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**REVERSE LOGISTICS SYMBIOSIS OF E-WASTE RECYCLING
SYSTEM: AN INVESTIGATION ON STAKEHOLDER'S
ENGAGEMENT AND HOUSEHOLD BEHAVIOUR**



**Thesis Submitted to
Othman Yeop Abdullah Graduate School of Business,
Universiti Utara Malaysia,
in Fulfilment of the Requirement for the Degree of Doctor of Philosophy**



Kolej Perniagaan
(College of Business)
Universiti Utara Malaysia

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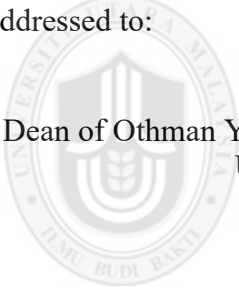
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ABSTRACT

The global shift toward digitalization has led to the widespread electronification, accelerated by expanding internet connectivity across both urban and remote regions. As electronic devices become increasingly integral, the volume of electronic waste (e-waste) continues to rise at an alarming rate. In 2022, global e-waste generation reached 62 megatonnes (Mt), with less than 25% properly managed through sustainable channels. The improper disposal of e-waste, which often ends up in landfills, poses serious threats to environmental health and highlights systemic weaknesses in existing waste management systems. This study addresses the urgent need for a more integrated and collaborative approach to e-waste management by introducing the concept of reverse logistics symbiosis. The core problem lies in the fragmented engagement between key actors, especially households and waste management authorities, which limits the effectiveness of reverse logistics systems. This study aims to examine stakeholder interdependence in household e-waste recycling practices and assess the role of symbiotic relationships in driving participation. This study employs an explanatory sequential mixed-methods design, using surveys and interviews to investigate household behaviours across urban, suburban, and rural subclusters in Malaysia. This research introduces and empirically validates the Symbiosis Effect Framework, capturing the mutual dependencies among actors in the reverse flow of e-waste. Findings indicate that fostering symbiosis through the integration of Household E-waste Recycling Systems (HERS) and Household E-waste Recycling Behaviour (HERB) significantly boosts household recycling participation. Situational factors such as convenience, engagement, advertising, education, and policies, and personal factors including attitude, knowledge, experience, awareness, and psychological ownership were found to directly influence household participation. Additionally, the relationship between HERS and HERB was moderated by demographic variables such as residential subclusters, age, and gender, underscoring the importance of context-sensitive strategies. The findings provide actionable insights for policymakers, manufacturers, and waste agencies to co-develop sustainable and socially inclusive e-waste solutions.

Keywords: Recycling; Reverse logistics; E-waste management; Household waste

ABSTRAK

Peralihan global ke arah pendigitalan telah mendorong peningkatan penggunaan peranti elektronik secara meluas, disebabkan peluasan sambungan internet di kawasan bandar dan luar bandar. Apabila peranti elektronik menjadi semakin penting, jumlah sisa elektronik turut meningkat dengan ketara. Pada tahun 2022, penghasilan elektronik global mencecah 62 megatan (Mt), dengan kurang 25% diuruskan dengan baik melalui saluran yang mampan. Pelupusan sisa elektronik yang tidak sempurna, kebanyakannya berakhir di tapak pelupusan, membawa risiko besar terhadap kelestarian alam sekitar dan menyerlahkan kelemahan sistem pengurusan sisa elektronik semasa. Kajian ini menangani keperluan mendesak terhadap pendekatan pengurusan sisa elektronik yang lebih menyeluruh dengan memperkenalkan konsep simbiosis logistik secara berbalik. Masalah utama adalah keterlibatan yang terpisah antara pelaku utama, khususnya isi rumah dan pihak berkuasa pengurusan sisa, yang mengehadkan keberkesanan sistem logistik berbalik. Kajian ini bertujuan menilai kebergantungan antara pihak berkepentingan dalam amalan kitar semula sisa elektronik isi rumah dan peranan hubungan simbiotik dalam menggalakkan penyertaan. Kajian ini menggunakan reka bentuk kaedah campuran berurutan penjelasan dengan mengaplikasikan tinjauan dan temu bual bagi menyelidik tingkah laku isi rumah merentas subkluster bandar, pinggir bandar dan luar bandar di Malaysia. Kajian ini memperkenalkan dan mengesahkan secara empirikal Rangka Kerja Kesan Simbiosis yang menggambarkan kebergantungan bersama dalam aliran pengurusan sisa elektronik secara berbalik. Dapatan kajian menunjukkan simbiosis menerusi integrasi Sistem Kitar Semula Sisa Elektronik (HERS) dan Tingkah Laku Kitar Semula Isi Rumah (HERB) meningkatkan penyertaan isi rumah dalam aktiviti kitar semula secara signifikan. Faktor situasi seperti kemudahan, penglibatan, iklan, pendidikan dan dasar serta faktor peribadi seperti sikap, pengetahuan, kesedaran dan pemilikan psikologi turut mempengaruhi penyertaan kitar semula. Selain itu, hubungan antara kedua faktor ini juga dipengaruhi oleh faktor demografi seperti subkluster kediaman, umur dan jantina. Kajian ini memberi panduan strategik kepada pembuat dasar, pengeluar dan agensi pengurusan sisa untuk bersama-sama membentuk penyelesaian sisa elektronik secara mampan dan inklusif.

Kata kunci: Kitar semula; Logistik berbalik; Pengurusan sisa elektronik; Sisa isi rumah

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List of Abbreviations

GCC	Green City Concept
MSW	Municipal Solid Waste
e-waste	Electronic Waste
EEE	Electrical and Electronics Equipment
IT	Information Technology
CPU	Central Processing Unit
ISWA	International Solid Waste Association
MCMC	Malaysian Multimedia and Communications Commission
DOE	Department of the Environment
HERS	Household E-waste Recycling Systems
HERB	Household E-waste Recycling Behaviour
SWCorp	Solid Waste and Public Cleansing Management Corporation
NGO	Non-governmental Organization
EPR	Extended Producer Responsibility
SCM	Supply Chain Management
EOL	End-of-Life
PLC	Product Life Cycle
ICT	Information and Communication Technology
EU	European Union
3R	Reduce, Reuse, Recycle
ELV	End-of-Life Vehicles
IMF	International Monetary Fund
TBP	Take Back Program
MNRE	Ministry of Natural Resources and Environment
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
SPSS	Focus Group Discussion
FGD	Statistical Package for the Social Sciences
AMOS	Analysis of Moment Structures
SEM	structural equation modelling
CFA	Confirmatory Factor Analysis
EFA	Exploratory Factor Analysis

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Efficient logistical activities, particularly those involving reverse logistics, play a crucial role in supporting the transition toward sustainable urban environments. The Green City Concept (GCC) is the newest idea for tackling dispersed cities' issues and for helping cities become sustainable, scattered, and more liveable (Brilhante and Klaas, 2018). Within the framework of GCC, reverse logistics has emerged as a vital operational component that enhances urban liveability and environmental performance since it involves issues primarily related to the design of networks for recycling, reusing, and remanufacturing, as well as collection planning that makes the city more sustainable (Agrawal et al., 2015).

The aims of these three networks are congruent with the overarching purpose of sustainable waste management, which is to restrict the amount of natural resources that are used up with the purpose of reducing the quantity of waste that is created. Reverse logistics constitutes an integral aspect of sustainable waste management, facilitating the appropriate treatment and disposal of waste in a manner that aligns with social acceptability (Coelho and Mateus, 2017). Recycling, reusing, and cutting down on the quantity of materials needed are all aspects of the process known as reverse logistics, which allows businesses to become more environmentally responsible.

A more comprehensive understanding of reverse logistics takes into account the reduction of materials in the forward system in such a manner that less material is returned, it is feasible to reuse materials, and it is easier to recycle material (Alnuwairan, 2021). According to Muhammad et al. (2020), an organization is able to maintain a presence in the market as a result of their conversion procedures because of the advanced processes existing in reverse logistics. The objective of reverse logistics is to either recover the value of the raw materials used in manufacturing or facilitate the ethical disposal of the output (Guarnieri et al., 2016). Stakeholders in the waste management industry may improve their economic growth and overall sustainable development by managing their waste operations using conversion techniques. This will thus help to reduce the amount of waste produced.

Sustainable waste management is critical to reaching the GCC. An efficient waste management systems help cities improve their waste management planning and operations by implementing sustainable and affordable solutions that are compatible with local conditions and ensuring the appropriate waste collection and disposal to achieve GCC. Many researchers have studied the concepts of green and smart cities and have found commonalities in terms of context and mutual influence on development. As per Table 1.1, almost all parts of the ideas behind smart cities and environmentally conscious cities have mutual interests (Helfert et al., 2015; Martin et al., 2015; Polzonetti and Sagratella, 2019; Rahul et al., 2018).

Table 1.1
The element of innovative and green city concepts

Green City Sectors	Smart City Dimensions
Renewable energy	Ability to adapt to climate change from the perspective of intelligence-based surveillance systems.
Green buildings	Environmental quality as well as dependability improvement utilizing digital technology.
Sustainable transport	Environmental improvement utilizing digital technology.
Water management	Ability to use natural resources in an efficient manner.
Waste management	Provide protection and conservation of the urban ecosystems.
Land management	Using digital technology to reduce dynamics and response times for emergencies.

