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Sustainability of Electronic Waste Management in Uganda: Driving Factors for the Extended Producer Responsibility Systems

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Abstract

Uganda recognized the Strategic Development Goals (SDGs), a worldwide blueprint to be reached by 2030 for a brighter and more sustainable future for all, and incorporated them into the development of its Vision 2040 and National Development Plan (NDP) for the 2020–2024–2025 timeframe. The need for solutions to the worldwide e-waste problem is growing since e-waste is one of the waste streams that is developing the quickest and needs immediate attention. The study examined the driving factors for the successful Extended Producer Responsibility (EPR) systems implementation in Uganda based on electronic products. The study employs the Behavioural Reasoning Theory (BRT) to understand Government employees' perspective on drivers of successful EPR systems implementation in Uganda. Through a questionnaire survey, data were collected conveniently from government employees, at the policy level, knowledgeable in E-waste and environmental-related issues. Data analysis was done through the Partial Least Squares – Structural-Equation Modeling - (PLS-SEM). Findings show that the establishment of the economic, administrative and informative instruments, as well as their proper enforcement, in implementing the EPR approach results in sustainable E-waste management outcomes. The government should encourage concerted stakeholder partnerships, establish a sustainable E-waste management system and fast-track the implementation of the EPR model that works for Uganda. For instance, deliberate government efforts towards green development paths, laws, policies, and enforcement of appropriate government legislation, strategic recycling of E-waste, enforcement of the 3R (Reduce, Reuse and Recycle) and local country processing. However, implementation of the EPR scheme also has several obstacles. Study implications and recommendations are also included.

Keywords: Extended Producer Responsibility, Policy, Instruments, Electronic Waste, Sustainable E-waste Management

Introduction

Waste generation from the electronic sector is one of those major continually worsening, and deteriorating matters impacting negatively on the environment and human health, despite all the

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attempts to control it (Steenmans *et al.,* 2019). The surging levels of Waste Electronic and Electrical Equipment (WEEE) pose a significant obstacle to the UN's sustainability goals achievement (Anderson, 2022; Forti *et al.,* 2020). Consequently, WEEE management is typically a worldwide emerging issue that need urgent attention, due to its unsafe and harmful content to the ecosystem and human health (Islam and Huda, 2020; Rodrigues *et al.,* 2020; Ilankoon *et al.,* 2018). This has been partly fuelled by unlawful recycling (Abbondanza & Souza 2019; Ravindra & Mor 2019); higher E-equipment consumption rates, limited repair rates, and short life cycles (Forti *et al.,* 2020). E-waste management has been widely backed as one of the strategies to minimize the adverse environmental and health impacts to the society. WEEE is the waste stream that is expanding the fastest, according to Islam and Huda (2019). It now makes up two to three times as much as municipal solid garbage. Governments are increasingly considering a range of alternatives to keep up with the exponential growth of e-waste.

Several interventions such as green rating systems and education enforcement by way of illegal dumping penalty and heavy land levy, as well as prevention through the Extended Producer Responsibility (EPR) by large, constitute an effective waste management system (Shooshtarian *et al.,* 2020, Caldera *et al.,* 2020). EPR, which originated in Germany in 1991 due to landfill shortage, is an effective market-based policy scheme proven to meaningfully contribute to the circular economy for E-waste management. Portugaise *et al.*(2023) and Pouokli (2020) state that EPR has been practiced severally in waste streams and types. Strictly, EPR renders producers responsible, physically and financially, for the whole lifecycle/lifespan of manufacturers' products during the materials supply chain (Tam & Lu, 2016), which includes design, manufacture, and recycling as well as final disposal (OECD, 2016). *EPR* creates shared responsibility among waste managers, producers, importers, and distributors. EPR essentially first prevents waste generation (Acree-Guggemos & Horvath, 2003), secondly diverts the additional waste away from landfills basically to reuse and recovery (Hanisch, 2000), and thirdly creates and stimulates markets for EEE. Encouraging manufacturers through incentives to take environmental factors into account when designing their products is the ideal way for EPR. This prevents waste from arising at the source through improved product design and technology development that integrates green design and other efficient waste management strategies into the overall production setup (Pouikli, 2020; Steenmans, 2019).

The EPR implementation, in prior studies, has been long cited as an effective regulatory policy approach in E-waste management (Duan *et al.,* 2019; Acree-Guggemos & Horvath, 2003; Steenmans, 2019). However, there is no standard and universal guideline and policy approach to implementing the Electrical and Electronic Equipment (EEE) waste stream. Also, most studies on EPR implementation factors and its adoption inhibitors have focused on the construction industry (Shooshtarian *et al.,* 2021; Xu *et al.*(2021). Previously, Ibn-Mohammed *et al.* (2021) and Mallawarachchi and Karunasena (2012) alerted that overlooking EPR policies and schemes would tantamount to a blunder with dire environmental and also community negative consequences. Furthermore, the majority of EPR research has concentrated on recycling e-waste (Wang *et al*., 2015), giving the Critical Success Factors (CSF) of EPR deployment less attention. For the purpose of managing solid waste, affluent nations have mainly embraced the developing policy idea known as the EPR. Developed economies first implemented the EPR approach, especially after the European Parliament (EP) passed a directive that required its member nations to establish an EPR program based on plastic products (Leal Filho *et al.,* 2019).

In order to properly manage e-waste, developing nations are gradually but steadily adopting this idea by incorporating EPR-related laws into their national laws (Xu *et al*., 2021). This can be seen in the speed with which EPR schemes are being introduced in nations like Ethiopia (Kitila & Woldemikael, 2021), India (Garg, 2021), Brazil (de Miranda Ribeiro & Kruglianskas, 2020), and China (Hou *et al*., 2020).

