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E-Waste Recycling Behavior in the United Arab Emirates: Investigating the Roles of Environmental Consciousness, Cost, and Infrastructure Support

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Abstract: This study examines whether consumers' behavior affects e-waste recycling in the UAE. This paper provides a theoretical model of e-waste recycling behavior based on the theory of planned behavior (TPB), and it goes on to analyze the impact of environmental consciousness, infrastructural support, and costs in e-waste recycling. To assess this study's constructs, a survey instrument is created. The theoretical model is tested using data gathered from a survey of UAE residents. PLS-SEM (partial least squares structural equations modeling) is used to assess the data. The results support the use of the TPB in the e-waste recycling behavior context. Furthermore, this study shows intriguing findings regarding the effect of environmental consciousness, perceived infrastructural support, and the cost of e-waste recycling. Environmental consciousness shows a positive moderation effect on the association between e-waste recycling attitudes and intentions. This finding implies that the environmental consciousness of residents should be increased to translate e-waste recycling intentions into behavior. Environmental consciousness can be enhanced through training programs. Furthermore, special sustainability courses in higher education that focus on improving environmental awareness among students will have a lasting impact. This study supports the positive moderation effect of perceived infrastructure support on the association between recycling intentions and behavior.

Keywords: e-waste recycling behavior; environmental consciousness; cost of recycling; infrastructure support; theory of planned behavior; UAE

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1. Introduction

The awareness of and emphasis on managing various kinds of waste worldwide are continuously on the rise, even though challenges related to policies, resources, and infrastructure remain the same. However, the challenges that developing countries face in waste management significantly differ from those of developed countries. In developed countries, resources do not pose constraints for waste management. However, the development of appropriate policies that encourage waste collection and disposal still needs to be strengthened. On the contrary, developing countries need to build resources and infrastructure and formulate policies that favor the proper management of various kinds of waste. Furthermore, developing countries must overcome the additional pressure of several environmental health issues.

E-waste is one of the most rapidly increasing wastes faced by all the countries across the globe, as it produced 50 million tons of e-waste in 2018. The United Arab Emirates

(UAE) is a top-ranking country in the production of e-waste. According to the United Nations Global Waste Monitor Report from 2016, the per capita e-waste production in the UAE amounted to 17.2 kg, with the total quantity of e-waste equaling 134,000 tons. The UAE government has taken several initiatives to combat the generation of e-waste and dispose of the collected e-waste through proper systems and practices. One of their major initiatives is to divert 70% of solid waste collected from landfills. Furthermore, the UAE government implements different initiatives targeted towards managing e-waste with the participation and support of the private sector as well.

Even though these initiatives will result in a reduction in the harmful effects of e-waste generation, a constant increase in the consumption of electronic gadgets supported by the rise in disposable incomes; the development of cost-effective e-waste management techniques; a lack of public awareness about the significance of e-waste management; and inadequate policies that encourage e-waste disposal in appropriate ways make e-waste management a challenging task for all countries, especially developing countries.

Most of the research related to e-waste recycling has been conducted in China, followed by the USA and India [1,2]. Research into consumers' e-waste recycling behaviors has applied various behavioral theories (e.g., theory of planned behavior (TPB), behavioral reasoning theory (BRT), norm activation theory, and valence theory) and investigated the fundamental factors around the applied theory. Additionally, researchers have extended the applied theory with various other contextual factors. For example, a study by Dhir et al. [3] in Japan applied the valence theory and extended it by investigating the moderating effect of consumers' past experiences with contacting recycling centers, government agencies, and second-hand sellers. Similarly, Nadarajan et al. [4] also extended the valence theory and conceptualized all the factors as antecedents of e-waste recycling intention and found that perceived convenience, environmental concern, willingness to change, and subjective norms have significant direct effects on e-waste recycling intention. Recent research by Lyu et al. [5] investigated online e-waste recycling in China and integrated the elaboration likelihood model, innovation diffusion theory, and social cognition theory. They investigated the moderating effects of privacy, price fairness, and environmental concerns and identified a negative moderation effect of these variables. Another study by Mohamad et al. [6] in Malaysia investigated e-waste recycling behavior by extending the TPB with direct effects of environmental consciousness, perceived convenience, and moral obligation on e-waste recycling intention and found that only perceived convenience and moral obligation had significant effects.

One of the significant observations from previous research is that the studies on e-waste recycling behavior are limited in examining moderation effects [1]. Most studies emphasize the direct or mediation effects of the factors contributing to e-waste recycling intention. Environmental consciousness is one of the important factors that have the potential to shape e-waste recycling intention [7–11]. This study proposes to investigate the moderation effect of environmental consciousness on the relationship between antecedents, such as attitudes, subjective norms, and perceived behavioral control, and e-waste recycling intention. This specific finding would imply the inclusion of the concept of sustainability in school and higher education curriculum so that students at a young age are aware of the causes and consequences of environmental degradation [12]. The findings of this study would imply an emphasis on science education in the secondary school curriculum in order to achieve sustainable development goals [13] as it has the potential to improve the environmental consciousness of students with different socioeconomic statuses (SESs). A study conducted in Finland by Sammalisto et al. [14] among undergraduate students confirmed that studying courses on sustainability resulted in improved sustainability behavior in the students. Higher education institutions should assume the role of educating all the stakeholders of society about sustainability to inculcate pro-environmental behavior, including e-waste recycling [15]. Furthermore, consciousness of the environment could drive educational institutions to work on research projects with the objectives of environmental protection and natural resources [12].

Another important observation from previous research is that the studies in this area are limited in diagnosing how the gap between e-waste recycling intention and behavior could be bridged [16,17]. In this study, we investigate the moderation effect of the perceived cost of e-waste recycling and infrastructure support in the relationship between e-waste recycling intention and behavior.

Therefore, this study addresses the following two research objectives: The first one is to investigate the moderation effect of environmental consciousness on the association between the antecedents of the TPB (attitudes, subjective norms, and perceived behavioral control) and e-waste recycling intention. The second is to examine the moderation effects of infrastructure support and costs of e-waste recycling on bridging the gap between e-waste recycling intention and behavior. Additionally, there are limited studies on understanding consumers' recycling behavior in the Middle Eastern region. This study is novel in attempting to address this research gap and integrates the relevant factors driven by the UAE context in understanding consumers' e-waste recycling behavior. This paper further discusses the basis of our proposed theoretical model and hypotheses development; the methodology used for data collection, analysis, and results; discussions; and implications in the subsequent sections.