Source: Mingaleva, Vukovic, Volkova and Salimova (2020)

Waste management is one of the fundamental parts of both the smart cities idea and the green cities concept, as shown in Table 1.1. This is done to safeguard and conserve the urban ecosystem. Therefore, municipal authorities must develop the correct sustainable waste management systems to develop a green city concept (Brilhante and Klaas, 2018). The implementation of the GCC has to include a suitable and sustainable waste management or disposal system in ensuring the minimization of the urban waste in order to transform cities to green cities (Mingaleva et al., 2020). A proper development of sustainable waste management for green cities can help to minimize the composition of waste produced in landfills, such as Municipal Solid Waste (MSW) and domestic and commercial waste (Haley and Guisti, 2018).

Waste in the urban cities are generated from many sources which mainly includes residential waste, industrial waste and electronic waste (e-waste) (Morris, 2016). E-waste is a discarded electrical waste which contains the technological items for example, computers, screens, printers, mobile phones, machines and etc. This type of waste is usually disposed of after a few years, as advances in technology make them obsolete. In recent decades, advancements in the global economy and technology have resulted in the generation of significant quantities of e-waste. The management of waste in both developed and developing countries has been notably challenged by the continuously rising volume of e-waste.

The increase in e-waste can be attributed to the rapid pace of technological progress and the ongoing reduction in the average lifespan of products (Baldé et al., 2017). Forti et al. (2020), report that global e-waste generation reached approximately 53.6 Megatonnes (Mt) in 2019, with only 17.4% of this total being officially documented as collected and properly recycled through designated recycling processes. Rautela et al. (2021) indicate that in 2019, Asia experienced the highest levels of e-waste, producing 24.9 Mt, while the collection and recycling rate remained below 12%. Moreover, the management of household e-waste in Asia remains inadequately addressed, which may contribute to the inefficacy of recycling operations in the absence of robust frameworks for e-waste management (Ilankoon et al., 2018). The generation of e-waste in Asia has commenced a significant upward trend.

According to studies conducted by academics, hazardous metals that are discharged into the environment as a result of e-waste have a detrimental effect on individuals and the ecosystem. Lead, cadmium, beryllium, and brominated flame retardants are among the potentially hazardous components found in e-waste (Schumacher, 2016). Recycling and extraction of valuable commodities from e-waste may pose a serious health danger to people and the environment, but it is still carried out as a form of unregulated recycling. Everything that remains after the value is extracted, goes to the landfill.

The possible adverse effects of growing fast usage of digital gadgets are not known to most individuals (Anderson and Rainie, 2018). Many of these devices contain toxic substances, such as heavy metals and harmful chemicals, which can leach into the soil and water, leading to long-term contamination. Compared to regular municipal waste, e-waste presents a greater threat to both ecosystems and human health, as exposure to these hazardous materials can cause serious health issues (Schumacher, 2016). As a result, e-waste present a considerable challenge because of the existence of these contaminants.

Implementing effective e-waste management systems is essential for the successful reuse, recycling, and value recovery of e-waste. Baldé et al. (2017) reported that only 20% (8.9 Mt) of the e-waste generated in 2016 was properly collected and recycled. This highlights the inefficiencies in current e-waste management systems, especially regarding household e-waste, a concern that is particularly relevant in Malaysia.

Considering the significance of systems for waste management is crucial for enhancing sustainability and the overall economics. Collaboration among all stakeholders in the e-waste logistics chain ranging from consumers (households) to both public and private institutions are crucial for ensuring the effectiveness and success of e-waste management. By working together, these groups can streamline processes, improve recycling rates, and implement sustainable practices that benefit both the environment and society.

The idea of reverse logistics has been applied and has significantly altered the operation of e-waste management. Reverse logistics may be quite useful, especially if all of the associated procedures are well-managed and make use of cutting-edge approaches to common problems (Muhammad et al., 2020). Recently, the field of reverse logistics involving the waste management has received widespread interest and dedication from those concerned about environmental impact (Muhammad et al., 2020). In light of its potential, reverse logistics is increasingly included in the environmental objectives of both governments and businesses (Guarnieri et al., 2016). As a result, researchers in a wide range of fields have come together to study e-waste management through the lens of reverse logistics, with the goal of better understanding the field's intricacies and creating effective tools and solutions.

Under the Environmental Quality (Scheduled Wastes) Regulations 2005 in Malaysia, e-waste falls within the category of Scheduled Waste as defined by Code SW110, First Schedule. On the basis of the source of its creation, e-waste is often divided into two categories: industrial e-waste and domestic e-waste. According to a report that was published by The Directive 2012/19/EU of the European Parliament and the Council of the European Union (2012), e-waste falls into ten distinct types.

Each of the ten types of e-waste has a distinctive lifespan profile, which means that every classification generates a distinct quantity of waste and has a unique commercial value, and possible environmental and health implications if recycled incorrectly. As a result, the collecting and logistics operations, as well as recycling technologies, varies for each category, much as customers' attitudes toward disposing of electronic and electrical items were varied.

Home appliances, both huge and small, Information Technology (IT) and telecommunications devices, consumer devices, lighting equipment, electronics and electrical tools, electrical toys and gadgets, recreational and sports equipment, medical instruments, monitoring and surveillance instruments, and automatic dispensers are the various types of equipment that fall under the overarching concept e-waste. Table 1.2 provides a detailed overview of ten distinct categories of electrical and electronic waste, accompanied by examples of the specific types of equipment included within each category.

Table 1.2
The categories of e-waste and example of the devices

E-waste Categories	Waste Description
Household Appliances	Large Household Appliances Refrigerators, washers and dryers, microwaves, air conditioning units, radiators and etc.
	Small Household Appliances Vacuum cleaners, appliances for sewing, hair dryers, toasters, water dispenser, electric cooking appliances and etc.
IT and Telecommunication Equipment	Personal computers [inclusion of Central Processing Unit (CPU) mouse, keyboard etc.], printers units, laptops, mobile phones and etc.
Consumer Equipment	Radios, televisions set, video cameras, audio sets, musical instruments and etc.
Lighting Equipment	Fluorescent lamps and other controlling lighting equipment with exception of filament bulbs.
Electrical Tools	Electrical and electronic equipment or tools for garage work (nailing, screwing, sawing, welding or any equivalent usage), electrical and electronic tools for gardening (mowing or similar use) and etc.
Electrical toys, Recreational and Sports Equipment	Computer and videos games, machines, electric or electronic sporting machineries, electrical locomotives or motor racing sets and etc.
Medical Equipment	Radiotherapy equipment, laboratory equipment, freezers, appliances for detecting, monitoring, alleviating illness, damage or impairment etc.
Monitoring and Surveillance Instruments	Heat controllers, smoke detectors, and other monitoring devices and control systems.
Automatic Dispensers	Beverage dispensers, vending machines and any other appliances with automatic product delivery.

Source: The Directive 2012/19/EU of the European Parliament and the Council of the European Union (2012)

E-waste has been an environmental issue parallel with the increasing of human population around the globe (Haron et al., 2018; Senawi and Sheau-Ting, 2016). Due to fast technological developments, greater technical usage and the resulting decrease in the lifetime of electric and electronic devices the worrisome problem of e-waste manufacturing and production continues to become a major issue. As being predicted by International Solid Waste Association (ISWA), the worldwide e-waste products will rise up to 74.7 Mt, a total of 16.4% of increment in nine years. E-waste creates environmental and health responsibilities for hazardous substances contained in many items such as lead, arsenic, chromium, dioxins, etc. (Park et al., 2017). As a result, the quantity of waste produced each year is continuously growing and this phenomenon is now regarded as one of the most significant issues pertaining to waste treatment and the environment in the twenty-first century.

This alarming trend has also been seen in Malaysia as Malaysia is a rapidly developing country with current total population of 32.7 million people had already contributed up to 364 kiloton (kt) of e-waste in 2019 (The Global E-waste, 2019). In addition, the Malaysian Multimedia and Communications Commission (MCMC) (2020) stated that Malaysia showed an increment in the level of e-waste produced at 39.7% annually (Shaharudin et al., 2020). In 2016, Malaysia's e-waste production was equivalent to 1.2 million tonnes, according to a list of waste generation in Malaysia conducted by the Malaysian Ministry of the Environment in collaboration with Japan International Cooperation Agency and it is expected to reach 2.4 million tons in 2025 (Masrom, 2019). The amount of e-waste generated by population growth and development continues to grow, with less than 5% recycled waste (Weber, 2017).

