8-2023

The analysis of extended producer responsibility (EPR) for e-waste management Policy Drivers and Challenges in Singapore

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The Analysis of Extended Producer Responsibility (EPR) for E-waste management policy drivers and challenges in Singapore

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Abstract

This work examines the role of the Extended Producer Responsibility (EPR) scheme in managing electronic waste (e-waste) logistics in Singapore. The study investigates the challenges and policy drivers of e-waste management, using an online survey to explore the attitudes and behaviors of young consumers, with a particular focus on young people. We use the Theory of Reasoned Action (TRA) and Theory of Planned Behavior (TPB) frameworks to develop a model that investigates the relationship among attitudes, perceived norms, awareness, and perceived convenience towards EPR awareness and stance. The findings highlight the needs for customized policies for different groups based on their attitudes and level of awareness towards the EPR, as well as the importance of increasing awareness of formal e-waste recycling channels to promote sustainable e-logistics. Moreover, a further study related to the association test is conducted to determine whether there exists any association between selected variables (e.g. the reasonable distance to dispose e-waste and the factor that can motivate us to recyle) and the variable related to attitude and awareness towards EPR is related or not.

Keywords: E-waste management, Extended Producer Responsibility, Theory of Reasoned Action, Theory of Planned Behavior, the association test

1 Introduction

Electrical and electronic equipment (EEE) is in high demand due to increased urbanization, industrialization, and population expansion. However, the disposal of waste from electrical and electronic equipment (WEEE) or e-waste has become a significant problem, particularly in cities, as it is the fastest-growing waste stream in the world, with an estimated 50 million tonnes produced annually. E-waste constitutes a significant source of household and corporate waste due to higher production, increased affordability, and limited repairing options. The management of e-waste has proven to be incredibly challenging, even in industrialized nations with well-established waste management systems [1].

Various countries globally have established regulatory frameworks to manage e-waste disposal and recycling, with the aim of reducing pollution and promoting resource reutilization. Due to the unique circumstances of each country, there is no universal model with established regulations for managing e-waste. Current e-waste legislation in different nations primarily includes import/export bans, recycling standards for specific categories of e-waste, and Extended Producer Responsibility (EPR) schemes. Despite e-waste accounting for less than 1% of the total waste generated in Singapore, it poses a potential danger to the environment. Therefore, e-waste has been prioritized as one of the top three priority waste streams to accomplish the Zero Waste Nation agenda. An estimated 60,000 tonnes of e-waste are discarded annually. To manage e-waste recycling in Singapore, The National Environment Agency (NEA) established a regulated e-waste management system based on the EPR approach, which was introduced in 2021 in accordance with the Zero Waste Masterplan (ZWMP) 2019.

EPR is a policy approach that holds manufacturers responsible for the end-of-life impact of their products, promotes responsible manufacturing processes, and facilitates proper collection and disposal of products after use. As part of this policy, EEE retailers are required to offer free in-store collection services [2]. In addition, ALBA E-waste Smart Recycling Pte Ltd has been designated as the Producer Responsibility Scheme (PRS) operator from 2021 to 2026, responsible for collecting regulated e-waste in Singapore and ensuring its proper treatment and recycling. The ZWMP also outlines plans to extend EPR to packaging waste by 2025.

Our study utilized data obtained from an online survey conducted in June-July 2021, during the EPR scheme execution phase. The survey was designed to gather information from young participants regarding their e-waste recycling behavior, intentions, understanding of environmental consequences, perceived convenience, awareness of EPR, and attitudes toward e-waste recycling and EPR. A Likert-type scale with endpoints and descriptive text were used for this purpose. This study is the first to explore the reverse logistics of e-waste in Singapore by analyzing the attitude-behavior factors based on the degree of EPR awareness and attitude toward EPR. This study also includes the independence test of demographic variables with the variable related to attitude and awareness towards EPR.

The remainder of the paper is structured as follows. Section 2 presents a concise literature review, while Section 3 details the theoretical context, data collection process, questionnaire design, proposed models, and hypotheses. In Section 4, the analysis

results are discussed, followed by presenting policy recommendations based on the study's findings. Finally, Section 5 provides a summary of the findings and outlines possible directions for future research.

2 Literature Review

Consumer behavior and attitudes towards sustainable consumption and production practices have gained significant attention in recent years due to the growing concern about environmental sustainability. The sustainability of different industries is crucial for the long-term viability of the economy, society, and the planet. Various studies have examined the determinants of consumer behavior and intention to participate in sustainable practices. The theory of planned behavior (TPB) and the Decomposed Theory of Planned Behavior (DTPB) are commonly used frameworks to identify the determinants of recycling intention and customers' participation in reverse supply chain management.

One such study utilized an extended Theory of Planned Behavior (TPB) model to explain recycling intentions, which accounted for 79% of the variance in recycling intentions. The study found that "Attitudes" and "Past recycling behavior" were statistically significant factors influencing recycling behavior. However, the study also emphasized the need to consider various psychological, situational, demographic, and other operational, environmental, and social factors to fully comprehend what influences recycling behavior [3].