Environmentally friendly features are integrated into the product chain by EPR (Esenduran *et al.,* 2019). However, a lot is unknown about the efficacy of EPR implementation forms and models for Electrical and Electronic Equipment (EEE).This is because all products have different demands due to their characteristics. Therefore, effective implementation of EPR for EEE is an issue that needs resolving. The current works on EPR implementation/deployment models by researchers such as Tasaki *et al*. (2015); Oklahoma (2016) in developed countries have largely focused on electronics, with limited studies on the EPR's system driving factors, as well as practical challenges, in the Ugandan context to achieve sustainable E-waste management. Besides, the E-waste stakeholders are still not involved in EPR practices and inadequately motivated, as well as poorly incentivized (Forti *et al.,* 2020). Against this background, and focusing on electronic products, the study explores the EPR's system driving factors, as well as practical challenges, and suggests how best to implement the EPR system/schemes in the Ugandan context for sustainability of E-waste management.

Literature Review

The Status of WEEE Management in Uganda

According to Pan *et al.* (2022), the amount of E-waste generated globally increased from 53.6 Mt in 2019 (Forti *et al*., 2020) to 57.4 Mt in 2021 (Mt). Furthermore, a surge in the production of e-waste is predicted to reach 74 million tons by 2030. Like in most developing countries, WEEE is collected and recycled predominantly in an informal sector (Secretariat, 2011; Wath *et al.* 2011), Uganda no exception. The unscientific practices typically utilized by unskilled and semi-skilled workers in the informal sector are linked to the harmful nature of WEEE, which poses a serious risk to human health and the environment (Pradhan & Kumar 2014; Bandyopadhyay 2010). According to Forti *et al.*(2020), the E-waste generation is first rising and in Uganda was approximately 0.8 kg per capita in 2019, 1.0 per capita in Tanzania, 0.6 per capita in Rwanda, 0.5 in Burundi, and, 11.5 and 7.1 per capita in Libya and South Africa respectively. On average, the E-waste generation in East Africa is 1.0 per capita. Quite a number of research have estimated the WEEE generation at regional, national, and international levels (Forti *et al.,* 2018; Ismail & Hanafiah, 2019; Sajid *et al.,* 2018). The WEEE in Uganda is relatively at its infancy stage. Similar to most developing countries, in Uganda, there arises difficulty in ascertaining the accuracy of WEEE in terms of data generation, recycling, reuse, and disposal aspects due to solid waste categorization.

Because of its rapidly increasing population, Uganda has one of the fastest-rising electronic markets globally. Electronic information technology (IT) products, primarily electronic electrical equipment (EEE), are comparatively widely used in Uganda (Gillwald *et al.,* 2019; UCC, 2018). Although the study's primary focus is on electronic waste, the Ugandan government is dedicated to the appropriate disposal and recycling of solid waste (Nyeko *et al.,* 2022). It is estimated that 57% of the population own computers with an equal number in the hands of public and private sector organizations amounting to an estimated 7.3 million units

(UNEP, 2011). The National Collection for E-waste was established by the government in 2021 through the National Environment Management Authority. Currently, no special tax incentives have been introduced to encourage the reduction, recycling and reuse of E-waste. Besides, the country has not conducted any proper inventory of WEEE as there no proper available official estimates of the quantities of E-waste generated (Ogenmungu *et al.,* 2022; Jang *et al.,* 2022; Forti *et al.*, 2020). Also, there is no knowledge of any meeting or a symposium organized by a government agency to discuss the Extended Producer Responsibility (EPR) role in the treatment and disposal of electronic waste in Uganda and yet the introductions of EPR practices based on other countries are aimed at addressing the pollution and also achieve waste recycling and reuse of products (Pouikli, 2020).

E-waste management through Extended Producer Responsibility (EPR)

EPR is applied internationally to wide-ranging wastes including electrical and electronic equipment (WEEE), used oils, packaging, batteries, paint containers, tires, and vehicles (OECD, 2016). EPR is a policy or strategy tool that requires manufacturers to manage their end-of-life (EoL) or used products financially and/or physically (Leal Filho *et al*., 2019). According to Xu *et al*. (2021), the concept of environmental policy known as extended producer responsibility (EPR) imposes financial and/or physical obligations on producers for the collection and safe disposal of their post-consumer waste. In other words, the EPR approach gives producers incentives to incorporate environmental considerations into the design and manufacturing of their products, and it also transfers responsibility up the value chain from municipalities to producers (Compagnoni, 2022). This promotes improved material selection, public recycling and material management, and the prevention or reduction of waste at the source. This is consistent with the polluter pays principle and cost internalization (Kunz *et al*., 2018). Environmentally friendly features are integrated into the product chain by the EPR. Dubois, de Graaf and Thieren (2016) highlight five (5) criteria for EPR adequacy in the context of construction and demolition context of waste management, which include control level of the EOL stage, political priorities, environmental scope requiring improvement, prevailing incentives for EOL treatment, and alternative policy instrument availability. Meanwhile, Acree-Guggemos and Horvath (2003) presented three (3) instruments, which include economic, information, and regulatory instruments as criteria for EPR adequacy.

Theoretical Support

Behavioral Reasoning Theory (BRT)

The Behavioral Reasoning Theory (BRT) was applied because it is a wide-ranging theory of behavior that largely explains the motives or reasons underlying and fundamental to human behaviors (Claudy *et al.,* 2015). BRT postulates that behavior may be predicted by their comprehensive motives. BRT is the choice of this study because it accommodates "reasons for" and "against" perfectly marching the EPR policy drivers and its associated obstacles. BRT empowers academics and scholars alike to explore the comparative influence of both 'reasons against' (contributing to challenges, obstacles, or problems) and 'reasons for' (linked to drivers) of an action (Sahu *et al.,* 2020; Dhir *et al.*, 2021). Kim *et al.* (2019); Claudy *et al.* (2015) considered behavioral intents as aligned to a consumer's and citizen's propensity to involve in a behavior, duty, task, or action.