Figure 1.1 illustrates the percentage of Malaysian households with access to various technological appliances between 2015 and 2020, highlighting a consistently high and increasing trend in ownership, particularly for mobile phones (above 97%) and televisions (above 98%). Usage of smart TVs and computers or laptops also shows notable growth, while fixed-line telephone usage has declined steadily. This widespread adoption of electronic devices reflects the nation's digital advancement but simultaneously raises significant concerns regarding the potential rise in e-waste generation. Without proper reverse logistics systems and sustainable e-waste management practices, the increasing ownership of these devices may contribute to improper disposal, leading to environmental degradation and public health risks. The data underscores the urgent need to strengthen policy frameworks and stakeholder engagement in managing Malaysia's growing e-waste footprint.

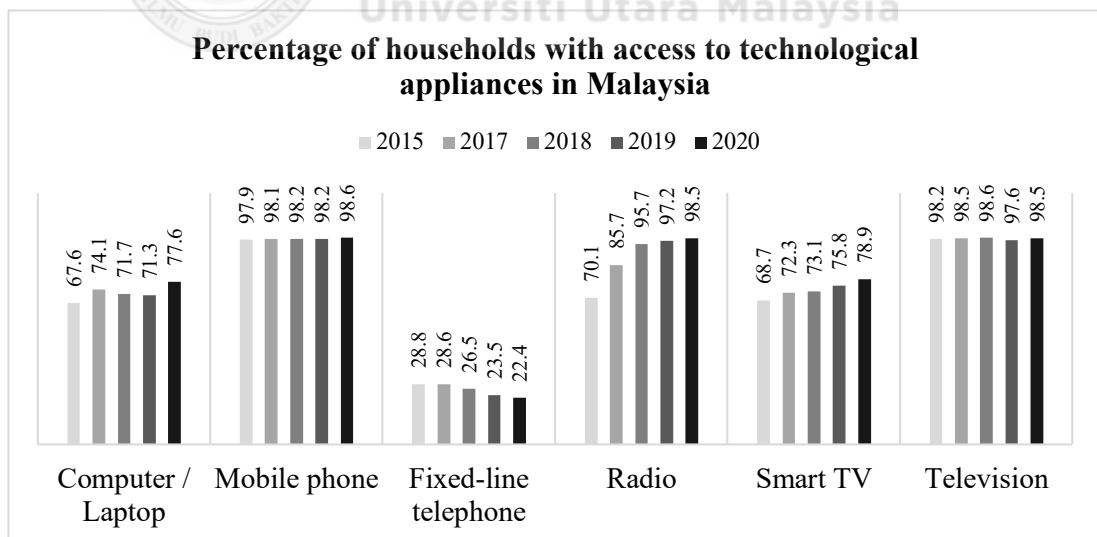


Figure 1.1
Percentage of households with access to technological appliances in Malaysia, 2015 – 2020

Source: Department of Statistics Malaysia (2021)

The Department of the Environment (DOE), the regulatory body responsible for national environmental protection for a sustainable future, provides only simple procedures for general e-waste recycling (Jayaraman et al., 2019). Currently, a complete recycling framework pertaining to the e-waste management is still undiscovered and there is no system developed in order to gather and properly dispose of scrap pieces of electronic and electrical devices coming from private residential areas (Weber, 2017).

This important problem not only requires proper management and effective solutions from the authorities and stakeholders, but also have to be tackle from the main cause. According to the DOE in 2017, only about 25% of the country's e-waste is properly managed, while the rest is sent to landfills, resulting in a staggering cost of approximately RM 3 billion. This highlights the urgent need for improved recycling practices to reduce environmental impact and associated costs. By taking part in recycling programmes for e-waste, residents of Malaysia may significantly cut down on the country's mountainous accumulation of e-waste (Lim, 2019).

The two major participants involves in household recycling systems are householders and stakeholders (A-Jalil et al., 2014). Considering the significant risks to both the environment and human health posed by improper e-waste management, this study aims to identify the key factors that influence householders' willingness to engage in e-waste recycling. By understanding these factors, the study seeks to improve household recycling rates and promote environmental sustainability.

Understanding the interactions between both players towards recycling is important in the design of successful Household E-waste Recycling Systems (HERS). By focusing on the interaction of personal and situational elements among householders, the purpose of this study is to provide a theoretical contribution to current knowledge of the connection that exists between local authorities and the members of the communities that they serve. The interaction between these two variables, personal and situational, capsulate the “symbiosis effect” between local stakeholders and households (A-Jalil et al., 2014). The “symbiosis effect” had been defined as the interaction between two entities that are closely related and live together for the benefit of each other (A-Jalil, 2015).

Since this research focuses on Household E-waste Recycling Behaviour (HERB), therefore, factors that may contribute to household recycling behaviour are drawn particularly on e-waste related research. The behaviour and participation of e-waste disposal have been influenced by several demographic profiles of individual characteristics such as national origin, social background, socio-economic settings such as property type, social economic status, residential category, maturity level, and income (A-Jalil et al., 2014; Akhtar et al., 2014; Haron et al., 2018).

Moreover, the interaction between behavioural factors and environmental conditions can influence household behaviours, including the availability of recycling facilities and infrastructure, convenience, communication or advertising efforts by municipalities, and the level of engagement from stakeholders. (A-Jalil et al., 2014;

Haron et al., 2018; Shaharudin et al., 2020). These elements collectively play a crucial role in shaping the willingness of households to participate in recycling initiatives.

The involvement of local stakeholders took place in the situational factors as to allow them developed the effective design and implementation of HERS. The central study of this paper is to investigate this symbiotic effect between HERS and HERB on the pursuit of sustainability and to try to explain the various factors in both circumstances and individuals that encapsulate the interactions between local stakeholders and households. Similarly, other studies that focus on recycling and individual factors provide a minimal explanation of the relevant aspects in situational variables (Akhtar et al., 2014; Malik et al., 2015).

The closest study to examine these two factors had been done by A-Jalil (2015), who examined municipal systems and household behaviour in the context of municipal solid waste. In addition to situational variables, personal factors are equally important to consider in supporting the HERS. Notably, previous studies have largely overlooked the combined impact of personal and situational factors. Therefore, the significance of this study lies in exploring the relationship between stakeholder engagement and household behaviour in e-waste recycling, with a focus on both situational and personal variables.

1.2. Problem Statement

The investigation of the relationship between HERS and HERB lead to the understanding of household e-waste recycling participation even deeper. This research specifically focuses on the recycling systems managed by stakeholders and household behaviour in Northern Region Malaysia namely; Kedah and Penang. The research focuses on the reciprocal relationship between HERS provided by the stakeholders' and HERB in order to promote household e-waste recycling participation.

Households have an important role in deciding whether end-of-life products are caught by a reverse logistics system or discarded. A-Jalil (2015) claims that the lifespan of the electronic equipment covered by take-back regulations is much less than that of common domestic waste materials like food and beverage packaging. According to the same research, local authorities waste management systems were mentioned to be comparatively underrepresented in the reverse logistics literature as compared to commercial reverse logistics systems.

Previous research performed by Keramitsoglou and Tsagarakis (2018) has shown that a number of reverse logistics characteristics, including ease of access, a perception of improved recycling facility communication, and financial incentives from the local stakeholders, are associated with increased rates of household to participate in recycling activities. This indicates that the degree to which individual households comply with recycling regulations is affected by a number of logistical design elements that are within the jurisdiction of local stakeholders.

Due to the high rate of technological progress and the increased use of technology, the worrisome problem of the creation of e-waste persists, which reduces the longevity of electrical and electronic devices. E-waste is rapidly becoming a concern on a global scale. DOE (2019) mentioned that composed of hazardous chemicals poses a risk to human health as well as to the atmosphere. If e-waste is not disposed and managed in an appropriate manner and is instead just thrown away, it will wind up in the landfills, which presents a risk not just to the natural environment but also to the health of people. The global population generated 53.6 Mt of e-waste in 2019, but only 17.4% was appropriately disposed and managed using the right methods (Forti et al., 2020).

The distressing trend also invades Malaysia and the country had already contributed up to the total of 364 kt of e-waste (The Global E-waste, 2019). According to a report by Watson (2020), over 70% of Malaysian households use smartphones, mobile phones, and computers or laptops for work-related purposes. This widespread reliance on digital devices reflects a high rate of EEE consumption across the country, contributing to the growing volume of e-waste. However, if these items are not appropriately disposed of, it would exert a negative influence on human health and the environment would be detrimental.

Due to this distressing issue, local stakeholders are under continual pressure to collect and recycle household e-waste more efficiently and effectively high expenses associated with landfills as well as environmental mandates. Consequently, stakeholders must enhance the quality of their waste recycling systems in order to increase the economic and environmental effectiveness. This necessitates the

participation of the local community (Botetzagias et al., 2015). As a result, authorities and local stakeholders must devise a comprehensive and targeted strategy to address the issue of e-waste in order to support both sustainable development and a green digital revolution.

Recycling rates may be improved statistically by the combined efforts of households and the recycling infrastructure offered by their local authorities (Barr et al., 2013). Barr et al. (2013) also emphasised the importance of attitudes when taking into account the many different sorts of situational factors that have an impact on stakeholders, particularly local stakeholders. Therefore, in this study, all of those characteristics were classified as situational factors, which are controlled by local stakeholders in their efforts to connect with households as supplier-consumers. This study also indicates that e-waste recycling involvement may be fostered via the interplay of situational elements and household behaviours.