A 2019 survey conducted by the Ministry of Environment and Water Resources (MEWR) and the National Environment Agency (NEA) in Singapore revealed that 60% of residents recycle regularly, with convenience being the primary motivator. However, e-waste is not among the most commonly recycled items, and the majority of Singaporeans misunderstand that recyclables must be sorted by type before being deposited [4]. The availability of infrastructure plays a critical role in encouraging sustainable practices. In a study by [5], the authors found that the availability of recycling bins and collection services was a significant factor that influenced consumers' recycling behavior. Similarly, in a study by Fuentes-Bargues et al. (2017), the authors found that the availability of eco-labeling and eco-certification schemes was an important determinant of consumer behavior.

Another study investigated the causes and interactions of different stakeholders in Extended Producer Responsibility (EPR) program design and implementation in Quebec. The study found that physical responsibility, financial responsibility, quality of treatment, and degree of enforcement were important factors affected by and responding to Quebec's EPR program. While EPR programs in Quebec have been more harmonized, some effects do not align with regulatory objectives [6].

Demographic and socioeconomic variables have been shown to contribute to predicting pro-recycling behavior over time. An analysis revealed that attitude and awareness towards e-waste recycling were the primary influencing factors for recycling intention, highlighting the importance of campaigns that increase people's understanding of the harmful impact on environmental and human health [7].

A study explored the relationship between awareness and behavior and discovered that awareness's ability to influence sustainable behaviors is behavior-specific. While raising awareness did not result in changes in sustainable travel/transportation behavior, all students at the University of Michigan could engage in sustainable waste prevention behaviors. Future research should examine socioeconomic factors that may impede or facilitate sustainable behavior [8].

Contradicting the Yale attitude change approach [9], which stated that changing the knowledge component would affect attitudes, another study found that awareness had no effect on attitude. The study suggested that the lack of effectiveness in communication could explain this finding, as the message used to change a person's attitude must be noticed, understood, accepted, and retained long enough to be effective [10]. Factors such as the source of the message, message characteristics, and audience can all impact the communication's effectiveness.

3 Materials and methods

3.1 Theoretical Background

To investigate the attitude-behavioral factors, this study employed the Theory of Reasoned Action (TRA) and Theory of Planned Behavior (TPB) frameworks, which are commonly used in attitude-behavioral investigations [11]. The TRA suggests that the initial determinant of behavior is a person's intention, influenced by their attitude and subjective norms [12]. However, factors such as lack of opportunities, skills, and resources may hinder behavior performance. The TPB expands on this by including a third variable - perceived behavioral control - which measures an individual's ability to perform the behavior. Figure 1 illustrates this expanded framework. As e-waste recycling requires sorting, preparation, and storage, it involves significant individual effort and various factors that may affect the recycling decision [12].
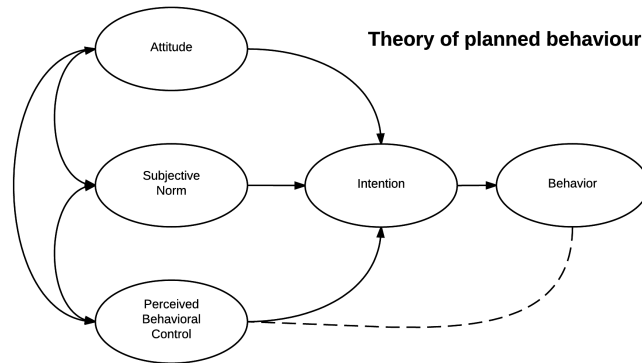

Fig. 1: Theory of planned behavior

3.2 Sample and Data Collection

Previous research has indicated that universities exhibit similar characteristics to the general public and serve as hubs for diverse communities engaged in activities that require significant resources and energy. As a result, universities can be considered as communities that have a considerable impact on society [11]. This study focuses primarily on the perceptions of young consumers, specifically university students, regarding the current e-waste management system in Singapore. The consumer sector was chosen for two reasons: first, this group represents individuals in society who are long-term users of electronic devices; second, they have significant consumption capacity due to technological advancements.

Data collection for this study was conducted online between June and July 2021, in light of the Covid-19 pandemic, and yielded 479 valid responses. The socio-demographic characteristics of the respondents include 228 male and 251 female participants. Nearly half of all responses were from individuals between the ages of 18 and 25 (48.64%), the majority of whom had at least a bachelor's degree (60.96%), and 85.8% of respondents reported living with their families.

