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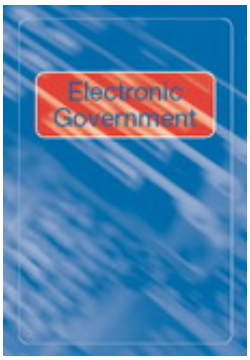

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An investigation on adoption of AI-enabled e-waste recycling kiosks in the post-pandemic era

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Abstract: Leveraging artificial intelligence-powered kiosks in e-waste recycling presents an efficient solution to address the pressing environmental concern of improper e-waste disposal. Therefore, this research aims to identify the key factors driving household consumers to embrace and utilise AI-enabled e-waste recycling kiosks. The conceptual model was empirically analysed using PLS-SEM with 2,750 survey responses from the household respondents. The results indicate that several factors, namely attitude, perceived behavioural control, societal norms, pro-environmental behaviour, and self-expressive benefits, are instrumental in influencing the intentions to adopt e-waste recycling kiosks by household consumers. These findings carry profound implications for society, emphasising the need to curtail e-waste and establish a sustainable circular economy. In this domain of consumer behaviour analysis, two novel additional constructs, self-expressive benefits, and pro-environmental behaviour are introduced to enhance the existing theory of the planned behaviour model. The current enriched model explores the intricacies of consumers' actions and the motivating factors driving their adoption and use of AI-enabled e-waste recycling kiosks, providing insights into this unexplored territory in the post-pandemic era.

Keywords: AI-enabled e-waste recycling kiosks; theory of planned behaviour; TPB; attitude; pro-environmental behaviour; self-expressive benefits.

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1 Introduction

Electronic waste remains a critical concern in our fast-evolving world (Aboelmaged, 2021). It encompasses discarded electronic products resulting from increased mobile and home appliance usage due to technological advancements and lifestyle changes (Boubellouta and Kusch-Brandt, 2022). This surge in electronic waste represents a substantial risk to both the ecosystem and community health. Unlike other conventional urban waste, traditional waste management policies are not suited for e-waste due to the presence of toxic elements that are harmful to both consumers and the environment if not properly handled (Nnorom et al., 2009).

Due to a lack of proper recycling infrastructure and environmental pollution risks, substantial volumes of e-waste are illicitly transported across borders, particularly from economically developed nations to less privileged ones (Nnorom et al., 2009). E-waste stands as the world's fastest-growing waste stream today. Addressing this issue through proper disposal and recycling methods in e-waste management would reduce harm to human health and promote a sustainable environment and circular economy.

It was reported that informal e-waste recycling has adverse effects on the labourers engaged, particularly during the COVID-19 pandemic prevailing all over the world. Improper physical handling and recycling techniques of hazardous e-waste are likely to increase the chances of health workers getting COVID-19 (El-Ramady et al., 2021). This may exacerbate the community spread of COVID-19, as the stains COVID-19 are reported to survive in physical waste for several days. Henceforth, the proposed AI-enabled e-waste recycling kiosks would greatly prevent the community spread of the COVID-19 virus, as physical handling of waste is largely reduced (Rene et al., 2021). Having said the importance of adopting AI in the arena of e-waste recycling during the post-pandemic era, it is also of paramount importance to analyse the household intentions in adopting AI-enabled e-waste recycling kiosks. This motivates the current study to

analyse the antecedents of household intentions in adopting AI-enabled e-waste recycling kiosks.

2 Review of literature and proposed model

In light of the rising volume of e-waste, it has become imperative to deploy appropriate recycling technologies to effectively address this acute environmental challenge of improper e-waste disposal. A substantial body of literature has diligently examined the determinants influencing individuals' intentions to recycle e-waste, as evidenced in studies such as those by Aboelmaged (2021) and Chen (2020). However, no study exists in the exploration of the adoption behaviour pertaining to artificial intelligence kiosks for efficient e-waste recycling, marking a notable research gap. Additionally, e-waste recycling has emerged as a contentious issue in many nations, drawing the attention of numerous scholars, exemplified by the work of Zhang et al. (2021).