EEE is a complex blend of materials and components including hazardous substances, which poses an environmental concern and causing health issues. Many environmental problems are driven by human activities and behaviour. The effects of e-waste that the amount of human health problems significantly increases when people lives to informal e-waste recycling areas (Park et al., 2017). Thus, it can be concluded that humans have an enormous influence on environmental problems occurred within their residents. Park et al. (2017) agreed that fostering a proper e-waste disposal management is a good strategy to develop a more sustainable environment among the nation. Therefore, it is relevant to study the importance of e-waste recycling

management and finding the determinants of situational and personal factors on HERS and HERB in Malaysia as to help develop those strategies. Consequently, by simultaneously examining both situational and personal factors, this study aims to uncover the key drivers that influence human behaviour in e-waste recycling at the source, providing a comprehensive understanding of how to effectively address this issue.

Research carried out in both developed (Bovea et al., 2018; Ylä-Mella et al., 2015) and developing nations (Borthakur and Govind, 2017; Yin et al., 2014) has shown that householders have a tendency to reserve their old EEE rather than recycle of their e-waste in an appropriate way. According to Rousta et al. (2020) and J. Yin et al. (2014), despite the closeness and convenience of the many waste treatment systems that are now in place all around Malaysia, up to 85% of customers retain their outdated mobile phones at home till they have the potential to be used in the future. When it comes to electronic devices, Tanskanen (2013) pointed out that many of the small electrical items such as cell phones and laptops are not actively used but are instead stored at home as a backup, either for nostalgic reasons or because householders feel the gadgets have a high resale value and are thus hesitant to complete e-waste recycling. Other countries have had similar inclinations to hoard as well.

The above issue portrays that the present e-waste management system is insufficient in encouraging the e-waste recycling among householder since the current e-waste recycling programmes are confronted with the constraints of home storage. Consequently, the existing e-waste recycling programmes are not able to effectively

recycle e-waste. As a result, it is of the utmost crucial to investigate the determinants that encourage the e-waste recycling by involving both householders and other stakeholders. The policymakers and authorities make several initiatives in managing household e-waste however, most of the regulations are not fully implemented, exacerbating the already deplorable environmental conditions in developing nations, including Malaysia. For example, government implements the Extended Producer Responsibility (EPR) as an initiative in improving recycling of materials. EPR shifts the burden of paying for waste collection and recycling from local authorities to manufacturers.

EPR mandates that producers take responsibility for the management and disposal of their products after such products have reached the end of their useful life (Kunz et al., 2018). However, EPR is not mandatory for producers, which discourages worldwide cooperation to address the e-waste problem (Abalansa et al., 2021). Apart from all of the initiatives established by government in promoting e-waste recycling, it is also important to investigate the current level of engagement among stakeholders in ensuring the continuation of the systems are adapted by each stakeholder.

The quantities of e-waste are annually expanding because of the speedy development of the EEE produced and imported into Malaysia (Al-Rahmi et al., 2018). According to a Malaysian DOE research on domestic e-waste creation portrayed that Malaysia generated 1.2 Mt of e-waste in 2016, and the volume is expected to reach 2.4 Mt in 2025. Despite the alarming forecasts about the quantity of e-waste that would be created, there is not yet a domestic e-waste management plan that has been put into

place. In view of the potentially catastrophic effects that might result from improper management of e-waste, the creation of laws for the management of e-waste is an absolutely credential step. The number of experimental studies by Malaysian researchers towards consumers' e-waste recycling intentions is increasing (Afroz et al., 2020; Kianpour et al., 2017; Mahat et al., 2019). However, these previous studies only focus on consumers' recycling intentions and behaviour in general with no link to the stakeholders' engagement. Therefore, it is significance to investigate and reveal the engagement level among different e-waste stakeholders in order to promote HERB among Malaysian.

Forti et al. (2020) listed three main challenges faced in accordance to the creation of an appropriate method for the handling of e-waste from the householders and businesses. Firstly, both of the stakeholders and householders usually are more interested to recycle valuable materials such as steel and aluminium as contrasted with the household of e-waste (Micu, 2021). The collection and transportation logistics on household e-waste is one of the issues that deviate authorities in developing a proper HERS to manage household e-waste. This is because of the fact that the whole process of reverse logistics is discovered to be so impossible in certain circumstances, mostly because the e-waste from households is both heavy and cumbersome in terms of its size. The mindset and behaviour of the people is considered to be the challenge that obstruct the development of appropriate HERS. Both stakeholders and recyclers are unwilling to invest in equipment and environmental protection measures, making the recycling and recovery process commercially unviable.

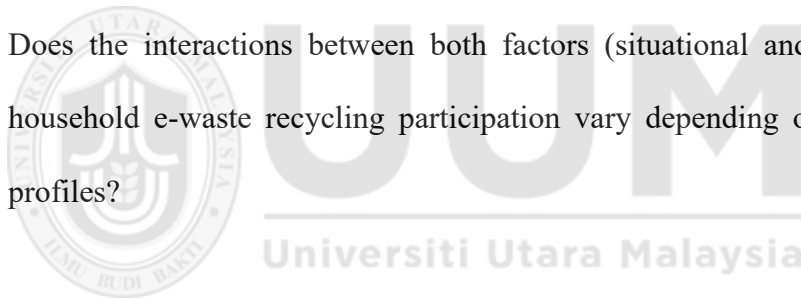
In order to cater the issues faced by both stakeholders and recyclers, stronger links between them is needed for the development of HERS. The symbiotic relationship between the stakeholders which includes local authorities, e-waste operators, NGOs and solid waste operations has abundant of potential for improvement in Malaysia. It is necessary to do research on the connections that exist between producers, consumers, householders, and the authorities in order to help authorities establishing the HERS which may contribute to the HERB. According to Forti et al. (2020), many recyclers are hesitant to reveal their technical operations when they are engaging with the other stakeholders. As a result, this creates a barrier in the path that should be taken to advance the recycling of e-waste in Malaysia. Therefore, it is crucial to reveal the interactions and conditions that support the symbiosis effects between HERS and HERB.

This study explores the fundamental aspects of household e-waste which the focal points are the situational and personal factors to deal with the issues in managing the e-waste flows from the source using a Symbiosis Effect Theory. This research examines how households and local stakeholders are collaborating as symbiotic social actors to show that it is possible to live in a way that is sustainable for both groups, in which households needs to rely on local stakeholders support for managing e-waste just as much as local stakeholders rely on households actions for separating and sorting their e-waste. In the end this research developed a relevant framework to address the e-waste issues from the source in Malaysia. At present, there exists neither a sustainable nor extensive structure for the management of e-waste, nor has a system been established for collecting and disposing of e-waste originating from households.

1.3. Research Questions

The aim of this study is to investigate stakeholders' engagement and HERB. This aim was addressed via a series of research questions (RQ) as noted below:

- RQ1. How does the situational factors influence households to participate in e-waste recycling in Malaysia?
- RQ2. How does the personal factors influence households to participate in e-waste recycling in Malaysia?
- RQ3. How does the reverse logistics symbiosis between situational and personal factors can influence and support the dynamic interactions between HERS and HERB?
- RQ4. Does the interactions between both factors (situational and personal) and household e-waste recycling participation vary depending on demographic profiles?



1.4. Research Objectives

The aim of this study is to investigate stakeholders' engagement and HERB. This aim was achieved with the following research objectives (RO):

- RO1. To determine the situational factors that influence households to participate in e-waste recycling in Malaysia.
- RO2. To determine the personal factors that influence households to participate in e-waste recycling in Malaysia.

- RO3. To identify the reverse logistics symbiosis between situational and personal factors that influence and support the dynamic interactions between HERS and HERB.
- RO4. To determine the impact of demographic profile on the interactions between both factors (situational and personal) and household e-waste recycling participation.

1.5. Scope of the Study

This section provides a comprehensive outline of the methods and scope that were adopted to achieve the ROs and address the pertinent RQs. The study focused on examining e-waste management practices by exploring the perspectives and experiences of both relevant stakeholders in the e-waste management sector and householders. A significant focus of the research was placed on two key components: HERS and HERB, both of which are crucial for understanding energy and e-waste management behaviours at the household level. The geographical focus of the study was on two states in the Northern Region of Malaysia: Kedah and Penang. These states were selected due to their diverse demographic, economic, and environmental characteristics, which provide a rich context for analysing waste management issues. By selecting these locations, the research aimed to capture a wide range of perspectives and gain a deeper understanding of regional variations in waste management practices.

To ensure a comprehensive understanding of the research topic, a mixed-methods approach was utilized, combining both quantitative and qualitative research methods. This approach allowed for a more nuanced analysis by providing numerical data through surveys, while also exploring personal experiences, perceptions, and attitudes through interviews. The combination of these methods helped triangulate the data and strengthen the reliability of the findings. As for data collection, the study used two primary tools: a structured questionnaire and semi-structured interviews. The questionnaire was designed to gather quantitative data on e-waste management practices, e-waste recycling strategies, and demographic information from a large sample of participants. The interviews, on the other hand, provided an opportunity to delve deeper into individual experiences and understand the motivations behind certain e-waste management behaviours and strategies. These two tools were carried out independently, ensuring that each method contributed to different facets of the research.