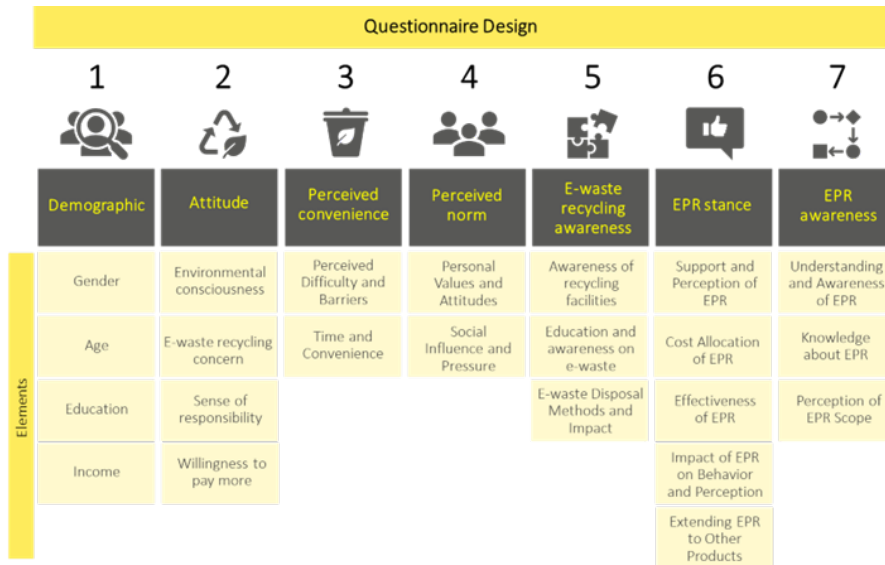## 3.3 Questionnaire design

Fig. 2: Questionnaire design overview

The survey was designed to gather information regarding their e-waste recycling behavior, intentions, understanding of environmental consequences, perceived convenience, awareness of EPR, and attitudes toward e-waste recycling and EPR. The study is unique in exploring the reverse logistics of e-waste in Singapore by analyzing the

attitude-behavior factors based on the degree of EPR awareness and attitude toward EPR.

Figure 2 illustrates the survey questionnaire design that consisted of seven main categories. The initial section of the questionnaire collected demographic information, such as gender, age, education, and income. Sections 2-5 comprised questions that related to the influencing factors outlined in the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB) frameworks. These sections included questions on attitudes, perceived convenience, perceived norms, and e-waste recycling awareness. The other two sections, 6-7, focused on questions about EPR scheme stance and EPR scheme awareness. The survey employed a five-point Likert scale to measure both dependent and independent variables, ranging from 1-"Strongly Disagree" to 5-"Strongly Agree." The details of the questionnaire can be found in Appendix A (Section ??).

3.4 Models and Hypotheses

The hypothesis in this study is that the determinants of intents will have an impact on the effectiveness of the EPR policy. Specifically, the level of knowledge and attitude towards the EPR scheme differs among various groups that have different determinants of intents. As a result, in addition to the overall analysis, distinct models are developed for four different groups based on their level of EPR awareness and their stance towards EPR. These groups include individuals who are aware of the EPR scheme and support it, individuals who are aware of the EPR scheme but do not support it, individuals who are not aware of the EPR scheme but support it, and individuals who are not aware of the EPR scheme and do not support it. These models provide a better understanding of the varying levels of EPR scheme knowledge and attitudes among the different groups and how they relate to their intentions towards the EPR scheme. By examining the determinants of intents in relation to EPR schemes, this research contributes to the development of more effective EPR policies that promote sustainable e-waste management practices.

1. **Attitude:** Attitude is defined as the individual's favorable or unfavorable evaluation of performing e-waste recycling. Our hypothesis is that there exist variations in the attitude towards e-waste recycling across groups that are classified based on their level of knowledge regarding EPR and their stance towards the EPR policy. To measure the attitude, we employed a questionnaire consisting of three questions that gauged the participants' concern for environmental pollution and their understanding of the importance of e-waste recycling. A higher score on the questionnaire indicated a positive attitude towards e-waste recycling, whereas a lower score indicated a negative attitude.
   H1: *There are differences in attitude towards e-waste recycling among groups categorized by their level of EPR knowledge and their stance on the policy.*

2. **Perceived norms:** To assess the participants' motivation to comply with the expectations of others in terms of e-waste recycling, we measured their perceived

norms. This refers to the subjective norms that influence an individual's decision to recycle e-waste. The participants' concern about being viewed as e-waste recyclers by their friends and family was evaluated using three questions. The questions aimed to determine how participants wished to be perceived by their social circle with regard to their e-waste recycling behavior. A higher score on the perceived norm scale indicates a stronger desire to be recognized as an e-waste recycler. Our hypothesis is that there are differences in perceived norms across groups categorized based on their level of knowledge about the EPR scheme and their stance on the EPR policy.

H2: *There are differences in perceived norms among groups categorized by their level of EPR scheme knowledge and their stance on the policy.*

3. **Perceived convenience:** This is defined as the time and perceived convenience for an individual to manage e-waste. To evaluate the perceived convenience of e-waste recycling, a questionnaire consisting of three questions was designed. The questions aimed to assess the participants' opinions on how easy or difficult e-waste recycling is and whether their current condition allows them to engage in recycling. A higher score on the questionnaire indicated a higher level of perceived convenience in e-waste recycling. Our hypothesis is that there are differences in perceived convenience across groups classified based on their level of knowledge about the EPR scheme and their stance on the EPR policy. By testing this hypothesis, we analyse whether certain groups find e-waste recycling more convenient than others and whether perceived convenience influence knowledge and attitudes towards EPR policy.