Hypotheses development

EPR Policy Drivers 'Reasons for' and Sustainable E-waste Management

In view of a particular behavior, the supposed 'reasons for' represent drivers or incentives that prompt optimistic insights between customers and generally end-users. The study specifically regards EPR policy drivers as 'reasons for' composed of EPR policy drivers such as economic instruments, administrative instruments, regulatory instruments, and the government's responsibility for managing e-waste, as supported by earlier research (Patil & Ramakrishna, 2020; Zeng *et al.,* 2017; Murthy & Ramakrishna, 2022; Dubois, de Graaf & Thieren, 2016; Shooshtarian *et al.,* 2021; Acree-Guggemos & Horvath, 2003).

Economic Instruments and Sustainability of E-waste Management

Dubois, de Graaf and Thieren (2016); Shooshtarian *et al.,* (2021); Acree-Guggemos and Horvath (2003) all present economic instruments as a criterion for EPR adequacy though in different contexts. Economic instruments are well applied in E-waste management for cost efficiency, especially for cost internalization, that is, the building of E-waste management costs into prices, that will be borne by whoever generates E-waste within the overall waste management system (Dubois, de Graaf and Thieren (2016). This serves to reduce the burden on E-waste managers and policymakers. The OECD suggests some valuable measures and actions upon which economic instruments are suitably assessed that include amongst others, economic efficiency, environmental effectiveness, soft effects, revenue, wider economic benefits, administration and compliance costs, and dynamic effects. According to Zhou *et al.* (2017), a deposit refund scheme is a kind of incentive designed to encourage pre-paid customers to return their end-of-life products to authorized recyclers. Several countries in both developed and developing countries employ advanced recycling charges such as landfill tax, recovery/recycling and collection targets, subsidy / upstream combination tax, virgin material tax, and recycled content standards, as a financing mechanism of EPR. Other charges or fees include advanced recycling fees and a deposit-refund scheme. Subsidies benefits encourage consumers to return their E-waste to formal/or recognized recyclers for planned recycling (Duan *et al,* 2016; Shevchenko *et al.,* 2019; Ramzan *et al.,* 2019).

Kaur & Lin. (2023) emphasizes the importance to incorporate some economic instruments together with the product life-cycle, such as the economic benefits of E-waste products obtained by recyclers. Economic instruments are important because they provide strong incentives for the lessening of waste generation and also encourage electronic waste source separation to ensure the maximization of the reuse and recycling opportunity for the E-waste fraction that has been generated and, besides, cannot be avoided (Zhou *et al.,* 2017; Kumar & Dixit, 2018). The financing of the EPR system in a more effective manner requires a fee designated for it, for instance, eco-levy fee, advance recycling fee, and also environmental fees, which are mostly dependent on regulation. Furthermore, economic instruments make it senseless for governments to assign financial resources for E-waste management arising from the public treasury, to the extent that, self-funding approaches are increasingly becoming more attractive. Thus, we hypothesize that:

H1: Enforcing economic instruments in implementing the EPR approach has a positive influence on sustainable E-waste management outcomes.

Information-based Instrument and Sustainability of E-waste Management
Information-based policy instruments may comprise booklets, flyers, reports, pamphlets, training, websites, advertisements, and portals. Information-based instruments are largely used to promote EPR programs' public knowledge and thus indirectly provide support to them (Murthy & Ramakrishna, 2022). Labeling the components and items, as well as collaborating with customers regarding producer responsibility and waste separation and treatment, and alerting recyclers about the ingredients utilized in products are all well-known possible measures (Patil & Ramakrishna, 2020; Zeng *et al.,* 2017). Toxic compounds are typically not adequately shielded from people and the environment when new items are used, which is something that should be considered throughout the life cycle of the product. The new products require some form of seal for environmental labeling or environmental information labeling (Chung & Zhang, 2011). In addition, a product hazard warning is also required (Bhaskar & Turaga, 2018). Scruggs *et al.,* (2016) emphasize that improving information flow relying on chemicals used in EEE, and how the chemicals are used, handled, and eventually disposed of or recycled, will benefit authorities when enacting meaningful public health and environment regulations (Scruggs *et al.,* 2016).

Bemelmans-Videc *et al.,* (2017) assert that information-based policy instruments comprise government-led efforts at encouraging citizens through the transfer of knowledge, communicating reasoned and balanced arguments, and moral persuasion to achieve a planned policy result. Moreover, all well-thought-about policies and programs, according to (Bemelmans-Videc *et al.,* 2017) is dependent on information that through minimal sense, will make people aware of their existence. Some forms of information may dissuade human behaviors and also interact and communicate information flow in both ways. Hence, we hypothesize that:

H2. Enforcing information instruments in the implementation of the EPR approach has a positive effect on sustainable E-waste management outcomes.