Harnessing the capabilities of AI-enabled kiosks for e-waste recycling management is not only pivotal for enhancing recycling efficiency but also for minimising the physical handling of e-waste, especially during the ongoing COVID-19 pandemic. Globally, technologies supporting the implementation of social distancing measures have gained widespread acceptance amid the pandemic and are anticipated to become integral in the post-pandemic period. This underscores the imperative need for the deployment of AI-enabled recycling technology with robust capabilities in India. Furthermore, there remains a conspicuous gap in scientific knowledge concerning how households in developing countries like India perceive and are willing to utilise AI-enabled kiosks for e-waste recycling. Consequently, this research endeavours to address this gap comprehensively. In doing so, it offers valuable insights to government policymakers and contributes to the existing theoretical framework surrounding e-waste recycling.

2.1 Proposed model

Extant literature attempts to unveil the antecedents of recycling behaviour (Aboelmaged, 2021), yet consumers' intention to adopt e-waste kiosks is not explored. This necessitates the current research study to comprehensively apply the theoretical lenses of the established model like the theory of planned behaviour (TPB) in investigating the antecedents in the intentions to adopt AI-enabled e-waste recycling kiosks. The proposed model extends the TPB model by incorporating two additional constructs, namely pro-environmental behaviour and self-expressive benefits to investigate the antecedents that motivate the behavioural intention (BI) to use artificially enabled e-waste recycling kiosks.

2.1.1 Attitude

A person's attitude is their or her assessment of conduct, either favourable or negative, that indicates their intention to act (Lau and Kwok, 2007). Grounded on the TPB, the current study presumes that a person's attitude towards the benefits of recycling E-waste using kiosks is reflected in his intention to adopt it. So far, the extant literature on the TPB has explored the influence of attitude on the intention to recycle waste (Ahmmadi et al., 2021) but ignored the critical role of AI-enabled kiosks in e-waste recycling,

particularly during the times of COVID-19. Hence it is critical to postulate the following hypothesis, which is empirically tested in the current study,

H1 The attitude of consumers positively influences the BI to adopt e-waste recycling kiosks.

2.1.2 Subjective norms

This indicates how an individual feels the pressure from society to engage in a particular action (Li et al., 2021). People who are part of an individual's reference group, such as family, friends, etc. largely influence his opinion or behaviour (Taufique and Vaithianathan, 2018) and are often inspired to comply with their opinions owing to the fear of social exclusion. Literature studies in the TPB model advocated that an individual's urge to satisfy the anticipations of his reference group influences his intention to adopt a technology (Despotović et al., 2019). Hence the study hypothesises the following,

H2 The subjective norms of consumers positively influence the BI to adopt e-waste recycling kiosks.

2.1.3 Perceived behavioural control

It indicates how competent an individual is in adopting a particular behaviour (Blagoeva et al., 2020). It is concerned with his capability and ease of indulging in a particular behaviour. The past obstacles of a person significantly impact his commitment to a behaviour. Prior literature studies evinced the importance of perceived behavioural control in predicting the adoption of e-technology (Blagoeva et al., 2020). Hence,

H3 The perceived behavioural control positively influences the BI to adopt AI-enabled kiosks in e-waste recycling.

2.1.4 Pro-environmental behaviour

Individuals who exhibit pro-environmental behaviour tend to be less inclined to damage the environment and are more likely to keep it safe (Li et al., 2021). Motivated by their altruistic values, such individuals are likely to express the intention to embrace environmentally friendly technologies designed to preserve the environment. These can encompass a range of initiatives, including responsible marine turtle tours (Olya and Akhshik, 2019), sustainable poultry practices (Gholamrezai et al., 2021), and more. The adoption of AI-enabled e-waste recycling kiosks is one such initiative that falls within this category, driven by a noble aspiration to safeguard the environment. Hence, we postulate,

H4 The pro-environmental behaviour positively influences the BI to adopt AI-enabled e-waste recycling kiosks.