H3: *There are differences in perceived convenience of e-waste recycling among groups based on their level of EPR knowledge and their stance on the policy.*

4. **Awareness of consequences:** The questionnaire on awareness of consequences is designed to measure individuals' knowledge and awareness of the environmental impact of e-waste and the importance of proper handling and disposal. The questionnaire included five items, each designed to measure a different aspect of awareness, such as knowledge of which types of e-waste can be recycled, familiarity with e-waste recycling locations and facilities in the area, and whether the individual has attended courses or received education on e-waste. A higher score on the awareness scale indicates a higher levels of awareness and knowledge on e-waste.

H4: *There are differences in awareness of the negative impacts of e-waste among groups based on their level of EPR knowledge and their stance on the policy.*

4 Results and Discussion

The largest group of respondents (64.51%) were those who supported the EPR scheme despite being unaware of it, followed by the group (27.14%) who were aware of and supported the EPR scheme. The third group (7.31%) comprised those who were unaware of and did not support the EPR scheme. However, the group of individuals who were

aware of the EPR scheme but did not support it was not considered in the analysis due to its small size.

4.1 Hypothesis 1

In this section, we would like to test whether any differences in attitude towards e-waste recycling among groups categorized by their level of EPR knowledge and their stance on the policy (Hypothesis 1).
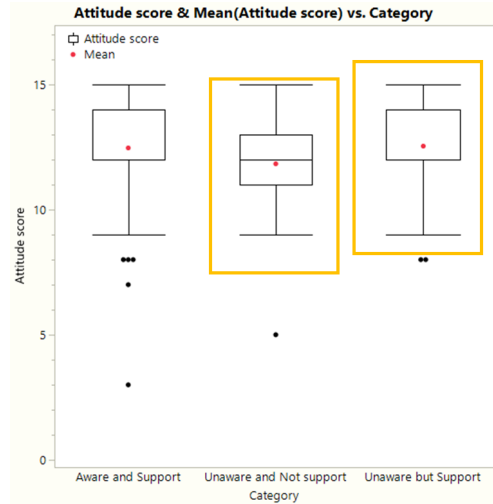

Fig. 3: Comparative boxplot of attitude scores for each group

Fig. 4: Nonparametric comparison of attitude for each pair using Wilcoxon Method

According to the results from the non-parametric Wilcoxon method with a significance level of 5%, as shown in Figure 4, the group of individuals who were unaware of the EPR scheme and did not support it exhibited significantly lower attitude scores towards e-waste recycling, as compared to the group who were unaware but supported the EPR scheme. The p-value for this comparison was 0.0378, indicating the statistical significance. However, no significant difference was observed in attitude scores between the group who were unaware but supported the EPR scheme and the group
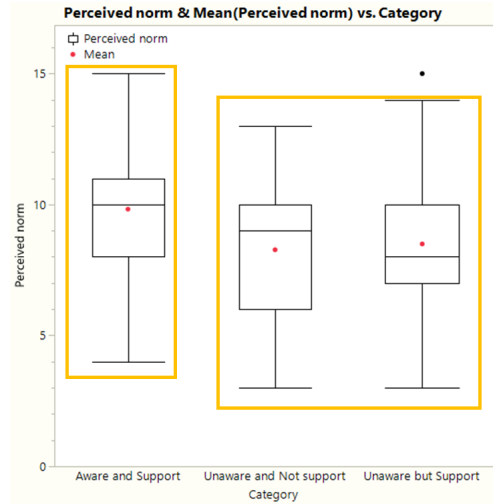
Fig. 5: Comparative boxplot of perceived norms scores for each group

who possessed knowledge about and supported the EPR scheme. These findings suggest that an individual's attitude towards e-waste recycling plays a critical role in shaping their stance on the EPR scheme.

4.2 Hypothesis 2

This section aims to examine whether there are any significant differences in perceived norms among individuals categorized based on their level of EPR scheme knowledge and their stance on the policy.

The extent to which participants were concerned about being perceived as e-waste recyclers by their friends and family was evaluated to gauge their perceived norms. Hence, perceived norms or subjective norms were measured using 3 questions, listed in Appendix A. A higher score on the perceived norm scale indicates a greater need to be seen as an e-waste recycler. By observing the box plots in Figure 5, we can see that the group of individuals who were aware of the EPR scheme and supported it had a relatively higher perceived norm score compared to the other two groups. To further confirm this finding, a nonparametric comparison test using the Wilcoxon method was conducted, and the results are shown in Figure 6. The comparison test revealed that the perceived norm score of the group who were aware of the EPR scheme and supported it was significantly higher than the other two groups, providing further evidence that knowledge and support for the EPR scheme can positively impact an individual's perceived norm towards e-waste recycling.

