 million metric tonnes.Hence, the persistently low rates of e-waste recycling underscore a prevalent lack of awareness among consumers regarding the significance of recycling e-waste. Consequently, this research endeavors to explore the determinants that significantly influence consumers' intentions and behaviors towards engaging in e-waste recycling initiatives. This investigation draws upon a critical review of pertinent literature on e-waste recycling intentions and behaviors to elucidate the relevant factors.

Literature Review
Electronic Waste
Electronic waste or generally known as e-waste, is defined as any electronic and electrical appliances or components that have been disposed of in which their previous consumers do not have any intention to reuse again (Baldé et al., 2017; Dias et al., 2019). Abd-Mutalib et al. (2021) have described e-waste as undesired electrical and electronic equipment that is obsolete, abandoned or reaching the end of its lifespan. Meanwhile, Mahmod et al. (2021) have stated that e-waste is sometimes referred to as e-scrap in some parts of the world.

Over recent years, e-waste has emerged as a global environmental problem that has captured the concern of many countries (Aboelmaged, 2021). This is because e-waste comprises potentially hazardous substances, including lead, arsenic, cadmium, mercury, cathode ray tubes, chromium and polybrominated biphenyls and chromium in which, if not managed properly, might turn potentially harmful and detrimental to the environment and human health (Abd-Mutalib et al., 2021; Batoo et al., 2021; Mahmod et al., 2021; Najmi et al., 2019; Ojha, 2020; Sharma et al., 2020)

On the other hand, e-waste are also highly valued as secondary raw materials such as gold and cooper. Leoi (2019) also added that most e-waste contains precious metals (such as gold, silver, platinum and palladium), iron, copper, aluminium and plastics that can be extracted and sold. Widmer et al. (2005) indicated that the recovery of these materials from e-waste is now becoming a profitable venture. Since a large number of precious metals are in e-waste, the recovery of e-waste will signify an appropriate economic advantage because it will help to save spending on limited and costly resources needed for the production of new electronic goods (Isernia et al., 2019). Hence, e-waste leads to a profitable business in developed countries. Despite being thrown away, it is supposed for reuse, resale, recovery, remanufacture, recycling, or disposal.

Factor Determinants That Influence Consumers' Engagement in Pro-Environmental Behavior
This section endeavors to explore the determinants that influence consumers' engagement in recycling activities or pro-environmental behavior. Drawing upon an extensive review of literature, this study incorporates several key factors that have consistently emerged in prior research as facilitators or triggers for consumer participation in recycling behavior or pro-environmental activities. These factors encompass environmental values (Ofori and Mensah, 2021), moral norms (Kumar, 2019), environmental knowledge (Zafar et al., 2021), accessibility of recycling facilities (Zhang et al., 2019), convenience of recycling practices (Mohamad et al., 2022), government initiatives (Sari et al., 2021), and economic incentives (Cossu and Masi, 2013).

Environmental Values
According to Cheung and To (2019), strong environmental values increase consumers' propensity to care about sustainable and environmental benefits. Meanwhile, Ofori and Mensah (2021) have stated that environmental values produce an internal encouragement to enhance environmental protection by activating pro-environmental behaviors such as waste sorting and recycling. Yang and Weber (2019) and Mintz et al. (2019) have indicated that an individual's environmental value structure can strongly influence how they form beliefs and their willingness to engage in environmental behaviors, as well as their willingness to support and join other environmental initiatives. Previous research have revealed that environmental values are associated with positive intentions and willingness to participate in pro-environmental behavior (Mintz et al., 2019; Steg and Nordlund, 2018; Yang and Weber, 2019; Zhang et al., 2018). Furthermore, in the study of e-waste recycling, Dwivedy and Mittal (2013) also discovered that environmental values enhanced consumers' willingness to participate in e-waste recycling. In conclusion, consumers are more inclined to engage in environmentally concerned behaviors when they assume they are responsible for environmental degradation and ecological issues.