The sample population consisted of key stakeholders in the waste management sector, such as government officials, local waste management companies, and non-governmental organizations (NGOs) involved in environmental advocacy, as well as householders from the two states. The selection of stakeholders and householders aimed to capture a broad range of insights from both those directly involved in e-waste management and those who are the primary participants in e-waste disposal and recycling activities. The data collected from this diverse sample formed the basis for the analysis and conclusions of the study.

1.6. Significance of the Study

The significance of this research originates from the fact that it contributes to three distinct spheres of information and evidence that are helpful to researchers, households, and stakeholders. This study is deemed to aid in a better understanding on the interaction between stakeholders' engagement and householder's behaviour to recycle e-waste in Malaysia. This study also provide information that can assist stakeholders that involve in waste management to build a relevant e-waste management system that are still undiscovered in Malaysia. In conclusion, the findings of this research add to the existing body of information and produce a better academic understanding of the impacts of symbiosis between HERS and HERB.

This study's contributions should primarily relevance for reverse logistics, waste management and environmental researchers, as well as practicing stakeholders, notably in HERS. Studies on the symbiotic effects of HERS and HERB represent part of exploratory research in the field of reverse logistics. This research further contribute to the area of supply chain management (SCM) acceptance because it explores and relate the use of symbiosis effect theory in the current research of e-waste management. Currently, there has been no research conducted adapting symbiosis effect theory established by A-Jalil (2015) specifically on the e-waste management thus, the contribution of this study should primarily appeal to academics in the domains of reverse logistics and waste management.

This study expands on existing literature by empirically validating the reciprocal nature of situational and personal factors. It underscores the multidimensional interplay that traditional behaviour models might overlook, emphasizing a dynamic systems approach. To date, the studied on the interaction between the HERS and HERB still limited, despite the focus of the debates in waste management literature especially in the context of e-waste. The theoretical model is anticipated to serve as theoretical reference for academic researchers to conduct further research. A deeper understanding of how the recapturing framework and model impacting the movement of e-waste recycles and recapturing the energy from waste, Therefore this study is expected to contribute the body of knowledge of supply chain and logistics management as this research provides expanding through the application of the theory of symbiosis in the area of recycling e-waste management.

This research aimed to provide valuable information relating to the implication of sustainable policy in regards to e-waste recycles from MSW in Northern Region of Malaysia and thus, contribute the body of knowledge of local governance and smart urbanization. The specific framework derived from the study were extended to a white paper for ministerial discussion in local stakeholders as well as waste operators to have a tandem collaboration to instil a sustainable surrounding in promoting household e-waste recycling participation. This research provides a framework that is expected to assist governmental bodies in assessing the sustainability of recycling waste systems in Malaysia for future generation. The study also provides explanations and evidence to help local authorities understand the impact of specific recycling systems on households' recycling behaviour and make informed policy decisions.

Furthermore, reverse logistics practitioners should have a strong foundation to support the development of systems that facilitate e-waste recovery. This study is expected to contribute toward the design of an appropriate HERS by relevant authorities or stakeholders. In doing so, it aims to enhance recycling participation and promote environmental sustainability. Even progressive HERS performance improvements can result in increased sustainability through better recycling rates and addressing all related issues pertaining to e-waste management. Therefore, it is convenient to design a sustainable reverse logistics system for e-waste management by taking into account appropriate participation and proactive factors that indicate household needs and requirements.

In addition, the findings of this research highlight the symbiosis effect, which emerged as a key driver of effective household e-waste recycling management. This effect underscores the interdependence between stakeholders and householders, shaped by both situational and personal factors. The research emphasizes how these factors, collectively, facilitate the recycling process and enhance the overall effectiveness of waste management strategies. The results indicate that HERB is significantly influenced by the HERS developed by local stakeholders, playing a key role in boosting household participation in e-waste recycling. Additionally, personal factors, such as individual attitudes, awareness, and motivation toward recycling, contribute to the likelihood of participation in recycling efforts.

This research aims to raise awareness among householders, helping them recognize how their recycling behaviours can be positively influenced by the presence and quality of recycling services. By understanding these dynamics, householders can make more informed decisions about e-waste disposal and contribute more effectively to sustainable waste management practices. The findings also provide valuable insights for stakeholders in the waste management sector, enabling them to design policies and initiatives that enhance the accessibility and convenience of recycling options, ultimately promoting a more sustainable and efficient recycling ecosystem.



1.7. Definition of Key Terms

i. Reverse Logistics

Reverse logistics is the management of the movement of materials in the opposite direction, from finished products back through the manufacturing and distribution chain to their respective places of disposal (De Brito and Dekker, 2003).

ii. Symbiosis

Symbiosis is the interaction between two separate living entities that live close together and rely on each other in specific ways, each receiving certain advantages from the other (Oxford University Press, 2022).

iii. Symbiosis Effect

Symbiosis effect is the interplay between both personal and situational factors, as demonstrated by the municipal waste disposal system and household recycling behaviour, respectively (A-Jalil, 2015).

iv. Electronic Waste (E-waste)

E-waste refers to all types of electrical and electronic equipment and its parts that have been discarded by the owner as waste without the intent of reuse, including items that are destined for recovery, recycling, or disposal (Baldé et al., 2017; Puckett et al., 2002).

1.8. Organization of the Thesis

A total of six chapters compensate the overall thesis and their respective topics were discussed in further depth in the following paragraphs.

Chapter 1: This chapter provides an overview for the whole thesis background. It has outlined the general introduction, research background, problem statement, research questions and research objectives, scope of the study, definition of key terms and organization of the thesis.

Chapter 2: The pertinent literature review that gives the evidence in relation to this research is discussed in this chapter. It elaborates the discussion of HERB research generally, and specifically in Malaysia. This chapter begins with the concept of the variables studied followed by the underpinning theories and summary. It is based on systematic literature reviews of review articles and journals, databases that may be accessed online (SAGE, Web of Science, Emerald, Elsevier, Wiley, etc.).

Chapter 3: The methods that were used to obtain the data for this research are broken down and discussed in this chapter. It outlines the research process including the conceptual and theoretical framework, research design, research instruments used, data collection procedures, data analysis techniques and summary. This chapter provides justification for the strategy using mixed methodologies that was selected, arguing that it is consistent with answering the research questions.

Chapter 4: This chapter discussed the finding and analysis of the data collected. It includes two phases whereby the first phase is the analysis of quantitative analysis of the household e-waste recycling participation in explaining householders' intention and behaviour to recycle e-waste. This part present the findings of the descriptive analysis, validity and reliability analysis, measurement, structural and reciprocal models. The second phase of this study further explained the qualitative analysis which were based on Focus Group Discussion (FGD) among local stakeholders and private individual interview session with householders.

Chapter 5: The results and analyses gained from Phase 1 and Phase 2 were interpreted and synthesised using triangulation method on explanatory sequential design. This chapter include the final phase, Phase 3 under the subtopic of triangulation. This chapter merged the results from the two phases in Chapter 4, and further highlighted and discussed the results obtained in the previous chapter.

Chapter 6: This chapter concluded the discussion of the entire study. It highlighted the main contribution, limitations and recommendations for future study under this research area.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides an explanation of the many pieces of literature and theoretical frameworks that were employed over the course of this investigation. The study begins with reviewing various concepts that contribute to the development and establishment of waste management, as evidenced by several literature reviews. The subtopic under focus encompasses the principles and practices of sustainable development, with a specific focus on its integration with waste management. The subsequent context reviewed in details the concept of reverse logistics pertains to the effective management of waste through the implementation of recycling initiatives.

The following subsection reviews the literature in relation to waste management and specifically, e-waste around the world. This section is followed by a discussion on the stakeholders' engagement and household behaviour issues related to e-waste recycling including the factors that contribute to it. The literature on the stakeholders' engagement focuses on the situational factors that influence HERS which include accessibility and availability, convenience, engagement, advertising, education, and policy and regulations.

All available evidence regarding household behaviour towards e-waste recycling in Malaysia were also discussed under this section. The behavioural literature focuses on the personal factors that influence HERB which includes attitude, social norms, knowledge and experience, awareness and psychological ownership. The purpose of

reviews for both situational and personal factors was to adequately obtained and describe the symbiotic relationship amongst HERS and HERB.

Despite the growing relevance of e-waste issues, studies focusing on stakeholders' engagement and household behaviour in the Northern Region of Malaysia are notably limited. Accordingly, this section provides a detailed discussion of the literature gap. Review on previous studies on the framework development of waste management is also discussed to get deeper understanding on the theories and methods used to develop a relevant framework for e-waste recycling management.