4.3 Hypothesis 3

Our goal is to determine if there are discrepancies in the perceived convenience of e-waste recycling among different groups based on their EPR scheme knowledge level and policy stance. The boxplots in Figure 7 display the perceived convenience level

Fig. 6: Nonparametric comparison of perceived norms for each pair using Wilcoxon Method

differences between each group. We further investigated variations in perceived convenience among groups and found that all disparities were statistically significant as shown in figure 8. This implies that perceived convenience influences both the level of EPR scheme awareness and support or opposition to the policy. Among all categories, the group that lacked EPR scheme knowledge and opposed it had the lowest perceived convenience level. In addition, a significant difference in perceived convenience existed between those who were unfamiliar with the EPR scheme but supported it and those who opposed it, implying that convenience perceptions significantly impact attitudes towards the EPR scheme.
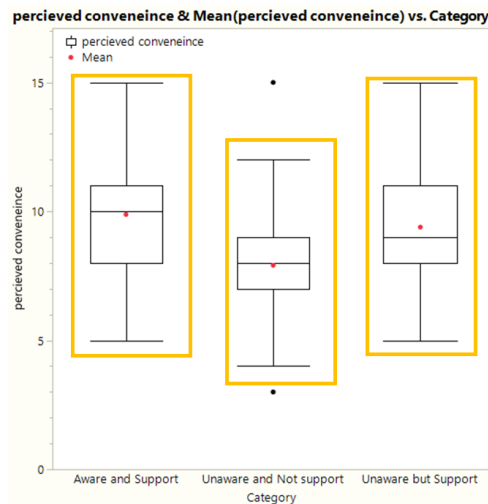
Fig. 7: Comparative boxplot of perceived convenience scores for each group

4.4 Hypothesis 4

Finally, in this section, our main focus is to test whether any differences in awareness of the negative impacts of e-waste among groups based on their level of EPR scheme knowledge and their stance on the policy.

The results indicated that the group that was aware of and supported the EPR policy had significantly higher levels of e-waste recycling awareness than the other

Nonparametric Comparisons For Each Pair Using Wilcoxon Method

q*	Alpha
1.95996	0.05

Level	- Level	Score Mean Difference	Std Err Dif	Z	p-Value	Hodges-Lehmann	Lower CL	Upper CL	Difference Plot
Unaware but Support	Unaware and Not support	67.6030	20.37823	3.31741	0.0009*	2.00000	1.00000	2.00000	
Unaware but Support	Aware and Support	-28.0846	13.07342	-2.14823	0.0317*	0.00000	-1.00000	0.00000	
Unaware and Not support	Aware and Support	-37.0907	9.86593	-3.75947	0.0002*	-2.00000	-3.00000	-1.00000	

Fig. 8: Nonparametric comparison of perceived convenience for each pair using Wilcoxon Method

groups. However, there was no significant difference in e-waste recycling awareness among those who were unaware of the EPR scheme, regardless of their stance on the policy. The findings imply that being aware of the negative impacts of e-waste may lead individuals to pay more attention to emerging policies related to e-waste and seek to enhance their understanding of them.
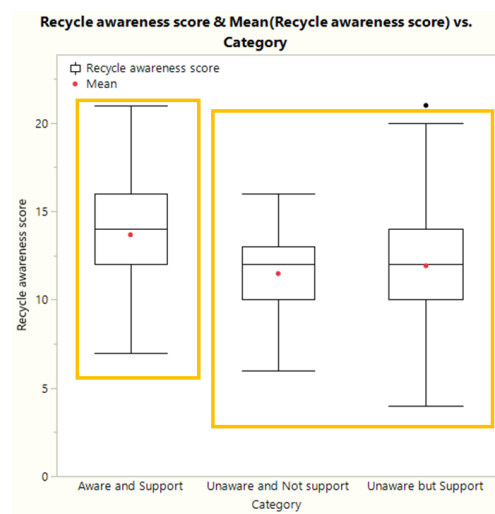
Fig. 9: Comparative boxplot of awareness scores for each group

Nonparametric Comparisons For Each Pair Using Wilcoxon Method

q*	Alpha
1.95996	0.05

Level	- Level	Score Mean Difference	Std Err Dif	Z	p-Value	Hodges-Lehmann	Lower CL	Upper CL	Difference Plot
Not aware but Support	Not aware and Not support	7.3108	20.61104	0.35470	0.7228	0.00000	-1.00000	2.00000	
Not aware and Not support	Aware and Support	-32.3654	9.95023	-3.25273	0.0011*	-2.00000	-4.00000	-1.00000	
Not aware but Support	Aware and Support	-75.8114	13.18886	-5.74814	<.0001*	-2.00000	-2.00000	-1.00000	

Fig. 10: Nonparametric comparison of awareness for each pair using Wilcoxon Method

4.5 The Association Test

The association test is conducted to check whether two selected variables are likely to be associated or not. Two variables selected are the distance travelled to dispose of e-waste at the collection points and the most important factor that can motivate the recycle e-waste. Both are tested with the three groups constructed based on the level of EPR scheme awareness and their stance towards the EPR scheme (Section 3.4).