2.1.5 Self-expressive benefits

The concept of self-expressive benefits is grounded in signalling theory (Boobalan et al., 2021). Signalling is a way of reflecting one's liking or interest by engaging in certain

behaviours. The self-expressive benefit is one such psychological benefit that people seeks to engage themselves in socially desirable activities such as protecting the environment, their commitment towards a sustainable environment, etc. From this standpoint of the signalling theory, it is evident that when signalling is likely, people are more inclined to adopt and use a system that benefits society (Hwang and Kim, 2021). Individuals tend to be proactively involved in socially desirable activities to manifest their interest in the well-being of society to others, thus deriving a self-expressive benefit (Sarkar et al., 2019). Therefore, self-expressive benefit forms a major reason for individuals to indulge in the consumption of environmentally friendly products. AI-enabled e-waste recycling kiosks are one such socially desirable initiative, which renders psychological benefits like self-expressive benefits for the consumers who adopt it. This inspires the study to incorporate self-expressive benefit as an additional construct to the conventional TPM model. Hence, we propose,

H5 The self-expressive benefits of the consumers positively influence the BI to adopt AI-enabled e-waste recycling kiosks.

2.1.6 Behaviour intention

Behavioural intention is regarded as an individual's tendency towards participating in a particular behaviour (Chang and Su, 2022), reinforcing their commitment to it (Despotović et al., 2019). As one's level of behavioural intention increases, so does the likelihood of performing the behaviour (Teoh and Sultana, 2022), making it a direct predictor of behaviour. Hence, in the context of exploring the adoption behaviour of consumers on AI-enabled e-waste recycling kiosks, it serves as a strong predictor of their actual usage behaviour. Past studies have consistently shown that the inclination of an individual to engage in socially desirable behaviours significantly influences their actual usage (Chang and Su, 2022). Hence, we hypothesise,

H6 The behavioural intention (BI) to adopt AI-enabled e-waste recycling kiosks positively influences the use behaviour of AI-enabled kiosks.

3 Methodology

3.1 Data sample

This research focuses on the ordinary residents of households in India as its primary target population. To collect data, a questionnaire was administered to the participants through the online survey platform, surveymonkey.com. A robust dataset comprising 2,750 valid and fully completed responses was collected. Table 1 depicts the sample's demographic data.

3.2 Questionnaire development

An online survey methodology was employed for data collection. This study utilised a self-report questionnaire, which had two sections. The participant's demographic data was gathered in the first section and the second section measured the latent variables such as attitude, subjective norms, self-expressive benefits, perceived behavioural control, and

pro-environmental behaviour in the study. The scale to measure the latent variables was adopted and the sources are exhibited in Table 2. A five-point Likert scale is employed to assess the items.

Table 1 Demographic profile of household consumers

Demographic variable	*Subject*	*Sample*	*Percentage (%)*
Gender	Male	1,430	52%
	Female	1,320	48%
Age	Below 25 years	357	13%
	25–40 years	1,485	54%
	40–60 years	660	24%
	Above 60 years	248	9%
Education	High school	302	11%
	Graduate	1,815	66%
	Postgraduate and above	633	23%
Occupation	Employed	1,513	55%
	Unemployed	1,237	45%
Income	Below 15,000/month	137	5%
	15,000–25,000/month	1,045	38%
	Above 25,000/month	1,568	57%

Table 2 Factor loadings of the items

Constructs	*Source*	*Items*	*Item constructs*	*Factor loadings*
Attitude	Jiménez-Parra et al. (2014)	AT1	I prefer e-waste recycling kiosks because it is fully automated and more efficient than manual e-waste recycling.	0.842
		AT2	I prefer e-waste recycling kiosks as it is a smarter method of sorting waste and recycling.	0.872
		AT3	I prefer e-waste recycling kiosks as they protect the environment from hazardous waste.	0.703
		AT4	Implementing e-waste recycling kiosks is good for public health, as physical handling is avoided.	0.785
Subjective norms	Taing and Chang (2021)	SN1	People who are known to me would recommend me to use e-waste recycling kiosks.	0.902
		SN2	My family and friends approve my decision to use e-waste recycling kiosks.	0.943

Table 2 Factor loadings of the items (continued)