Administrative Instruments and Sustainability of E-waste Management
Administrative instruments through legislation & regulations provide the infrastructure and organization for a waste management system, for instance, prescribing the details of collection systems (Omar & Bullu, 2022). According to Mayanti and Helo (2023), among the policy instruments for EPR, administrative instruments involves actions, commands and controls that involve executing specific tasks as well as banning certain activities. One of the first laws to use EPR as a framework for managing e-waste was the 2003 WEEE Directive from Europe. Producers and manufacturers were required by the WEEE Directive to establish E-waste collection centers, either jointly or individually, in order to collect used electronic and electrical devices from consumers. Under the take-back mandate, each inhabitant from a private household is required to collect four (4) kilograms of E-waste annually, with a recovery rate target, that took effect in 2014 (Bhaskar & Turaga, 2018). The regulation provides effect to international obligations, particularly for waste transboundary movement, for instance under the Basel Convention. The regulation also contributes by setting the parameters for managing specific waste streams, for instance, the EU's revised Directive 2012/19/EU on WEEE. Other economies both developed such as North America and developing economies in Asia also introduced some EPR regulatory forms for E-waste management (Tran & Salhofer, 2018; Wang

et al., 2013; Kahhat *et al.,* 2008; Ogushi & Kandlikar 2007). Regulations limit the manner in which types of products are produced, for instance, restrictions of certain harmful elements in electronic and electrical equipment (the EU's revised Directive 2011/65). Regulatory instrument concerns encompass energy efficiency standards, product bans, and restrictions, standards of a minimum recycled content, disposal bans, and restrictions as well as secondary materials utilization rate requirements (Ibanescu et al., 2018).

Regulations and legislation establish the root for the mandatory EPR programs that require that manufacturers of particular electronic products take back the products at the close of the use stage and eventually take obligation for somewhat waste implications (Bhaskar & Turaga, 2018). Under the China EPR regulation (2011), applicable to five electronic products that include computers, televisions, washing machines, refrigerators, and air conditioners, producers and importers, have the obligation to contribute to a fund based on units of products sold (Wang *et al.,* 2013; Chung & Zhang 2011). The fund is intended to subsidize validly licensed recyclers likely to meet prescribed E-waste treatment standards and also stipulate other stakeholders' responsibilities. When various electronic product types were regulated in South Korea in 2003, the mandatory EPR was implemented. Producers were required to recover obligation rates and recycle specific products at a rate determined by the weighted percentage of the previous year's sales volume (Yoon & Jang 2006). For missing volumes, financial penalties ranging from 115% to 130% of the cost of standard recycling are imposed. Although the impact of the EPR program in South Korea was very effective compared to the previously instituted deposit refund system, the overall collection rates stagnated and remained low relative to other developed European economies (Manomaivibool & Hong, 2014). Meanwhile, Manomaivibool and Vassanadumrongdee (2011) found that the EPR regulation in Thailand requires that producers pay an up-front but fixed product fee where the revenues or proceeds from the fee are then used to fund a buy-back program. The buy-back program is used to subsidize the consumers to facilitate the return of their end-of-life (EoL) electronic/electrical products to designated collection centers (Manomaivibool & Vassanadumrongdee, 2011). This program was found not effective as expected because it does not induce as many customers as possible to return E-waste to the formal recycling system (Manomaivibool &Vassanadumrongdee, 2012). Therefore, we hypothesize that:

H3. Enforcement of administrative instruments in the implementation of the EPR approach has positive effect on sustainable E-waste management outcomes.

EPR Obstacles 'Reasons against' and sustainable E-waste Management

According to Sahu *et al.* (2020), "reasons against" are the factors that can influence people's perceptions and insights about engaging in a specific behavior in a negative way. Ten consumers participated in a pilot study that suggested the traditional barrier cannot affect society (Dhir *et al.*, 2021). As a result, the study took into account four barriers: usage, risk, image, and value. Several obstacles toward the appropriate EPR application schemes for the E-waste stream exist, despite the verified financial benefits associated with schemes (Steenmans, 2019; Maitre-Ekern, 2021). One of the obstacles is the high costs related to the EPR programs' establishment, enforcement, and monitoring requirements (Shooshtarian *et al.,* 2020; Pouikli, 2020; Compagnoni, 2022) due to the gathering of mandatory information (Steenmans, 2019) and changes in product design and technology infrastructure (Pouikli, 2020; Shooshtarian *et al.,* 2020). Besides, establishing regional collection centers for used electronic products requires additional costs in managing the E-waste resources and is in turn subject to numerous regulatory frameworks that come along with different legal requirements (Kunz *et al.,* 2018). Joltreau (2022; Shooshtarian *et al.,* (2020); Pouikli, (2020) rightly state that the increasing public and stakeholders' awareness of EPR aims and benefits is also associated with high costs. Furthermore, Maitre-Ekern, (2021) asserts that meeting the policies of EPR does involve cumbersome practices necessitating data collection and reporting to government authorities (Liu *al.*, 2022; Lorang *et al.,* 2022). Some electronic products have a long product life thus creating a problem to apply EPR principles since it will impact the reusability and recyclability of such products. Acree Guggemos and Horvath (2003) averts that some electronic products previously manufactured were not designed with consideration of EPR requirements.

Another obstacle to the application of EPR principles in the sustainability of E-waste management is the diversity of stakeholder roles in the different stages of electronic product development (Andersen, 2022). This is an obstacle to the consistent or appropriate application of EPR and determining product responsibility in the enforcement of EPR schemes to ensure safety requirements; budget attention, quality issues, time and cost implications, and also, profit (Shooshtarian *et al.,* 2021). Difficulty in the assignment of the manufacturers' responsibility due to lack of labels and also identification of suppliers from the assessment and valuation of the electronic products (Acree Guggemos & Horvath, 2003). Without knowledge of the product producer, the responsibility for the electronic product cannot be appropriately assigned. Health, safety, and hygiene issues are a challenge during the destruction of E-waste (Shooshtarian *et al.,* 2021). The safety and health measures justifiably have higher cost implications that will hinder effective EPR implementation in projects. Thus, the study hypothesizes that:

H4 EPR obstacles in the implementation of the EPR approach have a negative influence on sustainable E-waste management outcomes.