With the level of significant 5%, it turns out that there is an association between each selected variable with the variable related to the level of EPR scheme awareness and their stance towards the EPR scheme. For those who are unaware or aware but support, the distance does not really matter since some of them are willing to travel to dispose between 1 to 3 km or beyond. On the other hand, for those who are aware but not support, shorter distances may still make them reluctant to travel. For the second variable which is related to the most important factor for motivating them, those who are aware and support, the main factor is about the environment benefits. For those who are unaware but support, the intensives and convenience are important factors. Cost is the main factor for those who are unaware and not support. The complete association test can be referred in Appendix B.

4.6 Suggestions

By referring to the results and findings mentioned earlier in the previous section, we propose the following suggestions to increase the success and effectiveness of Extended Producer Responsibility (EPR) policy implementation:
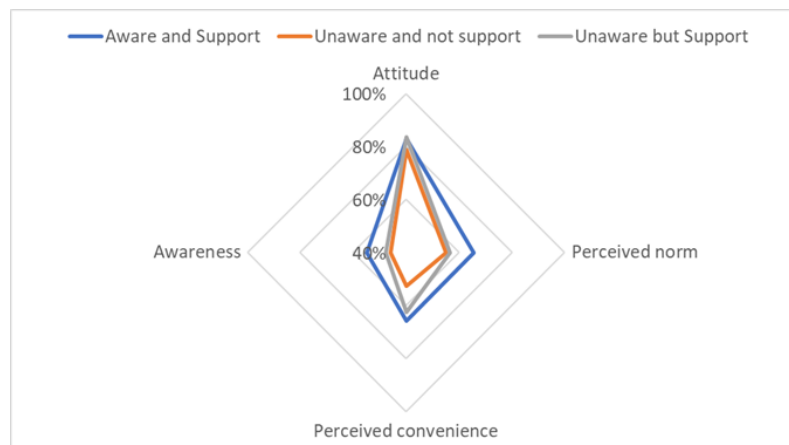

Fig. 11: A radar graph illustrating the standardized scores of each influencing factor

1. **Visibility of environmental handling fees**
   The survey results demonstrate that while most young people possess a high attitude score that reflects their awareness of the environmental impact of e-waste,

a majority are unwilling to pay more. This finding highlights the need for policymakers to consider this concern and make the cost of recycling services non-visible. By doing so, policymakers can encourage more people to recycle their e-waste, thereby reducing the environmental impact of this growing problem.

The survey also revealed that the attitude towards e-waste recycling is related to the stance on the EPR scheme, as supported by Hypothesis H1. Therefore, it is crucial to foster a positive attitude towards e-waste recycling and avoid aggressive policies such as forcing individuals to pay more, which may result in negative attitudes towards recycling. Policymakers must consider these findings and develop effective strategies that promote a positive attitude towards e-waste recycling, while implementing policies that do not burden consumers financially. By doing so, Singapore can effectively address the issue of e-waste while ensuring that citizens feel motivated to participate in the recycling process.

- Despite high environmental awareness levels among Singaporeans, the majority are unwilling to pay more for e-waste recycling services, with 54% of participants believing that it should be free.
- This finding highlights the need for policymakers to consider this concern and make the cost of recycling services non-visible.

2. **Using social norms to influence messaging**
   The result from this study shows a relatively low score on perceived norms, revealing that e-waste recycling has not yet become a norm for Singaporean consumers. Therefore, leveraging the herding effect through showcasing success stories of businesses that have successfully implemented the EPR scheme and promoting the increasing number of individuals who recycle e-waste at designated points can create a sense of social norm and encourage others to follow suit.

- The survey result reveals that e-waste recycling has not yet become a norm for consumers.
- Overall, the herding effect can be a powerful tool for promoting the EPR scheme and creating a culture of responsibility towards sustainable waste management in Singapore.

3. **Introducing an Economic Incentive to Increase the Collection Rates**
   Convenience is a prevalent determinant of consumer e-waste recycling behavior[13]. A considerable number of people are reluctant to dispose of their bulky appliances and mobility devices at designated recycling points, likely due to the challenges of transporting such large items, especially since many Singaporeans do not own cars. To address this issue and promote proper e-waste disposal, alternative collection methods could be explored. For example, home pickup services could be offered to residents who have large appliances to dispose of.

This would alleviate the burden of transportation and storage for individuals and encourage them to properly dispose of their e-waste. Additionally, promoting the availability of e-waste recycling services at retailers where new appliances are purchased could also increase collection rates. By providing convenient and accessible disposal options, it is more likely that people will properly dispose of their
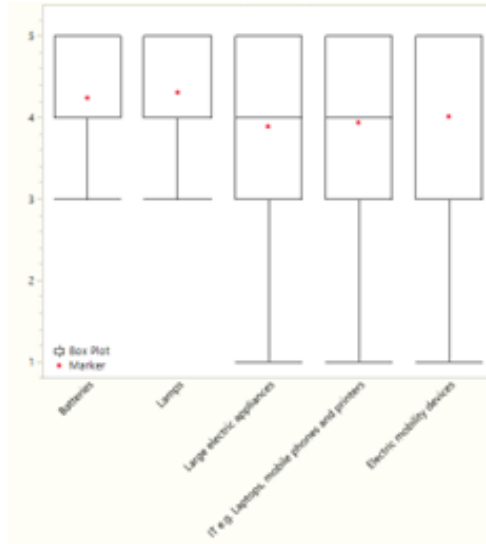
Fig. 12: Boxplots illustrating the willingness of participants to recycle different types of e-waste at a designated recycling point