Moral Norms
Tonglet et al. (2004) found that an individual who perceives it is necessary to recycle or vice versa is likely to include personal norms in the decision-making process. Moral norms are also frequently perceived as a significant determinant in determining the consumers pro-environmental behavior (Han et al., 2018; Li et al., 2018; Park and Ha, 2014; Wang et al., 2020). For instance, Pakpour et al. (2014) found that moral norms are the highest predictor of consumers' waste behavior and recycling behavior. Han et al. (2018) revealed that personal moral norms are substantially connected with the environmentally conscious intentions of

tourists regarding recycling and waste reduction. Also, Botetzagias et al. (2015) found that moral norms have a larger effect on recycling intention than attitude. In the same veins, Juliana et al. (2022) also found that moral norms have a substantial impact on consumers' recycling behavior in Malaysia. The study found that the participation of society in recycling could be increased through programs that enhance the moral obligation of individuals to conduct recycling practices. Thus, based on a significant number of evidence concerning the predicted relationship between moral norms and the recycling intentions and behaviors, moral norms can provide as a key factor of factor determinants engaging in e-waste recycling.

Environmental Knowledge
Yusuf and Fajri (2022) claimed that it is widely acknowledged that environmental education influences knowledge. Education is one of the most effective mechanisms for raising people's awareness, particularly in developing countries. Gibson et al. (2011) indicated that environmental education or knowledge aims to encourage individuals by engaging their altruistic motivations to adopt a green or pro-environmental lifestyle instead of overconsuming and harming the environment. Welfens et al. (2016) claimed that by obtaining adequate environmental knowledge, such as clear instructions provided in communication and collection programs, it might enhance the possibility of recycling behavior. In addition, in order to create policymakers and activists capable of promoting long-term sustainability, environmental knowledge is an essential component of this process (Heimlich and Ardoin, 2008). Environmental knowledge is more than just understanding the environment; it also improves analytical reasoning, problem-solving, and decision-making abilities (Ernst and Monroe, 2004; Fraser et al., 2015; Yusuf and Fajri, 2022). Thus, enhancing environmental knowledge tends to raise awareness of the importance of proper waste management (Tangwanichagapong et al., 2017). Apart from that, it also enhances understanding of the issues, allowing people to take action to protect the environment (Bamberg and Möser, 2007). Therefore, prior literature believed that environmental knowledge is one of the most important variables in predicting pro-environmental behavior since people would not have the ability or opportunity to conduct an environmentally responsible behavior without adequate knowledge. For instance, previous studies have found that environmental knowledge have significant impact with consumers' intention to perform environmentally responsible behaviors, including recycling (Meng et al., 2019; Otto and Pensini, 2017; Paço and Lavrador, 2017; Ramayah and Rahbar, 2013; Wang et al., 2016; Zhang et al., 2015). Therefore, environmental knowledge was regarded as the crucial component in relation to e-waste recycling behavior.

Facility Accessibility
According to Sari et al. (2021), accessibility is an objective condition for implementing a certain behavior. Hence, lack of accessibility would result in an inconvenience when engaging in a particular behavior (Zhang et al., 2016). The convenience of recycling infrastructure availability relates to the accessibility of recycling facilities (Juliana et al., 2022). According to Zhang et al. (2016), accessibility of facilities is described as one of the most significant situational barriers impeding the conversion from individual recycling intentions to actual behavior. Apart from that, Stoeva and Alriksson (2017) also agreed that the accessibility of waste separation facilities are significant motivators for consumers to engage in waste recycling, hence it can directly promote consumers' recycling behavior (Fan et al., 2019). Therefore, many empirical studies have consistently revealed and supported the influence of

facility accessibility on pro environmental behavior including recycling or waste sorting behavior (Ali and Yusof, 2018; Bernstad, 2014; Harsono and Suryana, 2014; Ma et al., 2020; Meng et al., 2019; Zhang et al., 2019) For example, Ma et al. (2020) have discovered that facility accessibility had the greatest direct influence on waste separation behavior. In addition, Kochan et al. (2016) and Afroz et al. (2020) indicated that consumers would be more motivated to participate in recycling activities if there were no challenges in recycling waste by developing more locations for collecting recyclable items. Consequently, the facility accessibility acts as an important component for the consumers to engage with recycling activity.