Methodology

Through a questionnaire survey, data were collected conveniently from government employees, at the policy level, knowledgeable in E-waste and environmental-related issues. 602 employees were targeted from the Ministries, Departments and Agencies (MDAs) in the eleven (11) Ugandan cities. The items to measure variables in the study were adopted from the literature. Employees were asked to rate these items on a 5-point Likert-type scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree"), with higher scores indicating the EPR's system driving factors for sustainability of E-waste management. The 5-point Likert scale selection was because it caters to neutral, middle and, extreme interests easier to interpret with minimal bias. Based on a population of 602 employees, a sample size of 232 employees was considered using the sample size determination Table by Krejce and Morgan (1970). The Table by Krejce and Morgan (1970) is widely considered because it simplifies the process of determining the sample size for a known population (Bukhari, 2021).183 (78.9%) usable survey questionnaires were returned and used during analysis. The data were analyzed using the partial least squares structural equation modeling (PLS-SEM) technique, while the hypotheses were statistically assessed using the SmartPLS3.0 software, which was followed by a two-stage analysis approach. The research utilized the bootstrapping technique to ascertain the generated hypotheses, and although data normalization may not be mandatory according to the PLS-SEM methodology, it was carried out. The PLS-SEM method relies on bootstrapping to verify and analyze the significance of the path coefficients.

Presentation and Discussion of Findings

Demographic characteristics of the sample

Table 1 shows that there were, respectively, 98 (54%) and 85 (46%) males and females. This indicates that there are more men than women involved in WEEE collection and recycling. The fact that 33.3% of the 61 respondents were between the ages of 36 and 45 suggests that younger people have greater awareness of e-waste.

Table 1: Participants' demographic profile

Variable	Description	Frequency	Percentage
Gender	Male	98	54
	Female	85	46
Age	20 - 35 years	49	26.7
	36 - 45 years	61	33.3
	46 - 55 years	49	26.7
	56 - 65 years	18	10
	Above 65 years	6	3.3
Level of Education	Diploma and below	33	18
	Undergraduate Degree	102	56
	Postgraduate	48	26

Measurement model assessment

The study's validity and reliability were evaluated by the measurement model, which employed the approach recommended by Hair *et al.* (2013) for the reflective constructs. The results of the measurement model show that the reflective constructs items which are shown in Figure 1 are valid for statistical analysis and have been developed appropriately.

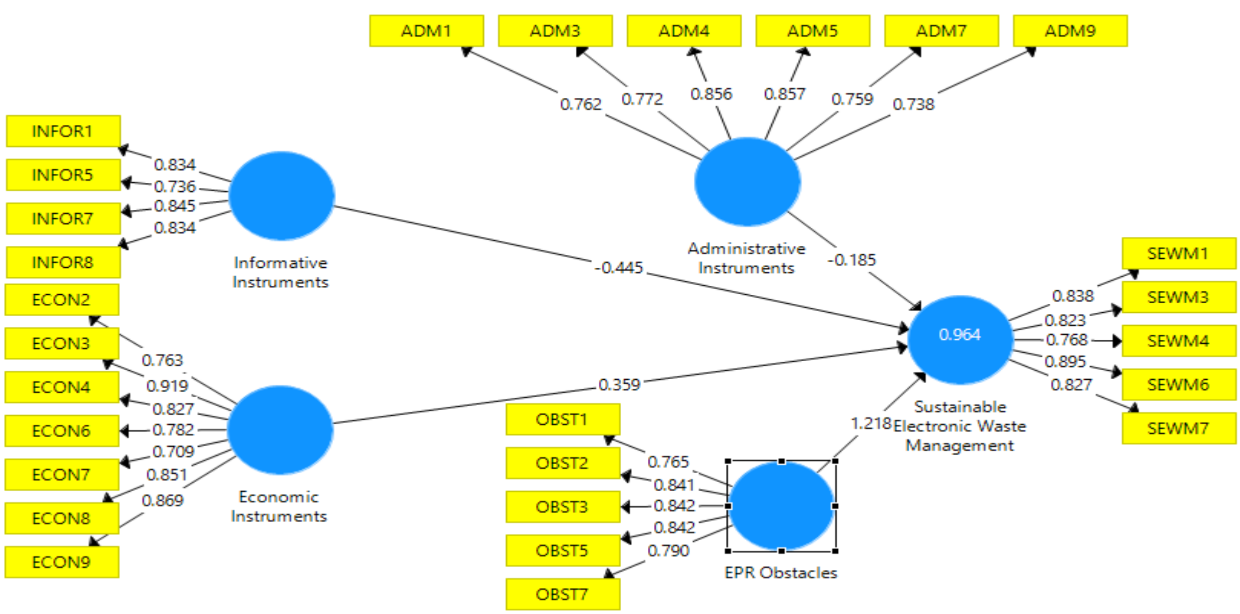

Figure.1: Main Effect Model (PLS Algorithm Assessment)

The R-squared (R^2) value is 0.964, as indicated in Figure 1 above, show that all the variables, for instance, administrative instruments, economic instruments, informative instruments, and the variable EPR obstacles, explain 96.4% variance in sustainable electronic waste management. This implies that only 3.6% is attributed to other factors not included in this study.
Vinzi *et al.,* (2010) state that the average variance extracted (AVE) and composite reliability (CR) values of the constructs should be greater than 0.5. Hair *et al.,* (2014) aver that whenever the AVE's problem occurs, the items with fewer loadings must be discarded. For example, ADM2, 6, and 8 were discarded as is the case with other variables. Based on the results, the AVE's values for all the constructs were more than 0.5 (for administrative instruments, 0.627; EPR obstacles, 0.667; economic instruments, 0.672; informative instruments, 0.662; and sustainable electronic waste management, 0.691).