Nonparametric Comparisons For Each Pair Using Wilcoxon Method

q*	Alpha
1.95996	0.05

Level	- Level	Score Mean Difference	Std Err Dif	Z	p-Value	Hodges-Lehmann	Lower CL	Upper CL	Difference Plot
Lamps	Electric mobility	159.584	21.11627	7.55738	<.0001*	0	0	0	
Lamps	IT	112.405	20.98463	5.35654	<.0001*	0	0	0	
IT	Electric mobility	60.600	21.62969	2.80170	0.0051*	0	0	0	
Large appliance	Electric mobility	34.865	21.75643	1.60253	0.1090	0	0	0	
Lamps	Battery	11.953	20.32141	0.58822	0.5564	0	0	0	
Large appliance	IT	-28.819	21.64735	-1.33129	0.1831	0	0	0	
IT	Battery	-97.425	21.00131	-4.63900	<.0001*	0	0	0	
Large appliance	Battery	-126.297	21.17274	-5.96507	<.0001*	0	0	0	
Large appliance	Lamps	-141.967	21.15474	-6.71090	<.0001*	0	0	0	
Electric mobility	Battery	-146.580	21.12911	-6.93734	<.0001*	0	0	0	

Fig. 13: Nonparametric comparison of the willingness of participants to recycle different types of e-waste at a designated recycling point for each pair using Wilcoxon Method

e-waste and contribute to a more sustainable waste management system in Singapore. The introduction of such economic incentives can complement efforts to reduce consumption and promote circular recycling behavior, ensuring that the value of parts and materials are saved and reused in the economy as long as possible.

4. **Increase awareness of environmental impact with eco-labels**

In recent years, there has been a growing interest among consumers in understanding the environmental impact of their purchasing decisions [14]. Eco-labeling programs have the potential to increase consumer awareness of environmental issues
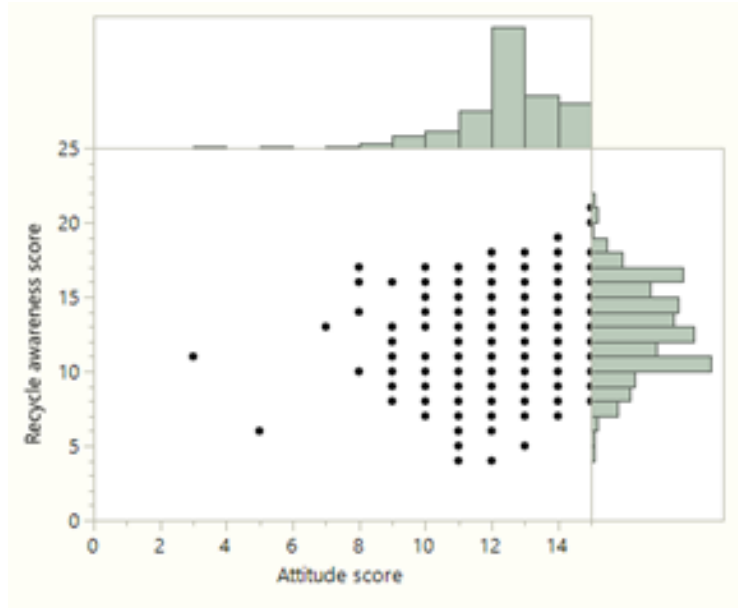
Fig. 14: Bivariate fit of e-waste recycling awareness score by attitude toward e-waste recycling score

and the impact of their purchasing decisions. This approach aims to inform consumers about the environmental impact of their consumption while also providing producers with an opportunity to differentiate their products and charge a premium for environmentally friendly products.

In countries where consumers are well-informed, a reliable eco label that provides credible information on the environmental impact of products can be an effective tool for promoting eco-labeled goods. Meanwhile, in countries where consumers may not be as environmentally conscious, eco-labeling can be used as a means to encourage more environmentally responsible behavior [15]. According to Figure 14, the survey results indicate that the level of environmental awareness among Singaporean consumers follows a normal distribution, whereas their attitude towards e-waste recycling is skewed to the left.

- The result indicates that young consumers are generally environmentally conscious but may lack awareness regarding e-waste recycling specifically.
- Implementing eco-label policies along with the EPR scheme for e-waste management could be an effective driver for promoting better e-waste recycling practices in Singapore.

5 Conclusions

The issue of e-waste management in Singapore is a multifaceted challenge that requires a comprehensive and coordinated approach from policymakers, industry players, and

consumers alike. Extended Producer Responsibility (EPR) scheme is one promising policy instrument that can promote sustainable waste management practices by placing the responsibility for e-waste disposal on manufacturers and importers. However, its success depends on several key factors, including effective stakeholder engagement, adequate enforcement mechanisms, and the availability of convenient and accessible e-waste collection and recycling infrastructure.