2. Literature Review

Many researchers have studied e-waste recycling behavior in the past. Generally, the basic psychological needs theory [18], theory of planned behavior (TPB) [19,20], norm activation theory [21], social cognitive theory [22], social capital embeddedness theory [23], and behavioral research theory [24] have been applied to investigate the factors that affect e-waste recycling behavior. Some researchers combined any of the two theories. For example, Wang et al. [25] applied both the TPB and norm activation behavior theory, and Dhir et al. [26] applied both the TPB and behavioral reasoning theory. In addition to the application of variables included in the respective theories, variables such as environmental consciousness and assessment [16,27] and demographic variables [16,28] have also been investigated. It is evident from past research that the complexities of human behavior necessitated the researchers to go beyond one model to understand human behavior in a specific context.

Among the theories mentioned above, the TPB has been widely used in the e-waste recycling context. Most researchers use the TPB as the base model, as it explains the fundamental structure of the behavioral process, and customize this theory to suit the context and purpose of the research. This customization is essential to provide context-specific policy-level implications towards a sustainable environment and healthy lifestyle. For example, in Brazil, Echegaray and Hansstein [16] found significant effects of environmental assessment and awareness of environmental problems on e-waste recycling behavioral intention along with the variables of the TPB.

Researchers have identified a variety of determinants for the formation of e-waste recycling intention. Yadav et al. [29] applied the BRT to examine e-waste recycling intention in India and posited inconvenience, the lack of a support system, and emotional attachment as the 'reason against' e-waste recycling and posited self-image, perceived negative effects, and salvage value as the 'reason for' e-waste recycling and found a direct correlation of these reasons with the intention to recycle e-waste. Interestingly, they found a significant positive effect of social and moral norms on attitudes towards e-waste recycling. They also found a moderating effect of self-efficacy on the association between 'reason for' and the intention to recycle and the association between attitude and the intention to recycle. Similarly, Dhir et al. [26] also applied the BRT to identify factors impacting e-waste recycling intention and included environmental and personal benefits as the 'reason for' e-waste recycling and included risk, image, value, and usage barriers as the 'reason against' e-waste recycling. They investigated the effects of the reasons on attitude and the intention to recycle e-waste. They further examined the moderation effects of environmental assessment and awareness on the relationship between the 'reason for' recycling e-waste and intention,

the 'reason against' recycling e-waste and intention, and attitude and intention. Wang et al. [28] investigated e-waste recycling intention in China by applying the TPB and found positive direct effects of attitudes and environmental awareness on e-waste recycling and negative effects of income, costs of recycling, and perceptions of informal recycling on e-waste recycling. Another study by Wang et al. [30] in China examined the effect of economic motivation on e-waste recycling intentions and found that it had a significant impact on e-waste recycling intentions. Kumar [27] examined the effect of convenience on recycling intentions in India and China and surprisingly did not find an effect in neither country. The author attributed the lack of availability of convenient facilities to this non-significant effect.

It is generally acceptable that information about environmental degradation and its associated long-term consequences is easily accessible to the consumers of electronic devices through different channels, including social media. Concerns about the environment play important roles in shaping the behavior of individuals towards environmentally friendly consumption and disposal. Realizing its importance, in previous studies, researchers have assessed the effect of environment-related factors on recycling behavior [11,16,31]. Consumers' concerns about environmental problems and their attitudes and intent towards reducing these problems are conceptualized as environmental consciousness [11,31,32]. Considering the abundant usage of electronic devices among consumers who are expected to have a good understanding of the environmental issues created by e-waste, their level of environmental consciousness is expected to play an essential role in the study of e-waste recycling behavior.

Most studies (except for a few; for example, [16,17]) only investigated the intention to recycle e-waste; limited attention was given to e-waste recycling behavior. The relationship between intention and behavior towards e-waste recycling is under-explored. In a study conducted by Echegaray and Hansstein [16] in Brazil, it was found that there was a higher level of intention to recycle e-waste (average rating of 4.7 on a five-point scale); however, merely 6% of the respondents ended up recycling their unused electronic devices. This statistic is reported to be only 11% in China, as per the studies by Wang et al. [33] and Yang et al. [34]. Similarly, another study conducted by Arain et al. [35] in the USA found that 80% of the respondents did not use formal e-waste recycling mechanisms, even though they knew the importance of recycling e-waste.

The gap between intention and behavior has been investigated in other pro-environmental behavior contexts, such as green purchase [36], energy conservation [37], and recycling [38]. The researchers focused on institutional, situational, and psychological factors to examine how intention is translated into behavior. Rausch and Kopplin [36] found the moderation effect of perceived economic and aesthetic risks on the relationship between sustainable clothing intention and behavior. Mack et al. [37] examined the roles of prompted commitment, implementation information, and guided process monitoring to narrow the intention–behavior gap in the context of electricity saving. Park and Lin [39] found that the intention–purchase gap for consuming recycled products depended on perceived consumer effectiveness and utilitarian value. Satisfaction and trust based on previous experience with consuming organic food were found to bridge the intention–behavior gap [40]. Goldsmith et al. [41] found a moderating effect of price sensitivity on the association between green purchase intention and behavior. Similarly, Ran and Zhang [17] found a significant moderation effect of price sensitivity on the association between mobile phone recycling intention and behavior. Research studies also highlight the role of access to facilities and government support in bridging the green intention–behavior gap [42].

3. UAE Context

E-waste generation in Gulf Cooperation Council (GCC) countries has grown significantly over the past forty years. GCC countries are mostly oil-based economies, and the economic growth in these countries resulted in population growth due to the residence of expatriates from across the world. An increase in population combined with higher per capita income resulted in an increase in the generation of e-waste. In 2018, Alghazo

et al. [43] estimated that GCC countries generate 857 KT (kilo tons) of e-waste with a growth rate of 3–5% every year. The studies conducted by Rene et al. [44] and Alghazo et al. [43] opined that GCC countries are limited by a lack of e-waste inventory, proper assessment of e-waste quantities, and policies and facilities to manage and recycle the generated e-waste. Attia et al. [45] conducted a study in Dubai, UAE and found that most respondents store unused mobile phones at home, with each household storing an average of 3.85 mobile phones. They also estimated that 208.53 tons of mobile phone waste could be generated in Dubai by 2030.