2.2 Reverse Logistics

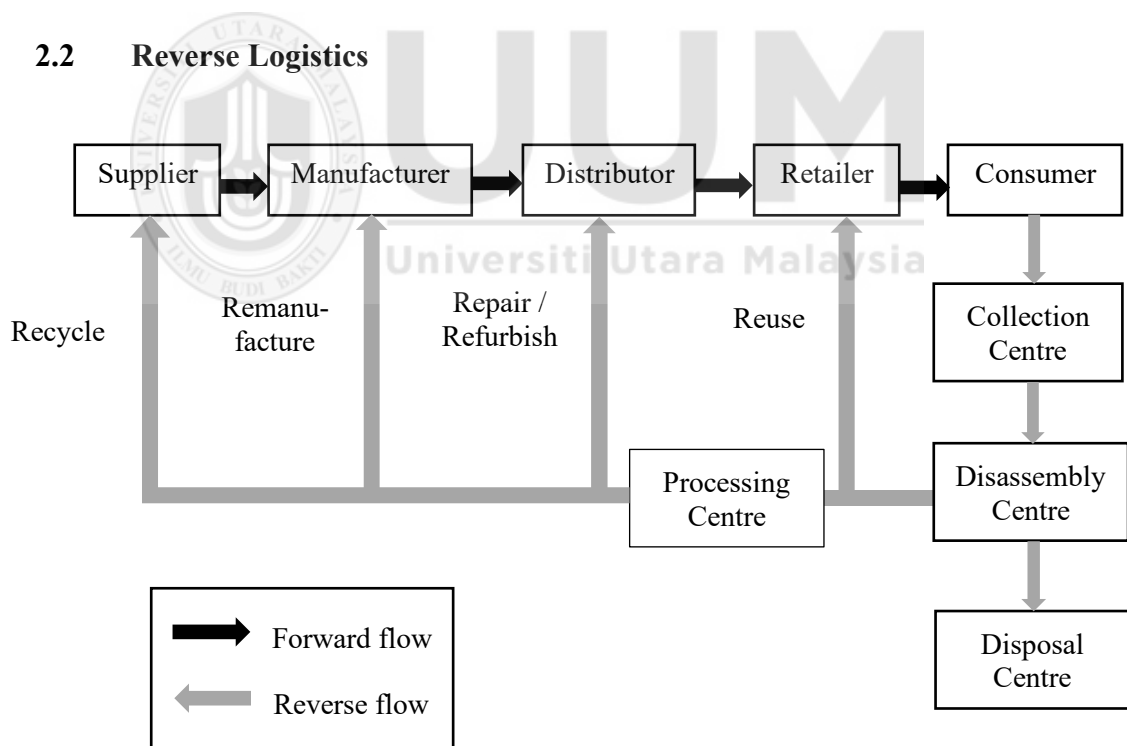


Figure 2.1
Forward and reverse logistics process
 Source: Misni and Lee (2017)

The flow of products in today's supply chains is not limited to consumer. Many products reach their second, third, or fourth life after fulfilling their original purpose with the first consumer. As a result, the product can generate sales multiple times. To capture this value, it requires a broadening perspective of supply chain and include a new process called "Reverse Logistics". According to Rogers and Tibben-Lembke (1998), reverse logistics refers to the process of planning, executing, monitoring, and managing the efficient movement of goods from the point of consumption back to their origin, including in-process inventories, finished products, and related information, with the goal of recovering or properly disposing of the product's value.

Unlike traditional supply chain flow, or forward logistics, reverse logistics operates in the opposite direction, moving products from the consumer back to the supplier. Referring to Nik Abdullah and Yaakub (2015), the process of moving goods or materials in the opposite direction of the traditional supply chain, from the consumer back to the supplier or point of origin is known as reverse logistics. This is done with the intention of either producing new value or recovering old value, or to dispose of goods or materials in an appropriate manner.

Reverse logistics comprises the processing of damaged, seasonal, restocked, salvaged recalls, and excessive stock returned products, as well as the processing of packaging and transportation materials obtained from the ultimate consumers or distributor. It also includes recycling programmes, hazardous material programmes, the disposal of old equipment, and asset recovery (Rogers and Tibben-Lembke, 1998).

In Figure 2.1, reverse logistics primarily includes all the operations concerning items or materials and information that may be reused, repair or refurbish, remanufacture and recycle to be disposed properly (Misni and Lee, 2017). Reverse logistics can also be related to several common terms such as recycling, reuse, remanufacturing and refurbishment (Andrushchak, 2018). One of the areas in reverse logistics process shown in Figure 2.1 is regarding recycling.

In 1969, the establishment of National Environmental Policy Act in the United States had a major impact on recycling and recovery of waste. At the end of the 1960s, the law provided a larger view upon the environment (Ginter and Starling, 1978). In the National Environmental Policy Act, both recycling and waste recycling activities are included in the environmental impact assessment, which has led to a positive increase in the creation of recycling projects and activities (Grabara and Man, 2014).

Reverse logistics services have grown in popularity since the 1960s because it provides value to recycled materials that focuses on recycling waste and recovering value from discarded products and equipment (Alnoor et al., 2019; Grabara and Man, 2014). Evidently, reverse logistics helps consumers understand the social obligations related to the environment through laws and directives. These are all elements that strengthen the importance of reverse logistics.

The environment is the main factor that affects the performance of the sustainable development of an organization. It is expressed by external variables such as economic, demographic and climatic and internal factors which have a beneficial

influence on products or services, emissions and waste and etc. (Alnoor et al., 2019). These elements have been shown to affect the sustainability performance of the company and to accept these social and environmental consequences, such as in a crisis, will increase the organisation's well-being (Abdulaali, 2018; Baumgartner and Rauter, 2016).

In order for to minimize the impacts and achieve sustainability, waste operators must adapt the concept of reverse logistics in their overall logistics process. Misni and Lee (2017) agreed that reverse logistics process can reduce the impact on the environment and is a good choice to prevent materials from being discarded. Sustainable development is an encompassing phrase that refers to practises that acknowledge the intertwined relationships between monetary prosperity, ecological preservation, and social development (Ali et al., 2018). Sustainable development has become an important concept for many organizations because it provides solutions to meet basic human needs, combining development and environmental protection, achieving quality and maintaining ecological integrity (Klarin, 2018).

As a consequence of this, several firms are required to endure pressure from a variety of stakeholders while simultaneously managing and sustaining their commercial operations (Ali et al., 2018; Alnoor et al., 2019; Lozano, 2015). According to Alnoor et al. (2019), these organizations should consider recovering products, recycling them, replacing damaged products and recycling parts in their supply chain, which emphasizes reverse logistics to achieve a closed network design and thus achieve a sustainable strategy. Therefore, it is very vital for companies to implement such

methods to achieve better economic performance and to avoid acquisition and financial liability by utilizing reverse logistics to accomplish supply chain sustainability that act as a strategic decision.

2.2.1 Role of Reverse Logistics in E-waste Management

With the growing concerns about protecting the environment, concept of sustainable development becomes more important since 1972 when it was officially presented at the United Nations Conference. The concept of sustainable development motivates stakeholders or authorities for several reasons, including the emergence of various environmental concerns as a result of globalization, economic expansion, and rising demand for production (Andrushchak, 2018). For example, the ozone layer's depletion, air and water pollution, and the scarcity of landfills. Due to all of the environmental issues, many organizations from various industries have started to focus on reverse logistics.

Stakeholders and authorities from all over the world have shown a strong desire to safeguard and preserve the environment in which they operate. Thus, stakeholders are interested not only in the traditional flow of products via the forward logistics flow (i.e., from supplier to consumer), but also consider eco-friendly activities that assure the reverse flow of used items via the reverse logistics flow proactively or reactively (i.e., from the final consumer to the supplier) (Mathiyazhagan and Noorul Haq, 2013). As previously discussed, the increase in environmental problems will directly affect

the economic and social aspects of development and vice versa therefore, greater efforts should be made to address them.

Reverse logistics demonstrated not just worldwide concern for sustainable development, but also impacted government at the strategic level to limit negative consequences on the environment (Purwani et al., 2020). With the pressure from multiple stakeholders in promoting sustainability, companies from various sectors across the globe utilise the reverse logistics concept to promote reverse logistics operations in order to make profit while conserving the environment (Agrawal et al., 2015; Yahya et al., 2021). The reverse logistics activities promoted by the various organizations includes advertising, reusing, and redistributing items to reduce waste affiliated with EEE (Yahya et al., 2021). Reverse logistics has become a strategy consisting of a number of procedures to properly analyse and allocate waste management post completion of the product life cycle (Banguera et al., 2017).

Stock (1998) defines reverse logistics as “... *the term often used for the role of logistics in recycling, waste disposal and management of hazardous materials; a broader perspective includes all issues relating to logistics activities carried out in source reduction, recycling, substitution, reuse of materials and disposal*”. This concept explicitly integrates reverse logistics operations within a scenario of waste management that gives a more complete way of preserving resources and recycling products at the End-of-Life (EOL).

EEE now pervades every area of our everyday lives, enhancing our quality of life. Unfortunately, continual technical breakthroughs and rising consumerism hasten the replacement of these devices, resulting in an exponential increase in the output of e-waste. The EEE manufacturing process necessitates significant quantities of materials that, if inadequately recovered or disposed of, may present potential hazards to both environmental integrity and the well-being of human beings. E-waste was determined to be one of the most important items among the many EOL products identified by reverse logistics study.