This study investigated the attitudes and behaviors of university students in Singapore towards e-waste recycling and the EPR policy using the Theory of Reasoned Action and Theory of Planned Behavior frameworks. The study found that awareness of the EPR scheme and support for it are positively affected by attitudes towards e-waste recycling, perceived norms, and recycling awareness. Perceived convenience was also a significant factor in the EPR scheme awareness and support. The study also revealed challenges and policy drivers for the EPR scheme implementation in Singapore, including the need for positive attitudes towards e-waste recycling and policies that do not burden consumers financially. Recommendations included making recycling services cost non-visible, leveraging social norms, and increasing awareness of environmental impact through eco-labels.

Overall, the success of the EPR scheme for e-waste management in Singapore depends on the effective collaboration among policymakers, industry players, and consumers. It is crucial to recognize that e-waste management is not just an environmental issue but also a social and economic issue that affects everyone. Therefore, policymakers need to prioritize the development of policies that promote sustainable waste management practices while balancing economic, social, and environmental considerations. By doing so, Singapore can continue to lead in sustainable waste management practices and set an example for other countries in the region and beyond.

6 Acknowledgement

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Appendices

Appendix A

Tag	Measure	Score
	Attitude toward recycling	
AT1	Recycling electronic waste is a great way to conserve natural resources	0-5
AT2	I am concerned about environmental pollution	0-5
AT3	It is important to dispose of e-waste responsibly	0-5
	Perceived Norms	
N1	Friends/family will be upset if they know I do not recycling e-waste	0-5
N2	My friends/family recycle e-waste	0-5
N3	Being viewed as recycles person is important to me	0-5
	Awareness of consequences	
AW1	I am aware that e-waste contains toxic substances that can have an adverse impact on human health and the environment if not handled properly	0-5
AW2	I know which kinds of e-waste can be recycled and which cannot be recycled	0-5
AW3	I am familiar with the type of e-waste accepted in the e-waste recycling locations in my area	0-5
AW4	I am familiar with the e-waste recycling facilities in my area	0-5
AW5	Have you ever attended courses or received education on e-waste?	Y/N
	Perceived convenience	
C1	Recycling is a difficult task	0-5
C2	I have enough time to sort the electronic products for recycling.	0-5
C3	How long do you think it takes to dispose of e-waste by dispose at a Recycling point.	0-5
	EPR Awareness	
EPR_A1	I am aware of EPR	Y/N
EPR_A2	I am knowledgeable enough to state my personal opinions about EPR	0-5
EPR_A3	I am aware that the EPR will be enforced in July 2021	0-5
EPR_A4	I understand what the EPR involves	0-5
EPR_A5	The EPR only affects product manufacturers	0-5
EPR_A6	Because of the EPR, the disposal of e-waste is no longer my responsibility	0-5
	EPR Support Attitude	
EPR_S	Do you support EPR implementation in Singapore?	Y/N

Appendix B

Category	Aware and Support	Unaware and Not support	Unaware but Support	All
How far are you willing to travel to dispose of your e-waste at the collection points?				
1km to 3km	22.0	0.0	26.0	48
	13.67	2.01	32.32	48.0
	8.33	-2.01	-6.32	
200m to 500m	34.0	3.0	82.0	119
	33.89	4.99	80.12	119.0
	0.11	-1.99	1.88	
3km to 5km	10.0	0.0	6.0	16
	4.56	0.67	10.77	16.0
	5.44	-0.67	-4.77	
500m to 1km	30.0	2.0	83.0	115
	32.75	4.82	77.43	115.0
	-2.75	-2.82	5.57	
Less than 200m	31.0	10.0	92.0	133
	37.87	5.58	89.55	133.0
	-6.87	4.42	2.45	
More than 5km	1.0	0.0	10.0	11
	3.13	0.46	7.41	11.0
	-2.13	-0.46	2.59	
Regardless of distance, unwilling to travel to dispose	1.0	4.0	6.0	11
	3.13	0.46	7.41	11.0
	-2.13	3.54	-1.41	
All	129.0	19.0	305.0	453

Fig. 15: Association test results-1

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Category	Aware and Support	Unaware and Not support	Unaware but Support	All
Which is the most important factor that can motivate you to recycle e-waste?				
Cost	20.0	7.0	36.0	63
	17.9	2.78	42.32	63.0
	2.1	4.22	-6.32	
Environmental benefits	30.0	2.0	29.0	61
	17.33	2.69	40.98	61.0
	12.67	-0.69	-11.98	
Having friends and family members who recycle e-waste	4.0	0.0	8.0	12
	3.41	0.53	8.06	12.0
	0.59	-0.53	-0.06	
Incentives	20.0	3.0	68.0	91
	25.86	4.01	61.13	91.0
	-5.86	-1.01	6.87	
Time/ convenience	55.0	8.0	164.0	227
	64.5	10.0	152.5	227.0
	-9.5	-2.0	11.5	
All	129.0	20.0	305.0	454

Fig. 16: Association test results-2