Constructs	*Source*	*Items*	*Item constructs*	*Factor loadings*
Perceived behavioural control	Ahmmadi et al. (2021)	PBC1	To use or not to use an e-waste recycling kiosk is entirely up to me.	0.907
		PBC2	I believe that I have the knowledge and time to use e-waste recycling kiosks if implemented.	0.944
Perceived behavioural control	Ahmmadi et al. (2021)	PBC3	I am confident that if I want, I can use e-waste recycling kiosks	0.764
Pro-environmental behaviour	De Leeuw et al. (2015)	PE1	I always put my trash in the proper recycling bin	0.939
		PE2	I have the sense of contributing to the well-being of humanity and nature by adopting e-waste recycling kiosks	0.847
Self-expressive benefits	Boobalan et al. (2021)	SE1	By using e-waste recycling kiosks, I can show my concerns to health workers who handle e-waste manually, which is hazardous to their health	0.973
		SE2	I could express my concern for the environment and society by encouraging the usage of e-waste recycling kiosks	0.814
Intention to adopt e-waste recycling kiosks	Theerthaana and Manohar (2021)	RI1	In the future, I will actively participate in e-waste recycling kiosks	0.845
		RI2	My family is more likely to use e-waste recycling kiosks	0.729
		RI3	The probability I would use AI-enabled e-waste recycling kiosks is very high.	0.809
Use behaviour of e-waste recycling kiosks	Hagger and Hamilton (2022)	BI1	How frequently will you use e-waste recycling kiosks if given a chance?	0.912
		BI2	How often will you use e-waste recycling kiosks during the next year if given a chance?	0.947

4 Data analysis and findings

The current research employs Smart PLS to test the proposed model of structural equation modelling (SEM). This method is superior to covariance methods for testing the significance of hypothesised paths owing to its strong prediction capability and its advantage of being less sensitive to normality issues (Teoh and Sultana, 2022). The

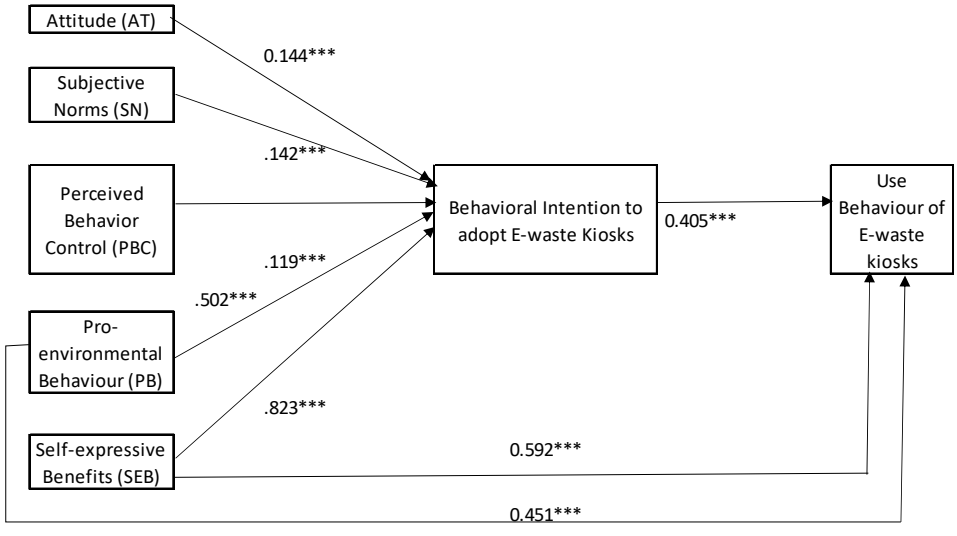
proposed model is executed by bootstrapping to 1,000 or more subsamples and the findings of the path analysis are exhibited in Table 4.

4.1 Structural model

The model fit of the proposed structural model was found good (CMIN/DF – 1.107; AGFI – 0.833; CFI – 0.851; RMSEA – 0.032). The findings of path analysis show that self-expressive benefits towards AI-enabled E-waste management significantly influence the household consumer's intention to adopt AI-enabled E-waste management ($p < 0.05$), thus accepting the H5a hypothesis. This was the most significant antecedent in predicting the intention to adopt AI-enabled E-waste management ($\beta = 0.823$). The next strongest predictor of the consumer's BI is the pro-environmental behaviour of the consumer ($\beta = 0.502$, $p < 0.00$), thus confirming the H4a hypothesis.