Convenience of Recycling
Tonglet et al. (2004) defined that convenience is an individual's time, space and perceived comfort as well as simplicity in conducting waste management. Wan et al. (2012) claimed that perceived convenience is the concept of which a person feels that the availability of time to remove, sort and store e-waste will impact his or her e-waste recycling behavior. Kochan et al. (2016) stated that participation of consumers in recycling could be increased through developing a close location of disposal recipients, reducing the difficulty in collecting and processing recyclable waste, and providing various recycling collection programs and courses such as recycling collection activity or event and curbside collection. For an example, there is an incrementing number of e-waste recycling facilities such as e-waste recycling bins that have been installed in urban areas in China. The recycling facilities have offered consumers with more convenient concept to drop their e-waste. Thus, consumers do not have to travel too far to recycle their e-waste (Zhang et al., 2019). That is why most of previous studies suggested that convenience is an important element in promoting the intention of recycling (Haron, 2019; Saphores et al., 2006; Sidique et al., 2010; Zhang et al., 2019). For instance, Kochan et al. (2016) indicated that perceived convenience is an important factor that leads to more involvement in ecycling. Liu et al. (2019) found that one of the most crucial aspects that plays a role in mobile phone recycling is the convenience of recycling facilities. This was supported by (Shaharudin et al., 2020) who indicated that consumers found that convenience, especially, in terms of their time, space and distance had motivated them to recycle their e-waste.

Government Drivers
Cossu and Masi (2013) have indicated that basically, the legislation served as the system's driving power in performing pro-environmental behavior because, without effective laws and regulations, even the most progressive governments would undoubtedly resort to dumping waste illegally, such as dump it in the open spaces, and possibly causing more damage like setting fire to pile of wastes. Similarly, Leonard (2008) and Qin and Song (2022) also have highlighted that individuals can be effectively driven by policies to make decisions on a path that the government anticipates would be advantageous for the overall welfare of societies. Mak et al. (2019) also agreed that compliance with legislation is the most essential factor for encouraging recycling behavior. The effectiveness of policy intervention has been proved into pro-environmental research including recycling behavior studies. For example, past studies found that the implementation of policies or laws and regulations had a positive effect on the pro-environmental behavior (Liao et al., 2018; Nduneseokwu et al., 2017; Nguyen et al., 2018; Shaharudin et al., 2020; Wan et al., 2014; Wang et al., 2016; Zhang et al., 2019). Sari et al. (2021) and Nguyen et al. (2018) have found that government drivers or laws and regulations

ruled by the government have the most significant influence on consumer intentions. This means that laws and regulations are the strongest predictor of consumer to return their e-waste to collection centers. Based on the previous literature, it showed that legal and regulatory policies can be the main instruments for the implementation of e-waste management.

Economic Drivers

To facilitate any pro-environmental action or increase the intention to perform pro-environmental behavior, it is believed that when incentive measures are provided, consumers can be reimbursed for the extra time, cost, and effort they have expended (Iyer and Kashyap, 2007; Wang et al., 2020). Zhang et al. (2019) also highlighted that even though, consumers have no intention or motivation to participate in waste sorting activities in their everyday routines, they may automatically perform that behavior if appropriate incentive measures are provided to them. According to Shaharudin et al. (2020), it is recommended that the government should demonstrate any rewards or incentives that may be offered to end-users who dispose of their portable e-waste properly, because these approaches may give consumers a stronger motivation to engage in disposal activities in the future. Wang et al. (2019) found that consumers' willingness to perform in recycling increases as the economic benefits provided by the on-line recycling platform increase. Similarly, Chen and Gao (2020) contended that financial benefits are a significant motivation for waste separation and that government incentives encourage consumers to utilize formal recycling channels. Previous research has demonstrated the effectiveness of economic incentives in influencing consumer environmental behavior (Mizobuchi and Takeuchi, 2013; Owusu et al., 2013; Sierzchula et al., 2014; Wang et al., 2020; Zhu et al., 2013). That is why economic drivers are frequently implemented to encourage pro-environmental behavior.