Table 2: Measurement Model

Model constructs/ references	Measurement items	Loadings	VIF	CA	CR	AVE
E-waste Administrative Instruments (Dubois, de Graaf & Thieren, 2016; Shooshtarian *et al.,* 2021; Acree-Guggemos & Horvath, 2003; Bemelmans-Videc *et al.,* 2017)	**ADM1:** *I believe the electronic product take-back mandate makes it mandatory for retailers and manufacturers to take back E-waste products.*	0.762	1.760	0.880	0.910	
	ADM3: *I believe the electronic product recycling rate targets make it mandatory for retailers and manufacturers to set specific recycling targets.*	0.772	2.429			
	ADM4: *I believe it should be mandatory for retailers to take-back old electronic goods in exchange for new products.*	0.856	2.841			
	ADM5: *I believe it should be mandatory for manufacturers to accept old electronic products from retailers and organize for their transportation and recycling.*	0.857	3.169			
	ADM7: *I believe a strict E-waste recovery rate and recycling targets are required in our country's E-waste management regulation.*	0.759	2.248			
	ADM9: *Management of E-waste must be understood as a priority by all stakeholders through awareness and education, to encourage waste minimization through waste recycling.*	0.738	2.091			
E-waste Economic Instruments (Dubois, de Graaf & Thieren, 2016; Shooshtarian *et al.,* 2021; Acree-Guggemos & Horvath, 2003; Bemelmans-Videc *et al.,* 2017)	**ECON2:** *I believe by the government raising the prices of some environmentally significant electronic products, through product tax reduced E-waste generation and consumption.*	0763	2.313	0.918	0.934	0.672
	ECON3: *I believe consumers should be exempted from paying recycling costs to promote the utilization of resources in an effective manner.*	0.919	4.979			
	ECON4: *I believe refunding deposit funds initially taxed on an electronic product, upon consumers returning reusable and*	0.827	2.558			

	recyclable electronic products should be promoted through a public-private partnership.					
	ECON6: *I believe it is important for the producers to pay advanced deposit fees to cover the recycling cost based on the volume of electronic products imported during the previous year.*	0.782	2.173			
	ECON7: *I believe to reduce the amount of E-waste generated, the government should provide incentives for households based on the quantity of waste collected.*	0.709	2.001			
	ECON8: *The environmental handling charge/fee should be used to pay incentives to the authorized stakeholders such as collectors, recyclers, and transporters for every volume of E-waste transported.*	0.851	3.063			
	ECON9: *I believe financial resources to cover the cost of collection and recycling of E-waste is secured by means of the advanced recycling fee (ARF) as tax, charged on all new electronic products.*	0.869	4.128			
E-waste Informative Instruments (Dubois, de Graaf & Thieren, 2016; Shooshtarian *et al.,* 2021; Acree-Guggemos & Horvath, 2003; Bemelmans-Videc *et al.,* 2017)	**INFOR1:** *It should be mandatory for importers or manufacturers under the Extended Producer Responsibility (EPR) scheme to register with an environmental agency in order to pay recycling fees for their electronic products.*	0.834	2.173	0.831	0.886	0.662
	INFOR5: *It should be mandatory for importers or manufacturers under the EPR scheme to report the amount/volume of electronic products imported and sold in the country.*	0.736	1.836			
	It should be mandatory for importers or manufacturers to properly label all recyclable electronic products before importation into the country.	0.845	1.932			
	INFOR8: *It should be mandatory for importers or manufacturers to display information regarding accepted E-waste returned by consumers.*	0.834	1.903			
	OBST1: Citizens do not follow any waste-minimizing activities.	0.765	1.730	0.875	0.909	0.667
	OBST2: The diversity of stakeholder roles in the different stages of electronic product development hinders the determination of product responsibility in the enforcement of EPR schemes.	0.841	2.327			
	OBST3: The electronic products previously manufactured were not designed with consideration of EPR requirements.	0.842	2.351			

	OBST5: The application of EPR application schemes is costly in terms of enforcement and monitoring.	0.842	2.268			
	OBST7: Difficulty in the assignment of the manufacturers' role due to lack of labels.	0.790	1.883			
Sustainable E-waste Management Practices (Echegaray and Hansstein, 2017; Tiep et al., 2015; Afroz *et al.,* 2012; and Akhtar *et al.,* 2014)	**SEWM1:** Results in increased resource utilization goals.	0.838	2.458	0.888	0.892	0.691
	SEWM3: Leads to improved environmental protection.	0.823	2.643			
	SEWM4: Lessens the risk of contaminating the environment.	0.768	2.260			
	SEWM6: Results in improved safety and health.	0.895	3.417			
	SEWM7: Results in improved E-waste quality.	0.827	2.544			

Multicollinearity

Prior to assessing the structural model using PLS-SEM, the researchers look for collinearity issues (Ringle *et al.,* 2020). As a general guideline for assessing multicollinearity problems, Hair *et al.* (2021) permit VIF values of less than 10. However, the highest level of VIF given by Ringle *et al.* (2020) is five (5). Three of the twenty-three values in our study, as indicated in Table 2 above, fall between 5.8 and 6.0. Consequently, VIF<10 is also acceptable according to the standards set forth by Hair et al. (2021), indicating that the model is free of the common bias method. Results of discriminant validity using the (Fornel & Larcker, 1981) method are shown in Table 3. 0.978, 0.965, 0.925, 0.868, and 0.831 are all larger than other diagonal values.