In UAE, there is a growing concern about e-waste among the authorities, and its Center of Waste Management in Abu Dhabi (Tadweer) categorized e-waste separately in its waste classification policy [43]. The Ministry of Environment, UAE has endorsed private sector participation in e-waste recycling. For example, a company called Enviroserve, located in Dubai Industrial Park, has established one of the world's largest e-waste recycling and processing plants with the capacity to recycle 39,000 tons of e-waste per year [43].

There are limited studies on e-waste recycling behavior in the UAE. For example, Attia et al. [45] analyzed e-waste awareness and disposal behavior and estimated the potential of mobile phone waste in Dubai. Their study included the magnitude of e-waste awareness and the extent of e-waste disposal among the respondents of a cross-sectional survey in Dubai. Furthermore, Aboelmaged [46] applied the TPB and added recycling habits as one factor that impacts e-waste recycling intentions in the UAE.

4. Conceptual Model and Hypotheses Development

The conceptual model highlighting all of the predictor variables that determine e-waste recycling behavior is shown in Figure 1. Broadly, the model suggests that attitudes, subjective norms, and perceived behavioral control determine e-waste recycling intentions, which further lead to recycling behavior. The model proposes the moderation effect of environmental consciousness on the predictor variables and e-waste recycling intentions. Furthermore, the cost of recycling and infrastructure support moderate the association of recycling intention with e-waste recycling behavior. The rationale for choosing these specific hypotheses is discussed.

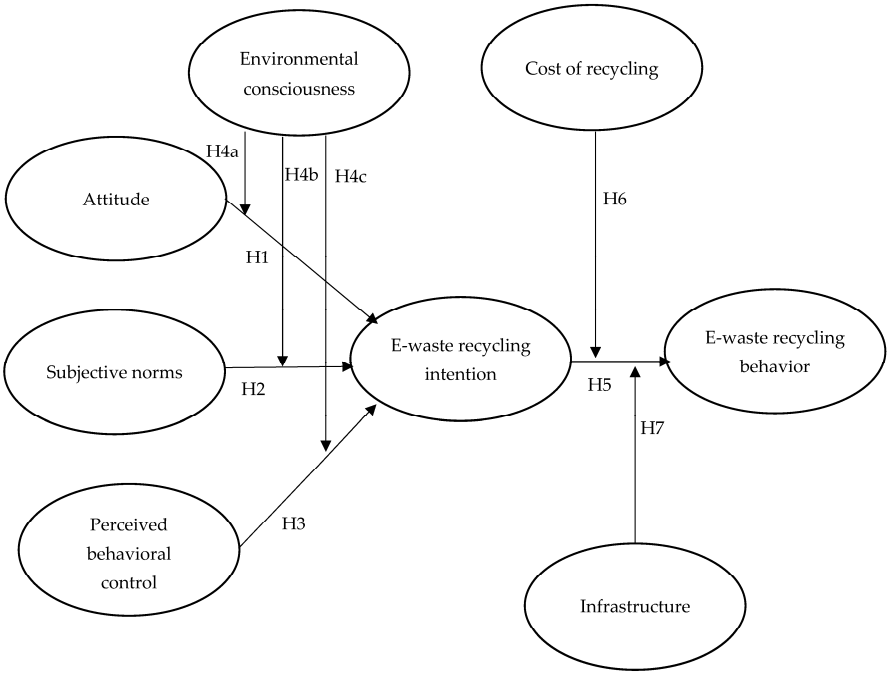

Figure 1. Conceptual model of e-waste recycling behavior.

Attitude draws theoretical background from the expectancy–value theory. It is an outcome of the psychological assessment and belief towards a particular object, issue, or entity reflected in terms of preference or no preference. According to the TPB, attitude determines an individual's intentions to behave in a particular manner [20,47]. It has been validated in several studies that favorable attitudes towards the environment are precursors for an individual's willingness to engage in behavior that protects the environment. For example, Wang et al. [48] identified that consumers' buying attitudes towards remanufactured products positively impact their purchase intentions. Previous studies on e-waste recycling [27,30,46] have also established a positive effect of e-waste recycling attitudes on e-waste recycling intentions. Thus, the following is hypothesized:

H1. *E-waste recycling attitudes will have a positive effect on e-waste recycling intentions.*

Subjective norms are acceptable levels of an individual's behavior determined by society, including reference groups [20]. Individuals in a society are bound to follow subjective norms, which influence their beliefs, ideas, emotions, opinions, and judgments. Due to this process, individuals succumb to social pressure, which can affect individuals either positively or negatively. The norms permit individuals to engage or not to engage in a particular behavior [49,50]. Previous research studies have established that subjective norms lead to pro-environmental behavior. For example, Kianpour et al. [51] found a positive effect of subjective norms on the intention of consumers to return end-of-life electronic products. Similarly, Wang et al. [30], Kumar [27], and Aboelmaged [46] demonstrated a significant positive association between subjective norms and e-waste recycling intentions. Therefore, H2 is proposed.

H2. *Subjective norms will have a positive effect on e-waste recycling intentions.*

Perceived behavioral control is about having self-confidence about a particular behavior [20]. This confidence is rooted in one's ability based on past experience and perceived difficulty. According to the TPB [20], behavioral control determines one's intentions to perform a specific behavior. Several research studies on pro-environmental behavior have validated the effect of behavioral control on behavioral intentions. For example, Taylor and Todd [52] found that behavioral control significantly impacted intentions towards household recycling behavior in waste management. Perceived behavioral control determined an individual's intentions to engage in construction and demolition waste recycling in a study conducted by Jain et al. [11] in India. Similarly, previous studies on e-waste recycling (for example, [27,30,46]) established a link between perceived behavioral control and e-waste recycling intentions. Therefore, the following is hypothesized:

H3. *Perceived behavioral control will have a positive effect on e-waste recycling intentions.*

Environmental consciousness is 'a kind of mentality that reflects an individual's value judgment about environmental concepts such as environmental protection, environmental policy, and environmental management' [53] (p. 149). In this study, environmental consciousness is defined as an individual's degree of concern towards environmental issues and problems [11,54,55]. Environmental consciousness influences environmental attitudes [9]. Individuals with greater levels of environmental consciousness are found to behave in an environmentally responsible way. Several research studies have proven that environmental consciousness plays a vital role in pro-environmental behavior (e.g., [56–58], green purchasing (e.g., [59]), and consumption (e.g., [60]) and recycling behavior (e.g., [11]). Lin and Chang [59] investigated the moderation effect of environmental consciousness on green product consumption. They demonstrated that environmental consciousness significantly moderates the effect of product type (green products versus regular products) on product usage amount. Garvey and Bolton [61] found an interaction effect of environmental consciousness on pro-environmental behavior.