E-waste contains a variety of unique qualities and functions, including a short product life cycle (PLC) and a significant quantity of both dangerous and valuable materials attached to it (Islam and Huda, 2018) which make its reverse logistics system different from the general reverse logistics system. Many organizations only consider reverse logistics from the point at which trash is created and must be recycled or disposed of in an ecologically responsible manner (Guarnieri et al., 2016). However, reverse logistics must be considered throughout the PLCs, including at the product design phase.

In light of the escalating environmental challenges, diminishing availability of resources and limited landfill capacity in many countries, reverse logistics for e-waste management is receiving more attention from governments, industries and researchers. As shown in Figure 2.1, its e-waste is collected from various sources such as primary suppliers, manufacturers, retailers and end customers. This collected e-waste is then treated and undergoes the necessary treatment stages before being

recycled and eventually modified to return to the respective sources. In point of fact, the reverse logistics system establishes connections between final consumers and their respective suppliers via way of merchants and manufacturers. The e-waste disposal system can reversely distribute products, return unsold goods, return damaged and improperly delivered goods, recall products and manage waste (Udhayakumar, 2017).

According to past and recent studies, recycling is agreed to be one of the best alternative to treat e-waste (Bhutta et al., 2011; Haron et al., 2018; Senawi and Sheau-Ting, 2016; Shaharudin et al., 2020). In fact, with the support of specific government regulations, the popularization of waste recycling and reuse processes has created new economic marketplaces and new commercial operations in many developed and emerging nations (Ghisellini et al., 2016).

In these circumstances, waste collection, recycling and reuse reverse logistics processes play an important role for a variety of reasons. Firstly, there are some significant, valuable and dangerous chemicals inside the e-waste that require particular recycling techniques and procedures for preventing environmental and health concerns (Isernia et al., 2019). These reasons are backed by a previous study, Menikpura and Hotta (Menikpura and Hotta, 2014) and the authors conclude that e-waste recycling is a means of reducing emissions and consequences of greenhouse gases on the environment.

Moreover, because a high number in e-waste are discovered with precious metals and specialized metals, recycling them provides a connected financial opportunity,

because it saves the limited and costly resources used in the production of EEE and other equipment (Golsteijn and Martinez, 2017). In the research by Siddiqi et al., (2020), the amount of metals determined to be present in e-waste will exceed US \$ 4.7 million per year based on the value of recycled metals. Moreover, the idea of green logistics for the promotion of sustainability clearly reflects recycling by closing the supply chain cycle and providing a more sustainable approach to HERS with the appropriate technology (A-Jalil, 2015).

2.3 Overview of Household E-waste Management

The large amount of e-waste generated comes from four major sources, namely, individual households, governments, industries, and hospitals (Mohd and Kaushal, 2018). There is a wide selection of home appliances available, ranging from major home appliances like television sets and washing machines to more compact home appliances like mobile phones and other hand-held electronic devices. Information and communication technology (ICT) equipment remained largely in government and industries such as computers and fax machines. DOE has created a system for household e-waste collection and recycling in Malaysia where households may deliver their e-waste to its collecting facilities under the management of solid waste local authorities, including cell phones, batteries and accessories, computers and accessories (Tiep et al., 2015).

In addition, previous researchers have conducted several studies on the measures that have been implemented to manage e-waste problems around the world. Researchers

have analysed strategies for resolving problems of solid and e-waste disposal and identified measures to resolve them through programs such as recycling and composting programmes (Haron et al., 2018; Tiew et al., 2015), drop-off programs (Afroz et al., 2020), waste separation programs (Yusop and Othman, 2019), curb side collection (Zen and Chamhuri, 2015) and EPR (Yan, 2017). Furthermore, recycling is considered an effective way to reduce waste sent to landfills (David and Sankriti, 2019; Mwanza and Mbohwa, 2017). Recycling is one of the processes to control high-quality and valuable e-waste. Through the recycling process, rare metals and non-ferrous metals can be used for other purposes.

Managing EOL products is one of the major concerns in many countries around the world. Recycling includes the processing of activities, tools, products, mechanisms, and resources related to the management of EOL products, as well as the complete recovery of the technical system that can be used to properly manage EOL products (Matlob et al., 2020). It is supported by Zen and Siwar (2014) that recycling is considered the most environmental friendly strategy for disposing of household waste by strictly follow source reduction and reuse prevention strategies. This indicates that recycling could be ranked as the most actively accepted method in solid waste management.

In addition, recycling is an approach that moves goods from their normal end-of-life stage for value creation and proper disposal. However, in the development process of HERB, the recycling process needs proper management, because in the recycling

process, these trace elements will have a negative impact on humans, so the environment thus, affect HERB.

2.3.1 Current Challenges of Household E-waste Management

E-waste is a global stream of waste generated by the increasing consumption of electronic products. This waste results from the growing demand for ICT and the rapid obsolescence of electronic devices. This section attempts to give a better understanding of worldwide e-waste movements in order to identify the risks and challenges of global e-waste management systems. E-waste has been shipped around the world for decades, but its quantitative properties are not yet fully understood and monitored. This is due in part to traders' desire to avoid disclosing the real status of the commodities they handle.

Both industrialised and developing nations face significant issues as a result of this distressing trend. Environmental contamination and health issues for the general population are directly linked to the improper treatment of e-waste during demolition. Practices such as open incineration and open dumps are among the worst options, yet they are often used by nations that lack appropriate regulations and fundamental waste management services.

As a result of insufficient environmental regulation being enforced by municipal and regional authorities in industrialised nations, illegal disposal of e-waste is also taking place in such countries. As reported by Baldé et al. (2017), 8.9 Mt of e-waste has been

collected and recycled, accounting for 20% of the total e-waste generated globally in 2016 (44.7 Mt). However, 1.7 Mt of e-waste in nations with greater incomes is more prone to be burned or dumped in landfills, as they are not collected or recycled. The global e-waste created in 2016 was twice as much as the amount reported back in 2005 (Zoeteman et al., 2010).

E-waste streams are often disposed of incorrectly due to ineffective urban waste management systems (Song and Li, 2014). This proportion is retrieved as residual waste and blended with other fragments before being discarded of in urban landfills or untreated landfills, where toxins are leached into the environment. E-waste fractions are a dangerous source of mixed municipal waste fractions containing toxic substances and substances such as persistent organic pollutants.

In addition, polycyclic aromatic hydrocarbons, heavy metals (cadmium, mercury, lead, chromium), batteries, and brominated flame retardants complete the list of toxic substances in e-waste (Mihai et al., 2019). Mihai et al. (2019) reported that numerous waste recycling workers are employed at very low wages using pollutive recycling methods in handling waste. This informal sector manage the e-waste streams without having a proper systems and services as required by the legislation. These illegal industries put their workers at risk for significant health problems by engaging in physical work while using substandard instruments.

The European Union (EU) directive on e-waste is particularly effective in requiring electronic manufacturers to collect and properly dispose of their EOL goods. Although

each country has its own standards for recycling and trash disposal, European legislation is often seen as more sophisticated and, as such, serves as a model for other nations (Lambert et al., 2011). For example, since the early 1990s, the Government of Japan has developed a planned strategy under the basic 3Rs (Reduce, Reuse, Recycle) (Department of Trade and Industry, 2005).

In addition to aggressive environmental concerns, there are a number of compelling arguments in favour of mandating that businesses manage their e-waste through a process known as reverse logistics. It is possible for the enforcement to be legal, economic, or commercial. Motives that are legal are among the most persuasive, despite the fact that they are not always warmly accepted. In the case of the e-waste directive, governments demand that manufacturers to be accountable for their goods throughout their full lifespan in order to ensure their long-term viability.

Research carried out in both developed (Bovea et al., 2018; Ylä-Mella et al., 2015) and developing nations (Borthakur and Govind, 2017; J. Yin et al., 2014) has shown that customers have a tendency to hoard old EEE rather than dispose of it in an appropriate way. When these old electrical items are stored away as a precautionary measure in industrialised nations, it is a sign that they are probably still usable in some capacity.

Shevchenko et al. (2019) state some of the causes consumer chose to kept their old electrical items at home which are, the quality of the goods, the functioning of the product, the psychological reasons (customer desirability), and the ever-changing

desires of the consumer market. As a consequence of their relative obsolescence, the appliances and equipment that people keep about the house as spares are often unusable or unrecyclable when they are no longer in use.

2.3.1.1 Household E-waste Management: Global

Addressing these pressing challenges requires coordinated and strategic action. Among the most significant global initiatives is the United Nations Sustainable Development Goals, which provide a comprehensive framework for tackling issues related to waste management and environmental sustainability. In the European context, several key environmental policy strategies have been established, including “waste prevention and recycling,” “sustainable use of resources,” “integrated product policy,” and “sustainable consumption and production.”