Table 3: Discriminant validity(Fornell-Larker)

	ADM	OBST	ECON	INFORM	SEWM
Administrative Instruments	0.978				
EPR Obstacles	0.880	0.965			
Economic Instruments	0.853	0.949	0.925		
Informative Instruments	0.838	0.926	0.869	0.868	
Sustainable Electronic Waste Management	0.792	0.817	0.820	0.843	0.831

Structural model assessment

The inner model/structural model assessment is used to evaluate the direct relationships. The structural model is evaluated by calculating the path coefficient and t-values. The acceptance of a proposed hypothesis is indicated by a t-value of 1.64 or higher. All four (4) of the proposed direct relationship hypotheses received support. The results of the direct effects hypotheses' general structural-model assessment are displayed in Figure 2.

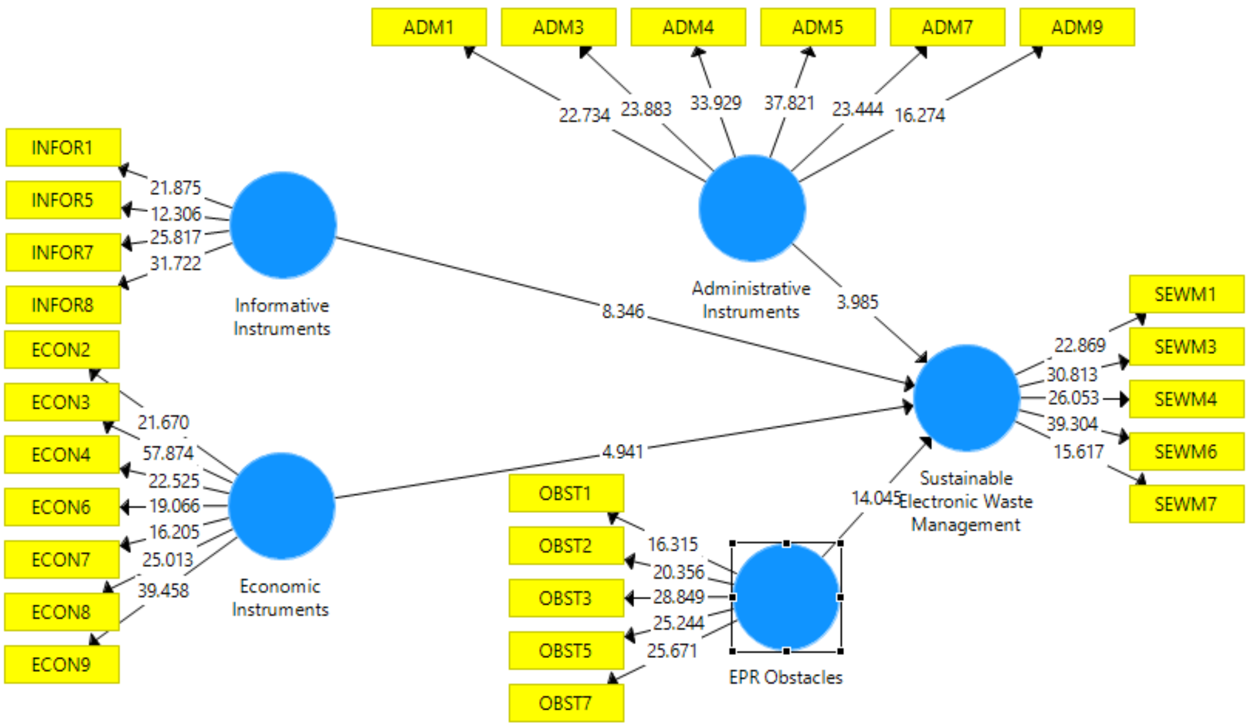

Figure 2: Structural Model Assessment

Table 4: Direct Relationships (Structural Model Assessment) – Path Coefficient

Hypothesis	Relationships	Std. Beta	Std. Error	T value	P value	Decision
H1	ECON -> SEWM	0.359	0.345	4.941	<0.001	Supported
H2	INFOR -> SEWM	-0.445	-0.446	8.346	<0.001	Supported
H3	ADM -> SEWM	-0.185	-0.177	3.985	<0.001	Supported
H4	OBST -> SEWM	0.218	1.226	14.045	<0.001	Supported

The outcome in Table 4 reveals the acceptance of the hypothesis (H1) that enforcement of economic instruments positively predicts the intention to realize sustainable E-waste management. It indicates that the enforcement of economic instruments in implementing the EPR approach towards sustainable E-waste management outcomes is supported. The hypothesis (H2) is also supported, as depicted that enforcement of economic instruments has a significant favorable effect on sustainable E-waste management. Likewise, hypothesis (H3) also indicates acceptance that enforcement of administrative instruments leads to sustainable E-waste management. Furthermore, the results show that obstacles in the E-waste cycle has a significant negative influence on sustainable E-waste management.

Discussion

Prior studies that employed the BRT established the 'reasons for' were generally positively related to attitude, intentions, as well as behaviour (Westaby *et al.,* 2010; Claudy *et al.,* 2015; Tandon *et al.,* 2020). Also, based on the Behavioral Reasoning Theory, H1, H2 and H3 analyzed positive relationships between 'reasons for' and sustainable E-waste management outcomes whereas H4 analyzed negative relationships between 'reasons against' and sustainable

E-waste management outcomes. In reference to H1, the result of testing the ECON variable with SEWM resulted in an estimated value of 0.359 with a t-value of 4.941 and a probability of $P<0.001<0.05$. From these results, it can be said that this research is statistically supported by empirical results. That is, appropriate enforcement of the economical instruments leads to sustainable E-waste management. This is consistent with (Dubois, de Graaf and Thieren (2016); Shooshtarian *et al.* (2021); Acree-Guggemos and Horvath, 2003). This shows that enforcement of economic instruments in implementing the EPR approach results in positive sustainable E-waste management outcomes. For instance, raising the prices of some environmentally significant electronic products through product tax and advanced recycling fee (ARF) charged on all new electronic products, will reduce E-waste generation and consumption as it reduces the appetite to buy new electronic products. This is in congruence with (Zhou *et al.,* 2017). Further, payment of advanced deposit fees to cover the recycling cost based on the volume of electronic products imported during the previous year, and, the provision of incentives for households based on the quantity of waste collected will ultimately reduce the amount of E-waste generated (Islam, 2018, Lee, 2018; Ramzan *et al.,* 2019; Zhu *et al.,* 2017; Kumar & Dixit, 2018). Furthermore, the environmental handling charge/fee as an incentive payment to the authorized stakeholders for every volume of E-waste transported reduces the amount of E-waste generated (Ramzan *et al.,* 2019; Zhou *et al.,* 2017).