In the context of e-waste recycling, Thi Thu Nguyen et al. [62] found a positive direct effect of environmental awareness on e-waste recycling intention. In a study in Nigeria,

Nduneseokwu et al. [63] investigated the direct effect of environmental knowledge on the intention to participate in formal e-waste collection.

Kautish et al. [64] established that environmental consciousness significantly moderates the influences of perceived behavioral control, environmental friendliness, and perceived effectiveness on green purchases. In contrast with Kautish et al. [64], we argue that environmental consciousness moderates the association between the antecedents of the TPB, including attitudes, subjective norms, and perceived behavioral control, and e-waste recycling intention. Because behavioral intention precedes actual behavior, it is expected that environmental consciousness has a higher likelihood of strengthening intentions than behavior. Several previous research studies have established a positive effect of environmental consciousness on pro-environment behavioral intentions [7–9,11,65].

The effects of attitudes, subjective norms, and perceived behavioral control on e-waste recycling intentions will be higher for individuals whose environmental consciousness is higher. In the context of e-waste recycling, the moderation effect of environmental consciousness on the association between the antecedents of the TPB and e-waste recycling intention has not yet been explored. Previous studies confirmed the moderating effect of environmental consciousness on the relationship between antecedent variables and behavioral intentions. For example, Lin et al. [53] demonstrated the moderating effect of environmental consciousness on the positive relationship between trust and intentions of purchasing IT products. Similarly, de Leaniz et al. [58] found that consumer environmental consciousness moderates the effect of green image on behavioral intentions.

Therefore, the following hypotheses are proposed:

H4a. *Environmental consciousness moderates the relationship between attitude and e-waste recycling intentions.*

H4b. *Environmental consciousness moderates the relationship between subjective and e-waste recycling intentions.*

H4c. *Environmental consciousness moderates the relationship between perceived behavioral control and e-waste recycling intentions.*

The TPB posits that behavioral intentions predict actual behavior [19]. Intentions have proven to be precursors of behavior in several studies on pro-environmental behavior. For example, Webb et al. [66] found that behavioral intentions towards energy saving positively influence household energy-saving behavior. Jain et al. [11] validated the association between construction and demolition waste intention and actual construction and demolition waste recycling behavior. Gilal et al. [67] found that consumers' integrated motivation towards e-waste disposal led to actual disposal behavior. Thus, the following is hypothesized:

H5. *E-waste recycling intention will have a positive effect on e-waste recycling behavior.*

Even though consumers' e-waste recycling intentions lead to actual recycling behavior, as hypothesized in H5, factors such as the cost of recycling and infrastructure support would play important roles in converting recycling intentions to actual behavior. Kirwy and Mecking [68] investigated the moderation effect of behavioral cost on the relationship between the motivation for healthy eating and the actual consumption of organic food. The cost of production was found to be one of the limitations preventing consumers from engaging in pro-environmental behavior [69]. When the costs are low, pro-environmental behavior is more likely to happen [70]. Lower-income households tend to save more energy as they cannot afford higher energy costs [71]. Infrastructure support towards recycling provides convenience and reduces the travel distance to collection points. Meneses and Palacio [72] found that the convenience of recycling encourages recycling behavior. Higher repair costs deter consumers from engaging in pro-environmental behavior and encourage consumers to buy newer electronic products in India [73]. Wang et al. [74] found that higher operational costs are one of the barriers to Internet-based e-waste collection systems in

China. A reduction in the travel distance to collection points offers convenience, and it provides a reduction in the time cost in addition to improving recycling behavior [75]. A study conducted in Beijing city, China revealed that taking care of specific portions of e-waste recycling costs affects residents' behaviors towards recycling [33]. In a study conducted in a Midwestern USA university, Arain et al. [35] demonstrated that the convenience and cost of recycling are the most important factors that affect e-waste recycling behavior. In the situation of a higher cost of recycling, the effect of e-waste recycling intentions on e-waste recycling behavior would be weakened. Furthermore, in higher levels of perceived infrastructure support, the effect of e-waste recycling intentions on e-waste recycling behavior would be strengthened.

Thus, the following hypotheses are postulated:

H6. *The cost of recycling moderates the relationship between recycling intentions and behavior.*

H7. *Infrastructure support moderates the relationship between recycling intentions and behavior.*

5. Materials and Methods

5.1. Questionnaire

The measures for the constructs included in the model have been widely used in previous studies in the field. The environmental consciousness construct was measured with the scale used by Huang et al. [56] and Bittar [31]. Attitude towards e-waste recycling were measured with the scales used by Aboelmaged [46] and Dhir et al. [26]. The subjective norms construct was measured with the scales used by Wang et al. [30] and Aboelmaged [46]. Perceived behavioral control was measured using a scale from Kumar [27]. E-waste recycling intention was measured with the scales used by Wang et al. [30], Thi Thu Nguyen et al. [62], Dhir et al. [26], and Aboelmaged [46]. The cost of recycling was measured with a scale used by Thi Thu Nguyen et al. [62]. Infrastructure support was measured with a scale used by Nduneseokwu et al. [63]. All the constructs were measured on a seven-point Likert scale. The questionnaire was prepared, including measures of all the constructs and classification information. Five subject matter specialists assessed the prepared questionnaire to check the content validity of the questionnaire, and all the identified inconsistencies were removed. Furthermore, the refined questionnaire was pretested with a sample of 30 respondents. The pretesting process helped to rectify any language issues in the questionnaire.

5.2. Sample and Data Collection

The institutional research committee approved the final questionnaire for ethical clearance, and it was then deployed for a cross-sectional survey among UAE residents.

The sample size used in previous studies in the area was used as one of the factors to determine the sample size in addition to the requirement of the statistical technique to be used for this study. We planned to achieve a sample size of 500 people for this study with respondents from all the major states of the United Arab Emirates. We used a convenience sampling method to select the respondents. The questionnaire was prepared on Google Forms, and the link to the questionnaire was shared with the prospective respondents. The survey was conducted during the period of August–November 2022. The list of prospective respondents was gathered through referrals and from other respondents as well. The survey was self-administered and the respondents independently filled in the questionnaire by accessing the Google Forms link. At the beginning of the questionnaire, on Google Forms, the respondents were provided with a brief description of the purpose of the study and were informed that their participation in the study was voluntary and all information would be kept confidential. Next, the respondents were specifically asked whether they would like to participate in the study. A total of 732 people were contacted, out of which 471 people provided responses, which resulted in a response rate of 64.34%. After discarding incomplete responses of 15 respondents, the sample size achieved for the study was 456.