According to the findings of the structural model (Table 4), attitude ($\beta = 0.144$, $p < 0.00$), perceived control ($\beta = 0.119$, $p < 0.01$), and subjective norms ($\beta = 0.142$, $p < 0.01$) all significantly affected behavioural intention to adopt AI-enabled e-waste management, thus confirming H1, H2, and H3 respectively. The significant latent variables (self-expressive benefits, pro-environmental behaviour, attitude, perceived control, and subjective norms) accounted for 53% of the variance in BI to adopt AI-enabled e-waste management. Figure 1 exhibits the results of the structural model. Also, the self-expressive benefits ($\beta = 0.451$, $p < 0.00$) and pro-environmental behaviour ($\beta = 0.592$, $p < 0.00$) of household consumers are found to significantly influence them to use AI-enabled E-waste management, thus confirming H4b and H5b.

Figure 1 Hypothesis test results



4.2 Reliability and validity analysis

The Smart PLS is employed to test the reliability and validity of the questionnaire. The estimated Cronbach's alpha, α for each of the seven latent variables of the current study

is found to be greater than the cut-off value 0.7. Henceforth, the internal consistency of the constructs is rightly established, confirming the reliability of the proposed model (Table 3).

The convergence validity can be established using average variance extracted (AVE) and composite reliability (CR). The validity results are exhibited in Table 3, and it is evident that the validity of the proposed model is established as the AVE > 0.5 and CR > 0.7 (Fornell and Larcker, 1981).

Table 3 Results of reliability analysis

	Cronbach's alpha	*rho_A*	*Composite reliability*	*Average variance extracted (AVE)*
Pro-environmental behaviour	0.759	0.86	0.888	0.799
Self-expressive benefits	0.794	1.317	0.891	0.805
Perceived behaviour control	0.844	0.867	0.907	0.766
Subjective norms	0.828	0.868	0.919	0.851
Attitude	0.817	0.851	0.878	0.645
Behavioural intention	0.846	0.883	0.927	0.865
Use behaviour	0.711	0.727	0.838	0.633

Table 4 Results of hypothesis testing

	t-statistics	*Beta*	*p-value*	*Result of hypothesis*
H1: Attitude → BI to adopt e-waste recycling kiosks	3.829	0.144***	0	Significant
H2: Subjective norms → BI to adopt e-waste recycling kiosks	3.014	0.142***	0.003	Significant
H3: Perceived behaviour control → BI to adopt e-waste recycling kiosks	3.077	0.119***	0.002	Significant
H4a: Pro-environmental behaviour → BI to adopt e-waste recycling kiosks	10.774	0.502***	0	Significant
H4b: Pro-environmental behaviour → Use Behaviour	3.663	0.592***	0	Significant
H5a: Self-expressive benefits → BI to adopt e-waste recycling kiosks	2.336	0.823**	0.02	Significant
H5b: Self-expressive benefits → Use behaviour to use e-waste recycling kiosks	3.836	0.451***	0	Significant
H6: BI to adopt e-waste management system → Use behaviour to use e-waste recycling kiosks	3.297	0.405***	0.001	Significant

5 Discussion

The proposed extended TPB model with the incorporation of two additional constructs, namely, pro-environmental behaviour and self-expressive benefits seeks to explore the driving forces behind the intention to adopt AI-enabled e-waste recycling kiosks. Firstly,

the current study accentuated the dynamic effect of self-expressive benefits as the most crucial enabler of the intention to adopt AI-enabled e-waste kiosks among household consumers (β = 0.823, $p < 0.05$). This finding aligns with previous literature that emphasised the significant role of consumers' self-expressive benefits in accelerating an individual's inclination to adopt environmentally and socially desirable activities (Boobalan et al., 2021).

Secondly, consumers' intention to adopt an AI-enabled e-waste management system is directly influenced by pro-environmental behaviour ($\beta = 0.502$, $p < 0$). It means that the more positive the consumer's pro-environmental behaviour, the stronger their intention to adopt AI-enabled E-Waste recycling kiosks. People with pro-environmental behaviour are less likely to harm the environment and more likely to develop a sustainable environment (Li et al., 2021). With such a benevolent motive, those individuals are expected to adopt and use AI-enabled e-waste recycling kiosks.