The effect of INFOR on SEWM is -0.445 with t value of 8.346 and a probability of $P<0.001 <0.05$. The results show that the effect of INFOR is more dominant that ECON. This finding advises that enforcement of informative instruments in implementing the EPR approach results in positive sustainable E-waste management outcomes. This is consistent according to a study by (Murthy & Ramakrishna, 2022; Scruggs *et al.,* 2016). In addition, mandatory registration of the importers/manufacturers with an environmental agency under the EPR scheme to pay electronic recycling fees and restriction on the volume of electronic products imported and sold in the country results in a reduction in toxic waste thereby protecting the environment and human life (Patil & Ramakrishna, 2020; Zeng *et al.,* 2017; Murthy & Ramakrishna, 2022; Scruggs *et al.,* 2016). Also, in line with the findings, (Bhaskar & Turaga, 2018; Chung & Zhang, 2011) found that mandatory labeling of all recyclable electronic products by importers, display of information by importers regarding E-waste collection points for E-waste, and accepted E-waste returned by consumers ensures improved quality of E-waste and safety and health standards.

Similarly, the effect of ADM on SEWM is -0.185 with t value 3.985, is supported. Consistent with (Bhaskar & Turaga, 2018; Tran & Salhofer, 2016; Wang *et al.,* 2013) the study found enforcement of administrative instruments to be positively associated with sustainable E-waste management outcomes. The study suggests that the development of capacity for monitoring recovery and target rates and the mandatory acceptance of old electronic products from retailers are some of the administrative instruments with proper enforcement that lead to the achievement of resource utilization goals, and environmental protection. This is also in line with (Kahhat *et al.,* 2008; Ogushi & Kandlikar 2007; Wang *et al.,* 2013; Chung & Zhang 2011).

Likewise, the influence of Obstacle to e-waste (OBST) variable on Sustainable E-waste Management (SEWM) is 0.218 with t value of 14.045, is supported, thus consistent with Andersen (2022), Shooshtarian *et al.* (2021), Lorang *et al.* (2022) who found a significant link in the context of E-waste. The current study results suggest 'reasons against' play in driving sustainable E-waste management outcomes. This is in congruent with Sahu *et al.*(2020), Dhir *et al.* (2021), Steenmans (2019), Maitre-Ekern (2021) who suggest that to achieve sustainable E-waste management outcomes, citizens should participate in waste-minimizing activities and the role of diverse stakeholders should be integrated the different stages of electronic product development. Non-participation in E-waste activities have impacted negatively on sustainable E-waste management outcome (Shooshtarian *et al.,* 2020; Pouikli, 2020; Liu *al.*, 2022; Lorang *et al.,* 2022). Also, as hinderance to sustainable E-waste management outcome, the application schemes of EPR are costly in terms of enforcement and monitoring (Pouikli, 2020; Compagnoni, 2022). Besides, the electronic products previously manufactured were not designed with consideration of EPR requirements, and coupled with difficulty in the assignment of the manufacturers' role due to lack of labels. This impacts negatively on sustainable E-waste management (Shooshtarian *et al.,* 2020; Pouikli, 2020; Shooshtarian *et al.,* 2020; Kunz *et al.,* 2018) and also hinders the determination of product responsibility in the enforcement of EPR schemes (Joltreau, 2022) as found in the current study.

Conclusion, Recommendations and Policy Implications

Based on the Behavioral Reasoning Theory-(BRT), the study contributes to the literature by examining the drivers of successful EPR implementation. Practically, and with keen interest on specific recycling targets, clear electronic take-back mandate, and strict E-waste recovery rate, sustainable E-waste management outcomes can be realized. Besides, government can develop capacity for monitoring and enforcement of instruments all levels to enable cost recovery from E-waste. Also, the government will have to provide incentives for households based on the quantity of waste collected. Further, the environmental handling charge/fee and other fees can be used to pay incentives to the authorized stakeholders such as collectors, recyclers, and transporters for every volume of E-waste transported to reduce on the quantity of E-waste generated. Furthermore, it will be mandatory for importers or manufacturers under the Extended Producer Responsibility (EPR) scheme to register with an environmental agency and pay recycling fees for their electronic products, label all recyclable product and also report the amount/volume of electronic products imported and sold in the country on a regularly. All, in all, there is a need for regulatory frameworks that adequately supports EPR schemes in Uganda. Thus, decision-makers will have to steer a policy direction towards a sustainable E-waste management outcome based on the EPR scheme.

Findings show that establishing the economic, administrative and informative instruments and its proper enforcement in implementing the EPR approach results in sustainable E-waste management outcomes. The government should encourage concerted stakeholder partnerships, establish a sustainable E-waste management system, as well as fast-track the implementation of the EPR model that works for Uganda. However, implementation of the EPR scheme has several obstacles that include difficulty in the assignment of the manufacturers' role due to lack of labels, and high costs in enforcement and monitoring of EPR schemes.

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