6. Analysis and Results

The first level of data analysis was performed to understand the sample characteristics. Table 1 contains information on the sample's characteristics. Around 61% of the respondents were male, and the remaining respondents were female. Around 32% of the respondents ranged in age from 18 to 25, 25% of the respondents were in the age category of 26–36 years, and around 23% ranged in the age category of 37–47 years. Around 19% of the respondents were above the age category of 48 years. Around 59% of respondents had a bachelor's education, while around 15%, 17%, and 10% had school, master's and PhD educations, respectively. A total of 44.52% of respondents were Dubai residents, while 23.25%, 20.83%, 7.24%, 2.19%, and 1.97% were residents of Abu Dhabi, Sharjah, Al Ain, Ajman, and Ras Al Khaimah, respectively. A total of 47.59% and 42.11% of respondents replied that they were fully and partially aware of the concept of e-waste management, respectively. Only 10.31% of respondents replied that they had no idea about this aspect. A total of 69.52% of respondents answered that they possessed left-over electronic devices at home.

Table 1. Sample characteristics (n = 456).

Characteristics	Frequency	Percentage
Gender		
Male	279	61.18
Female	177	38.82
Age		
18–25	147	32.24
26–36	114	25.00
37–47	106	23.25
48–59	62	13.60
60 and above	27	5.92
Education		
School	68	14.91
Bachelor's	267	58.55
Master's	77	16.89
PhD	44	9.65
City of residence		
Dubai	203	44.52
Abu Dhabi	106	23.25
Sharjah	95	20.83
Al Ain	33	7.24
Ajman	10	2.19
Ras Al Khaimah	9	1.97
Awareness of e-waste management		
Fully aware	217	47.59
Partially aware	192	42.11
No idea	47	10.31
Possession of left-over electronic devices		
Yes	317	69.52
No	139	30.48

A second level of analysis was performed to assess the reliability and validity of the constructs used and to validate the hypotheses proposed in this study. This analysis was performed with the help of partial least squares structural equations modeling (PLS-SEM) using SmartPLS 4.0. Table 2 shows the loadings of the items with their respective constructs and their cross-loadings with the other constructs. A factor loading of more than 0.60 and a cross-loading value lower than that of the factor loading were required to establish the convergent and discriminant validity of the constructs [76]. In the initial analysis, two items of environmental consciousness constructs were found to have factor loading values of less than 0.60 and cross-loading values higher than the factor loading, and these items were removed from further analysis. All items in Table 2 had factor loadings greater than the 0.60 cut-off and had cross-loadings that were less than the respective factor

loadings, indicating that the constructs included in this study had sufficient convergent and discriminant validity.

Table 2. Factor loadings and cross-loadings of the items.

Factors/Items	ATT	SN	PBC	EC	RI	CR	INF	RB
Attitudes (ATT)								
ATT1	0.72	0.19	0.21	0.13	0.23	0.02	0.21	0.14
ATT2	0.75	0.13	0.24	0.19	0.24	−0.03	0.15	0.16
ATT3	0.80	0.12	0.22	0.20	0.29	−0.05	0.21	0.14
ATT4	0.79	0.06	0.32	0.20	0.30	−0.03	0.19	0.18
ATT5	0.72	0.00	0.25	0.16	0.21	−0.01	0.15	0.17
Subjective norms (SN)								
SN1	0.09	0.76	0.14	0.08	0.25	−0.11	0.20	0.21
SN2	0.11	0.76	0.11	−0.02	0.27	−0.06	0.24	0.17
SN3	0.09	0.72	0.11	0.05	0.27	−0.13	0.25	0.12
SN4	0.07	0.71	0.07	0.04	0.20	−0.11	0.19	0.16
SN5	0.12	0.74	0.10	0.02	0.27	0.00	0.23	0.18
SN6	0.10	0.71	0.14	0.07	0.26	−0.08	0.20	0.22
Perceived behavioral control (PBC)								
PBC1	0.21	0.13	0.73	0.03	0.38	−0.11	0.26	0.20
PBC2	0.26	0.09	0.71	−0.04	0.36	−0.21	0.27	0.22
PBC3	0.30	0.07	0.75	−0.04	0.35	−0.08	0.28	0.20
PBC4	0.20	0.17	0.73	0.03	0.39	−0.13	0.33	0.25
Environmental consciousness (EC)								
EC1	0.18	0.04	−0.01	0.71	0.06	−0.04	0.04	0.06
EC2	0.15	0.04	−0.02	0.77	0.09	−0.05	0.02	0.09
EC3	0.22	0.02	−0.03	0.75	0.07	0.07	−0.02	−0.04
EC4	0.20	0.04	0.04	0.71	0.05	−0.05	0.06	0.09
EC5	0.13	0.07	0.03	0.76	0.08	−0.02	−0.04	0.03
EC6	0.16	0.00	−0.03	0.72	0.06	0.04	0.05	0.03
EC7	0.20	0.03	−0.01	0.71	0.06	0.03	0.02	0.03
EC8	0.17	0.06	0.00	0.70	0.05	0.07	−0.05	0.01
EC9	0.17	0.05	−0.01	0.76	0.09	0.01	0.03	0.05
Recycling intention (RI)								
RI1	0.28	0.27	0.41	0.09	0.79	−0.14	0.58	0.29
RI2	0.27	0.29	0.34	0.12	0.76	−0.20	0.55	0.30
RI3	0.27	0.30	0.33	0.08	0.78	−0.19	0.59	0.32
RI4	0.26	0.21	0.40	0.03	0.78	−0.15	0.54	0.38
RI6	0.27	0.29	0.47	0.05	0.77	−0.11	0.51	0.29
RI7	0.24	0.27	0.40	0.07	0.77	−0.11	0.55	0.36
Cost of recycling (CR)								
CR1	0.00	−0.07	−0.19	0.04	−0.15	0.80	−0.17	−0.22
CR2	−0.04	−0.09	−0.10	−0.04	−0.14	0.81	−0.18	−0.26
CR3	−0.03	−0.11	−0.15	0.02	−0.17	0.77	−0.20	−0.21
Infrastructure support (INF)								
INF1	0.17	0.26	0.33	−0.04	0.60	−0.17	0.80	0.34
INF2	0.21	0.22	0.33	0.06	0.59	−0.15	0.81	0.35
INF3	0.24	0.25	0.31	0.00	0.57	−0.19	0.79	0.30
INF4	0.16	0.22	0.27	0.03	0.51	−0.24	0.80	0.31
Recycling behavior (RB)								
RB1	0.21	0.21	0.28	0.06	0.40	−0.17	0.37	0.78
RB2	0.24	0.18	0.22	0.08	0.38	−0.20	0.33	0.78
RB3	0.12	0.22	0.26	0.00	0.39	−0.29	0.35	0.83
RB4	0.08	0.23	0.21	−0.02	0.27	−0.25	0.26	0.75
RB5	0.13	0.13	0.23	0.06	0.27	−0.25	0.34	0.79
RB6	0.14	0.15	0.13	0.06	0.17	−0.21	0.19	0.65
RB7	0.18	0.08	0.21	0.06	0.21	−0.13	0.23	0.61