Research Methodology

This study adopts a systematic literature review to evaluate the determinants influencing consumers' engagement in recycling activities or pro-environmental behavior. In order to review the determinant factors influencing consumers' participation in recycling activities or pro-environmental behavior, this study encompasses all papers published in the Web of Science (WOS) and Scopus databases. Employing appropriate search terms is essential in electronic database searches, and the "keyword" approach was utilized as it is commonly practiced by past researchers to identify relevant literature. Keywords employed to retrieve titles and abstracts included "recycling behavior," "pro-environmental behavior," "waste management," "recycling activities," "recycling intention," "recycling waste," "electronic waste," "electronic waste management," "e-waste recycling," "e-waste recycling behavior," "e-waste management," "e-waste intention," "environmental behavior," "environmental knowledge," "environmental values," "convenience recycling," "government drivers," "economic drivers," "economic incentives," "moral norms," and "facility accessibility."

Subsequently, this study selected seven determinant factors consistently utilized by prior literature to stimulate or drive consumer participation in environmental behavior, namely environmental knowledge, environmental values, convenience recycling, government drivers, economic drivers, economic incentives, moral norms, and facility accessibility. A systematic review was then conducted, focusing on studies related to e-waste management or recycling that incorporate these factors. The findings indicated the significance of these

factors in influencing e-waste recycling behavior (see Table 1). This study encompasses all papers related to e-waste recycling behavior published between 2016 and 2022.

Table 1
Factor Determinants Influencing Consumers' Engagement in e-waste Recycling Behavior

Variables / Author	Environmental	Moral Norms	Environmental Knowledge	Facility Accessibility	Convenience of Recycling	Government Drivers	Economic Drivers
Kochan et al. (2016)		√					
Wang et al. (2016)			√		√		
Nduneseokwu et al. (2017)	√			√		√	
Nguyen et al. (2018)	√				√	√	
Wang et al. (2018)		√					
Haron (2019)					√		
Kumar (2019)		√					
Liu et al. (2019)			√		√		
Wang et al. (2019)							√
Zhang et al. (2019)				√	√		
Afroz et al. (2020)					√		
Shaharudin et al. (2020)					√	√	
Ofori and Mensah (2021)	√			√			
Ramzan et al. (2021)					√		
Sari et al. (2021)			√	√		√	
Zhang et al. (2021)		√					
Koshta et al. (2022)			√				
Mohamad et al. (2022)		√	√		√		
Mokkhamakkul (2022)							√
Sabbir et al. (2022)						√	
Sajid et al. (2022)			√				

Results and Discussions
This study has examined 21 papers related to consumers' e-waste recycling behavior published between 2016 and 2022. Based on the findings (see Table 1), it shown that previous research has found that the convenience of recycling have influence substantial impact on consumers' e-waste recycling behavior (Afroz et al., 2020; Haron, 2019; Liu et al., 2019; Mohamad et al., 2022; Nguyen et al., 2018; Ramzan et al., 2021; Shaharudin et al., 2020; Wang et al., 2016; Zhang et al., 2019). As stated by Kochan et al. (2016) that the participation of

consumers in recycling could be increased through developing a close location of disposal recipients, reducing the difficulty in collecting and processing recyclable waste, and providing various recycling collection programs and courses such as recycling collection activity or event and curbside collection. For example, there is an incrementing number of e-waste recycling facilities such as e-waste recycling bins that have been installed in urban areas in China. The recycling facilities have offered consumers with more convenient concept to drop their e-waste. Thus, consumers do not have to travel too far to recycle their e-waste (Zhang et al., 2019). Next, environmental knowledge emerges as the second prominent determinant affecting consumers' e-waste recycling behavior (Koshta et al., 2022; Liu et al., 2019; Mohamad et al., 2022; Sari et al., 2021; Wang et al., 2016). Liu et al. (2019) posit that comprehensive knowledge empowers consumers to proficiently sort e-waste, thereby bolstering their confidence and reducing perceived obstacles.