Thirdly, the results of this research are in line with the postulation that consumer's attitude directly influences their intention to indulge in environmentally friendly ventures (Taufique and Vaithianathan, 2018). Also, the empirical results of the study supported Hypothesis H2, emphasising the significant impact of subjective norms on the consumer's intention to adopt AI-enabled e-waste recycling kiosks ($\beta = 0.142$, $p < 0.01$). It acknowledges the conventional model of the theory of planned behaviour together with the previous findings on the role of subjective norms in influencing the behavioural intention to adopt socially desirable ventures (Osei-Marfo et al., 2022). The results revealed perceived behavioural control as one of the motivators triggering the behavioural intentions of the consumers to adopt AI-enabled e-waste recycling kiosks ($\beta = 0.119$, $p < 0.01$). This contention is in line with the TPB model which advocates perceived behavioural control as a legitimate variable in enhancing consumer's intentions for any socially desirable activities (Zhang et al., 2013).

6 Conclusions and implications for policymakers

Adopting the AI-enabled e-waste recycling kiosks is the need of the hour, particularly during this COVID-19 crisis, as it is a critical alternative for reducing health-worker exposure to hazardous e-waste. Furthermore, the deployment of kiosks aids in the enforcement of social distancing norms of COVID-19.

The findings of this study offer valuable practical insights for policymakers to accelerate consumer's adoption behaviour of e-waste kiosks. Having empirically proved the significant influence of self-expressive benefits in the behavioural intention to adopt e-waste kiosks, policymakers can skilfully utilise self-expressive benefits as a strategic tool to encourage people to responsibly dispose of their electronic waste using e-waste kiosks. Adopters of e-waste kiosks can be offered digital badges and can be provided with selfie sticks or photo booths with a label 'Go green with e-waste recycling' tag. This allows taking pictures near e-waste kiosks while responsibly disposing of their e-waste and sharing their photos with relevant hashtags like #GoGreenWithE-wasteKiosks or #SaveOurEarth in social media, thus quenching their self-expressive benefit of indulging in a socially responsible behaviour like adoption of e-waste kiosks. Certain other taglines like 'Kiosk-contactless e-recycling' in the post-COVID era can also draw the attention of

the consumer. This strategy can strengthen the self-expressive benefits of the consumers, thereby creating positive cues and motivating them to adopt and use e-waste kiosks.

Also, the findings of this research imply that consumers' pro-environmental behaviour can be tapped to motivate them to adopt e-waste kiosks. Grounded on the findings of this research, policymakers can conduct extensive awareness campaigns to educate consumers about the significant role played by the e-waste kiosks in creating a circular economy and in providing positive environmental and social impact by largely reducing landfills, unsustainable consumption, etc. This way of repositioning the e-waste recycling kiosks in creating a major environmental impact and in a circular economy will motivate people with pro-environmental behaviour to adopt and use these kiosks.

In addition, the study findings imply that enhancing consumers' perception of control over using e-waste kiosks could inspire them to adopt such kiosks. For this, self-served, fully automated recycling kiosks can be installed in multiple and easily accessible places like shopping malls, retail showrooms, supermarkets, etc. This strategically minimises their perception of the difficulty in accessing e-waste kiosks for waste disposal. Moreover, these kiosks can be made user-friendly by providing clear instructions and helpline numbers to guide users through the process. With a user-friendly design and by adequately expanding the kiosks installations, consumers' perceived difficulty in operating such complex kiosks will be minimised and thus will accelerate their intention to adopt e-waste.

The study empirically proved that a consumer will adopt e-waste kiosks if his associates think that he should recycle e-waste using such kiosks (i.e., societal norms). Therefore, policymakers can involve community leaders, celebrities, or even local ambassadors to actively support these initiatives. Also, slogans like 'Join hands with your neighbours to recycle e-waste responsibly' can create a sense of social conformity. When opinion leaders or influencers embrace this practice, individuals are more likely to comply with their actions, reinforcing positive subjective norms.

AI-enabled e-waste management kiosks play a vital role in creating a positive environmental impact by largely reducing landfills, unsustainable consumption, etc. Repositioning the e-waste recycling kiosks in creating a major environmental impact and in a circular economy will motivate people behaviour to adopt and use these kiosks.

Data availability

The datasets utilised in the present study can be obtained from the corresponding author upon a reasonable request.

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