ATT: attitudes; SN: subjective norms; PBC: perceived behavioral control; EC: environmental consciousness; RI: recycling intention; INF: infrastructure; CR: cost of recycling; RB: recycling behavior.

Table 3 provides the statistics related to reliability and other convergent and discriminant validity measures. A reliability analysis was performed through Cronbach's alpha, which was expected to exceed the cut-off of 0.70 [76]. All the constructs used in this study surpassed the minimal threshold of 0.70, which establishes the reliability of the constructs of this study in a satisfactory manner. The convergent validity was tested through the average variance extracted (AVE) by the constructs. To establish satisfactory convergent validity, the AVEs should be more than the minimum threshold of 0.50 [76]. All the constructs surpassed the minimum threshold of 0.50; thus, the convergent validity of the constructs was proven satisfactorily. The discriminant validity was tested using Fornell and Larcker's [77] criterion. As per this criterion, the square root values of the AVEs of the constructs were expected to be higher than their respective inter-construct correlations. In Table 3, the square root values of the AVEs of the constructs are shown in the diagonal in bold. All of the constructs were found to have higher square root values of the AVEs than their inter-construct correlations, thus confirming the discriminant validity of the constructs used in this study.

Table 3. Construct reliability and validity.

Constructs	Cronbach's Alpha	AVE—Convergent Validity	Discriminant Validity (Fornell–Larcker Criterion)							
			Inter-Construct Correlations and the Square Root of AVE in the Diagonal							
			ATT	**SN**	**PBC**	**EC**	**RI**	**INF**	**CR**	**RB**
Attitude (ATT)	0.81	0.57	**0.76**							
Subjective norms (SN)	0.83	0.54	0.13	**0.73**						
Perceived behavioral control (PBC)	0.71	0.53	0.33	0.16	**0.73**					
Environmental consciousness (EC)	0.89	0.54	0.23	0.05	−0.01	**0.73**				
Recycling intention (RI)	0.87	0.60	0.34	0.35	0.51	0.09	**0.78**			
Infrastructure (INF)	0.71	0.63	−0.03	−0.11	−0.18	0.01	−0.19	**0.79**		
Cost of recycling (CR)	0.81	0.64	0.24	0.30	0.39	0.02	0.71	−0.23	**0.80**	
Recycling behavior (RB)	0.87	0.55	0.21	0.24	0.30	0.06	0.42	−0.29	0.40	**0.74**

ATT: attitudes; SN: subjective norms; PBC: perceived behavioral control; EC: environmental consciousness; RI: recycling intention; INF: infrastructure; CR: cost of recycling; RB: recycling behavior.

To validate the hypotheses proposed in this study, two PLS-SEM structural models were examined; the first was used to test the model's main effects, and the second was used to test the proposed model's moderation effects. The results of the main effects of the structural model are presented in Table 4. The explanatory power of the structural model is shown by the R^2 value. The main effects model of our study includes two dependent variables: e-waste recycling intention and recycling behavior. The R^2 value related to the dependent variable, recycling intention, is 0.359. Around 36% of the variation in recycling intention was explained by independent variables such as environmental consciousness and attitudes, subjective norms, and perceived behavioral control towards e-waste recycling. The R^2 value related to recycling behavior is 0.235. Around 24% of the variation in recycling behavior was explained by independent variables such as recycling intention, cost of recycling, and infrastructure support. The Q^2 value confirms the predictive relevance of the model, and it should be more than zero [76]. The Q^2 values related to the dependent variables, recycling intention and recycling behavior, are 0.212 and 0.125, respectively. As these values are found to exceed the value of zero, the main effect model was found to confirm predictive relevance. Table 4 shows the standardized path coefficients, which represent the significance of the association of the independent variable with the dependent variable. All of the independent variables related to H1, H2, and H3, such as attitudes (path co-efficient = 0.157; p-value < 0.01 level), subjective norms (path co-efficient = 0.260; p-value < 0.01 level), and perceived behavioral control (path co-efficient = 0.415; p-value < 0.01 level) towards e-waste recycling, were found to have a significant positive effect on recycling intentions, thus confirming all of these hy-

potheses of our study. The hypothesis related to the effect of recycling intention on recycling behavior, H5, was validated (path co-efficient = 0.180; *p*-value < 0.01 level).

Table 4. Results of main effects structural model.