Furthermore, moral norms (Kochan et al., 2016; Kumar, 2019; Mohamad et al., 2022; Wang et al., 2018; Zhang et al., 2021) and governmental initiatives (Nguyen et al., 2018; Sabbir et al., 2022; Sari et al., 2021; Shaharudin et al., 2020) emerge as consequential factors. For instance, Nguyen et al. (2018) discovered that the appropriate disposal of electronic goods in Vietnamese households was highly dependent on the individual's moral norms or obligation. In the same veins, Mohamad et al. (2020) also found that moral norms have a substantial impact on consumers' e-waste recycling behavior in Malaysia. The study found that the participation of society in recycling could be increased through programs that enhance the moral obligation of individuals to conduct recycling practices. On the other hand, Sari et al. (2021) and Nguyen et al. (2018) have found that government drivers or laws and regulations ruled by the government have the most significant influence on consumer intentions. This means that laws and regulations are the strongest predictor of consumer to return their e-waste to collection centers. Also, from the Malaysian context, Shaharudin et al. (2020) indicated that Malaysian youth might view the efficiency of the government drivers as an effective strategy, which might influence their intention to dispose of their e-waste.

Apart from that, the fourth-place factor determinant that significantly impact consumers' e-waste recycling behavior are facility accessibility (Nduneseokwu et al., 2017; Ofori and Mensah, 2021; Sari et al., 2021; Zhang et al., 2019). For instance, Ofori and Mensah (2021) have claimed that the availability of waste management facilities improves convenience and accessibility, hence its impact on increasing recycling rates. Furthermore, Sari et al. (2021) have found that facility accessibility has a significant effect, either directly on consumer intention to participate in e-waste collection programs or indirectly through PCB. This shows that people need facility accessibility to participate in e-waste collection programs.

In addition, the fifth place for the factor determinant that can influence consumers participation in e-waste recycling behavior is environmental value (Nduneseokwu et al., 2017; Nguyen et al., 2018; Ofori and Mensah, 2021). For instance, Nguyen et al. (2018) have found that environmental value towards recycling was the second strongest determinant factor impact the residents' recycling intention effectively. It can be concluded that environmental value had a strong contribution, leading the development of consumers' willingness to participate in recycling. Lastly, the least factor that can influence consumers to engage with e-waste recycling behavior is economic drivers (Mokkhamakkul, 2022; Zhang et al., 2019). For instance, Zhang et al. (2019) have claimed that due to the presence of useful and precious

elements in e-waste, such as heavy metals, gold and silver, e-waste recycling can generate economic benefit for consumers. For instance, most of the collection centers in China offer financial incentives to consumers who drop in their e-waste.

Conclusions

In conclusion, this study focuses to review the determinants that influence consumers' participation in e-waste recycling behavior. Thus, from the academic perspective that conducting similar studies could be used this paper as a resource for their studies, especially in understanding the factors that can be facilitators to engage with e-waste recycling. In addition, the findings and results of this study might be beneficial to the government in an attempt to encourage environmental, social, and economic sustainability. For example, the government may encourage consumers to return such unwanted electrical and electronic goods to licensed recovery facilities and implement more e-waste recycling programmes or initiatives, especially to consumers or community. So that consumers will realize that e-waste should be recycled to reduce contamination of the environment and human health. This study also can help to enhance awareness for the government and policy makers to introduce new legislations or structures to handle and cope with the ever-increasing e-waste in which have been generated by consumers in an effective method. From the industry context, especially in the electronics industry, they will be more conscious that e-waste can obtain environmentally friendly treatment through an appropriate management strategy as well as implementing systematic reverse logistics techniques. Therefore, through the process of remanufacturing, reconditioning and recycling the e-waste, industry can recapture valuable components from e-waste and produce more eco-friendly goods.

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