Dependent Variable: Recycling Intention					Dependent Variable: Recycling Behavior				
Hypotheses	**Independent Variables**	**Std. Path Coefficients**	***t*-Value**	**Hypothesis Supported?**	**Hypotheses**	**Independent Variables**	**Std. Path Coefficients**	***t*-Value**	**Hypothesis Supported?**
H1	Attitudes	0.157	3.424 **	Yes	H5	Recycling intention	0.180	3.573 **	Yes
H2	Subjective norms	0.260	6.969 **	Yes		Cost of recycling	−0.201	4.192 **	Yes
H3	Perceived behavioral control	0.415	9.485 **	Yes		Infrastructure	0.180	2.595 **	Yes
	Environmental consciousness	0.046	1.020						
R^2	0.359				R^2	0.235			
Q^2	0.212				Q^2	0.125			

** *p* value < 0.01 level.

A second PLS-SEM analysis was performed to validate the moderation effect hypotheses of our study, H4a, H4b, H4c, H6, and H7. The results of the moderation effect structural model are shown in Table 5. The moderation effect of environmental consciousness on the association between TPB constructs and recycling intentions and the moderation effect of the cost of recycling and infrastructure support on the association between recycling intentions and recycling behavior were tested. The R^2 values related to the dependent variables, recycling intention and recycling behavior, are 0.377 and 0.247, respectively, thus establishing the explanatory power of the models. The Q^2 value was also found to be satisfactory (Q^2 value related to recycling intention = 0.221; Q^2 value related to recycling behavior = 0.127), confirming predictive relevance. The hypothesis related to the moderating effect of environmental consciousness on the effect of attitudes towards e-waste recycling and recycling intention was positively significant (path co-efficient = 0.142; *p*-value < 0.01 level), validating H4a of our study. However, the moderating effect of environmental consciousness on the effects of subjective norms and perceived behavioral control on recycling intention was found to be non-significant. Hence, H4b and H4c of our study were not supported. The moderating effect of infrastructure support on the effect of recycling intention on recycling behavior was positively significant (path co-efficient = 0.117; *p*-value < 0.05 level). Hence, H7 of our study was supported. However, the moderating effect of the cost of recycling on the effects of recycling intention and behavior was found to be non-significant. Hence, H6 of our study was not supported.

Table 5. Results of moderation effects structural model.

Dependent Variable: Recycling Intention					Dependent Variable: Recycling Behavior				
Hypotheses	**Independent Variables**	**Std. Path Coefficients**	***t*-Value**	**Hypothesis Supported?**	**Hypotheses**	**Independent Variables**	**Std. Path Coefficients**	***t*-Value**	**Hypothesis Supported?**
	Attitudes	0.194	4.052 **			Recycling intention	0.243	3.461 **	
	Subjective norms	0.269	7.014 **			Cost of recycling	−0.188	4.137 **	
	Perceived behavioral control	0.381	8.405 **			Infrastructure	0.254	3.288 **	
	Environmental consciousness	0.033	0.761		H6	Recycling intention X cost of recycling	0.037	0.806	No
H4a	Attitudes X environmental consciousness	0.142	2.866 **	Yes	H7	Recycling intention X infrastructure	0.117	2.0269 *	Yes
H4b	Subjective norms X environmental consciousness	−0.008	0.188	No					
H4c	Perceived behavioral control X environmental consciousness	−0.094	1.805	No					
R^2	0.377				R^2	0.247			
Q^2	0.221				Q^2	0.127			

* *p* value < 0.05 level; ** *p* value < 0.01 level.

7. Discussion

7.1. Theoretical Implications

The recycling of e-waste is an important sustainability issue worldwide, and several studies have investigated e-waste recycling behavior among consumers. However, there are limited studies from the Middle Eastern region. This study attempted to integrate all the relevant factors influencing e-waste recycling behavior in the UAE. This study applied a well-known consumer behavior model, known as the theory of planned behavior, as an overarching framework. The proposed model investigated the effects of attitudes, subjective norms, and perceived behavioral control towards e-waste recycling on e-waste recycling intention and investigated the further effect of recycling intention on e-waste recycling behavior. The proposed model also examined the moderation effect of environmental consciousness on the effects of attitudes, subjective norms, and perceived behavioral control on recycling intention. Furthermore, the model examined the moderation effects of the perceived cost of recycling and infrastructure support on the effect of recycling intention on recycling behavior. The proposed model was validated with survey data collected from 456 UAE residents using PLS-SEM. The analysis results suggest that six of the proposed nine hypotheses were supported (H1, H2, H3, H4a, H5, and H7).

H1 of our study examined the positive effect of attitudes towards e-waste recycling on e-waste recycling intention, which was supported. This finding is consistent with previous studies on e-waste recycling in other contexts (e.g., [26,28,30,78]). H2 examined the positive effect of subjective norms regarding e-waste recycling on e-waste recycling intention, which was supported. Similarly, H3 examined the positive effect of perceived behavioral control towards e-waste recycling on e-waste recycling behavior, which was supported. Both of these findings are consistent with those of previous works in the literature that applied the theory of planned behavior in the context of e-waste recycling behavior (for example, [17,30,46]).

The hypothesis (H4a) related to the moderating effect of environmental consciousness on the association between attitudes towards e-waste recycling and e-waste recycling intention was supported. The role of environmental consciousness in pro-environmental consumption behavior has been studied in various contexts since the construct was initially examined in the study by Schlegelmilch et al. [79] on green purchasing. Environmental consciousness is a broader construct and has been examined for its moderating effect on the association between the antecedents (attitudes, subjective norms, and perceived behavioral control) and behavioral intentions of a specific context, such as green purchasing (e.g., [59]) and pro-environmental behavior (e.g., [58]). In the context of construction and demolition waste recycling behavior, Jain et al. [11] applied the norm activation theory and used environmental consciousness as an antecedent variable of recycling intention. Wang et al. [26] examined environmental awareness as an antecedent to e-waste recycling in China. However, the studies investigating the role of environmental consciousness in the association of antecedents of e-waste recycling with e-waste recycling intentions were limited. The finding of a positive moderation effect of environmental consciousness on the positive effect of attitudes towards e-waste recycling on e-waste recycling intention is aligned with previous research on pro-environmental behavior. For example, in a study by Dhir et al. [26] on e-waste recycling that applied the behavioral reasoning theory, although the environmental consciousness construct was not used, they tested the moderating effect of environmental assessment and awareness on the effect of attitudes on the intention to recycle and found a significant positive moderation effect of environmental awareness.

This finding on environmental consciousness highlights the call for sustainability in education by offering educational programs and research activities to enhance environmental consciousness among students and the academic community [12]. When sustainability in education is addressed, emphasizing science education at the secondary level could result in higher levels of environmental consciousness [13]. Sustainability in education is concerned with the interplay of social and environmental systems, which necessitates interdisciplinary thinking abilities, and these abilities could be developed through real-life

problem-oriented learning abilities [80]. A study by Jeronen et al. [81] prescribed outdoor education, which involves field trips and nature studies, to develop such abilities. This finding also implies sustainability in education in terms of identifying the ways and means of designing environmental awareness messages for students [82]. Environmental consciousness among students could be improved through extra-curricular activities in addition to courses on environmental education [83]. Even though the concept of sustainability has been addressed in different academic disciplines, to effectively institute sustainability in education, the curriculum must be integrated across the campus using an interdisciplinary approach [84]. Holst [85] argues in favor of whole institution approaches for sustainability in education, which 'means that aligning all functional components of educational organizations (e.g., campus management, curriculum design, or community partnerships) with sustainability becomes a core objective of organizational development' (p. 1016).

The moderation effects of subjective norms and perceived behavioral control were found to be non-significant, and therefore, H4b and H4c of our study were not supported. This could be because factors such as subjective norms and perceived behavioral control are related to society and are not innate to an individual. Because the attitude towards e-waste recycling is individual-specific, environmental consciousness appears to affect attitude more than the other antecedents of e-waste recycling intentions.

H5 of our study relates to the positive effect of e-waste recycling intention on e-waste recycling behavior. This hypothesis was found to be supported in our study. This finding is consistent with other studies on pro-environmental behavior that have applied the theory of planned behavior. For example, Sweeney et al. [86] found a positive effect of energy-saving motivation on energy-saving behavior. Delcea et al. [87] found a positive effect of e-waste recycling intention on e-waste recycling behavior in Romania.

H6 of our study relates to the moderating effect of the cost of e-waste recycling on the effect of recycling intention on recycling behavior, which was not supported. However, the cost of recycling was found to have a negative effect on e-waste recycling behavior, thus suggesting that the perceived cost of e-waste recycling decreases e-waste recycling behavior. The hypothesis related to the moderation effect of perceived infrastructure support for e-waste recycling on the positive effect of recycling intention on recycling behavior (H7) was supported. Although previous research investigated the effect of convenience or infrastructure support on pro-environmental and recycling intention and behavior (e.g., [33,35,75]), only our study established the moderation effect of infrastructure support on the association between e-waste recycling intention and behavior. This finding broadly addresses the gap in the research in identifying the factors that help bridge the gap between e-waste recycling intention and behavior and clarifies its role more succinctly. This finding supports the previous research of Thukral et al. [2], Wang et al. (2019) [30], and Chen et al. [42], who found that infrastructure was one of the major barriers to the implementation of e-waste recycling and management.

7.2. Practical Implications

This study's findings provide avenues for several practical implications to policymakers in promoting e-waste recycling intention and behavior. Importantly, policymakers should give importance to enhancing attitudes towards recycling by way of communicating the ill effects of not recycling e-waste. While doing so, agencies should also focus on enhancing people's environmental consciousness through regular messaging using publicly available communication mediums, including digital and social media marketing. Furthermore, the sustainability education course curriculum should emphasize various forms of environmental degradation and various initiatives that help protect the environment [12]. This would improve students' environmental consciousness and strengthen the positive effect of the attitude towards e-waste recycling on intention. Sustainability in education should also emphasize research related to sustainable production and consumption, and educational institutions should assume the role of disseminating research

findings related to sustainability to all stakeholders [12]. Policymakers should emphasize prioritizing secondary science education to build sustainability in education [13]. The curriculum on sustainability in education should promote nature connectedness as it improves pro-environmental behavior and sustainable well-being [88]. Sustainability in education should be taught using new teaching approaches focusing on mindfulness, compassion, and sustainability to enhance inner transformation [89].

Policymakers should also plan to arrange short-term seminars to train individuals regarding the dos and don'ts related to e-waste recycling, as this training would enhance individuals' control over their e-waste recycling behaviors. The government and pro-environment organizations should also continue to conduct public awareness campaigns against the detrimental effects of unsafe e-waste disposal. Furthermore, the higher education sector can also play a significant role in improving the level of awareness towards the environmental impact of e-waste by way of offering specific courses for students. Particularly, the current practice in the UAE of offering courses on sustainability under the category of General Education in all bachelor's programs needs to be strengthened with topics related to the impact of e-waste [90]. These initiatives could have a lasting impact on students regarding sustainable development issues, particularly responsible production and consumption. As perceived behavioral control was found to positively impact e-waste recycling intention, implementing sustainability in education with a focus on the harmful effects of e-waste will improve students' self-efficacy at a young age so they can develop e-waste recycling intention. The sustainability education course curriculum should emphasize how e-waste harms all living organisms, including humans. The curriculum should include how the unsafe disposal of e-waste results in air and water pollution and how these pollutants in air and water bodies could lead to various harmful effects on all living organisms. Sustainability in education should focus more on text forms of communication related to e-waste recycling, as the research by Nanath and Kumar [82] found that the text form was more persuasive and impactful in changing students' attitudes than showing them a video. Policymakers should identify the barriers and challenges in adopting sustainability in education [91]. Sustainability education teachers should be trained to teach using new methodologies involving indoor and outdoor learning activities [92]. This requires a transformation in institutions' approaches towards teaching and learning sustainability that involves collaboration in developing curricula and multicultural orientation, integrating the concept of social justice and environmental responsibility [93].

Policymakers should also implement strict rules and regulations so that people would have tendencies to follow the norms related to e-waste recycling that are acceptable to government authorities and society in general. The findings imply that policymakers should gain confidence in their measures to improve e-waste recycling intention as it leads to a favorable consequence of e-waste recycling behavior. The findings imply that policymakers should reduce the perceived cost of e-waste recycling as it reduces e-waste recycling behavior. Furthermore, policymakers should continue their efforts in improving infrastructure support that would provide convenience to individuals to engage in e-waste recycling behavior. This would also help to translate individuals' e-waste recycling intentions into behaviors.

8. Limitations and Future Research

Even though the study's findings provide a number of theoretical and practical implications, one needs to be aware of the study's limitations while applying the findings. Importantly, the study was conducted in the UAE, where the consumption of e-devices is very common, leading to regular e-waste generation at the household level. Therefore, it may be possible to assume a higher level of general awareness of the consequences of e-waste generation and the need for safer ways of e-waste recycling. When the study results are applied in other contexts, due consideration of these aspects may be required. The R^2 values of e-waste recycling intention and recycling behavior in our study are 0.359 and 0.235, suggesting that around 64% of the variation in recycling intention and 76% of the

variation in recycling behavior in our study were revealed by factors that were not included. Still, there are a variety of factors not included in our proposed model that could affect e-waste recycling intention and behavior. Future research could focus on these aspects that influence e-waste recycling intention and behavior. For example, future research could focus on factors such as psychological ownership of the environment and frugal consumption that limits the generation of e-waste.

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