These priorities are embedded to varying extents in the General Union Environment Action Programme to 2020, titled "Living well, within the limits of our planet" (European Environment Council, 2013), which reflects the EU's long-term vision for sustainability and responsible resource use. The program outlines the issue of transitioning to a circular economy as a clear form of consumption and economic model. The EU circular economy action plan covers the entire life cycle covering production, consumption, secondary raw materials and waste management (Shevchenko et al., 2019).

The demand for EEE is growing very rapidly. In addition, the life cycle of these products is getting shorter and shorter. This leads to an increasing amount of waste

that must be reused or disposed of. Since 2005, the member states of the EU have begun implementing the e-waste directive that requires manufacturers to provide a network of used electronic device returns. Manufacturers have several partnerships to help collect and recycle used equipment. However, the value of e-waste collected varies dramatically between European countries, from 3 kg per capita in Poland to over 20 kg per capita in Norway (Golinska and Kawa, 2012). As the volume of returned product streams grows, the right planning tools for dynamic decision making is needed in managing e-waste.

As a consequence of the complexities of the e-waste issue, most nations have a plethora of e-waste legislation. For example, the Cleaner Production Promotion Law, the Solid Waste Pollution Prevention Law (Amendment), and the Circular Economy Promotion Law were all recently adopted in China (J. Yin et al., 2014). The competent authorities have adopted twelve rules and regulations to regulate the recycling and treatment of e-waste based on these laws.

When designing a brand new system for the collection and recycling of e-waste, it is essential to give careful consideration to the respected authorities in taking charge of maintaining overall management and taking responsibility for the efficient functioning of the system. Each state is at liberty to delegate this obligation in whichever manner it sees fit, whether it via the establishment of partnerships between householders and centralised authorities or through the delegation of authority to local governments since both of these options are viable (Corsini et al., 2017).

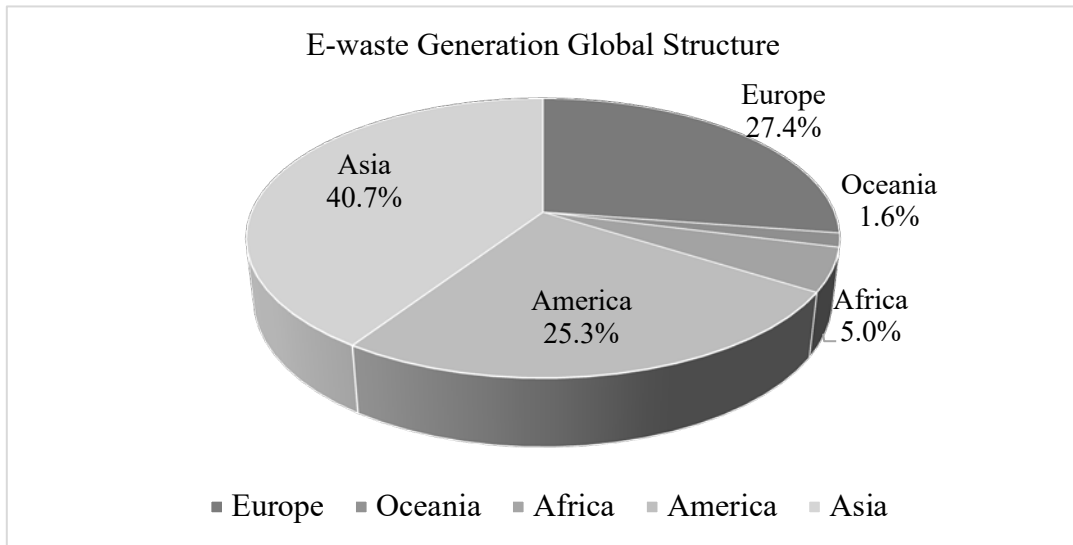


Figure 2.2
E-waste generation global structure
 Source: Baldé et al. (2017)

Globally, countries' e-waste collection rates differ. E-waste production and collection rates by continent are shown in Figure 2.4. Only 15% of the e-waste generated in Asia is recycled as reported by Baldé et al. (2017). The import of e-waste from other continents contributes to this high percentage of e-waste creation. E-waste production in Europe and the Americas is almost similar, at 27.4% and 25.3%, respectively.

Next, Europe's 35% remittance rate is about double that of the United States. One tenth of the worldwide e-waste creation comes from the United States, which produces more than five Mt of e-waste each year. In Africa, just 0.004 Mt of electronic garbage is collected and recovered each year. The amount of e-waste generated per person in African nations is also the lowest.

In Asian nations, e-waste management programmes are extremely difficult since financial attributions generally dictate householder e-waste disposal behaviour, as opposed to European or American householders, who feel that recycling operations help to mitigate environmental deterioration (Borthakur and Govind, 2017; Dixit and Vaish, 2015). As a result of the absence of statutory standards in many Asian nations and the prevalence of economic incentives that encourage consumers to recycle, the unofficial industry of e-waste collecting is gaining ground in many regions (Shevchenko et al., 2019). A comparable state of affairs is discovered in some African countries.

Due to shorter PLCs and rapid changes in customer attitudes towards its handling, e-waste is now known as one of the world's fast-growing streams (Islam et al., 2016). Based on the 2020 Global E-waste Monitor Report, in the year 2019, 53.6 Mt of e-waste has been produced all over the globe and less than 20% was recycled via an appropriate channels (Forti et al., 2020). Compared to other EOL products, this generation volume is much substantial. Compared with other EOL elements, this amount of production is significant. As stated by Islam and Huda (2018), only 80 to 90 million tons of end-of-life vehicles (ELV) are produced annually is far lower than the quantity of e-waste generated.

Next, the issue of transboundary movement of e-waste is one of the highly debated issues among researchers. Japan, Italy, Switzerland and Norway are signatories to one or more of the international laws and conventions such as Basel convention, and Rotterdam convention as well as national laws to prevent the transboundary movement

of e-waste (Abalansa et al., 2021). However, developing countries, including Mexico, Brazil, Ghana, Nigeria, India and China, are no longer fully implemented with many policy and regulations developed that contribute to poor environmental conditions (Abalansa et al., 2021). For example, development of Basel convention lacked in terms of the rules and regulations involved, since does not restrict the transfer of hazardous waste to developing and underdeveloped countries, thus creating loopholes in the context of cross-border movement of waste (Ghosh et al., 2016).

Additionally, the EPR is not obligatory for producers which discourages worldwide cooperation to address the e-waste problem (Abalansa et al., 2021). Therefore, it is critical for authorities to take initiative in updating present laws and policies so that developed countries may assist developing countries in the managing the issue of e-waste rather than exporting their environmental issues to all vulnerable regions in e-waste dumping.

Low-technology recycling systems relying on intense manual work are prevalent throughout Africa and Asia (Zoeteman et al., 2010). It is possible that the export of wastes of this kind from industrialised countries may be reduced if there was a regional plan for the management of e-waste that included higher level recovery applications. A substantial amount of e-waste comes from the urban cities because of the higher spending power of the residents, but rural regions should not be neglected in this regard. Rural areas are particularly vulnerable to waste operators' negligence, which encourages households, especially e-waste, to engage in inappropriate e-waste disposal.

A comprehensive waste management strategy has to be properly executed at several scales of geography (Mihai et al., 2019). In order to accomplish this objective, it is necessary to have in place, on both the global and the regional level, an exhaustive monitoring mechanism for the flows of e-waste.

2.3.1.2 Household E-waste Management: Malaysia

The Asia-Pacific countries has a large population and is one of the world's most rapidly growing regions. Many nations in this area, particularly Malaysia, saw fast industrialization as a result of foreign direct investments owing to the comparatively inexpensive cost of labour (Shiraishi, 2019). Referring to Andeobu et al. (2021), in 2019, the International Monetary Fund (IMF) placed Malaysia's economy as the third biggest in Southeast Asia and the 37th largest economy in the world. This ranking was based on the IMF's economic prognosis for the globe.

It is anticipated that the amount of e-waste produced in Malaysia would rise in the years to come as a result of the country's robust economic performance. This is supported through the studies conducted by Ismail and M.Hanafiah (2017) and Kusch and Hills (2017) that shows there is a significant association between economic development and the creation of e-waste, it is projected that the amount of e-waste that is produced would increase all over the globe.

E-waste can only be collected and handled in Malaysia at facilities that have been granted a license by the DOE. According to the updated 2024 data published on the

DOE Malaysia's official e-waste management website, the country currently has a total of 147 licensed collection centres, 131 designated e-waste collection points, and 66 licensed recovery facilities. These facilities are authorised by the DOE to carry out the recovery of precious metals such as gold, silver, and platinum as well as valuable base metals including copper, aluminium, and nickel, from discarded e-waste.

These facilities are also concurrently handle the dangerous materials contained in e-waste, such as heavy metals (cadmium, lead, mercury) to prevent them from damaging the environment and putting the health of humans at risk, and also manage the recyclable things, such as plastic and glass. In Malaysia, initiatives have been taken such as the collection of data on the production of e-waste, the establishment of regulations and processes, and the restriction of the treatment and recovery of e-waste to only facilities that have been accredited. More stringent procedures, on the other hand, are necessary to assure that all e-waste is collected, processed, and recovered by approved facilities.

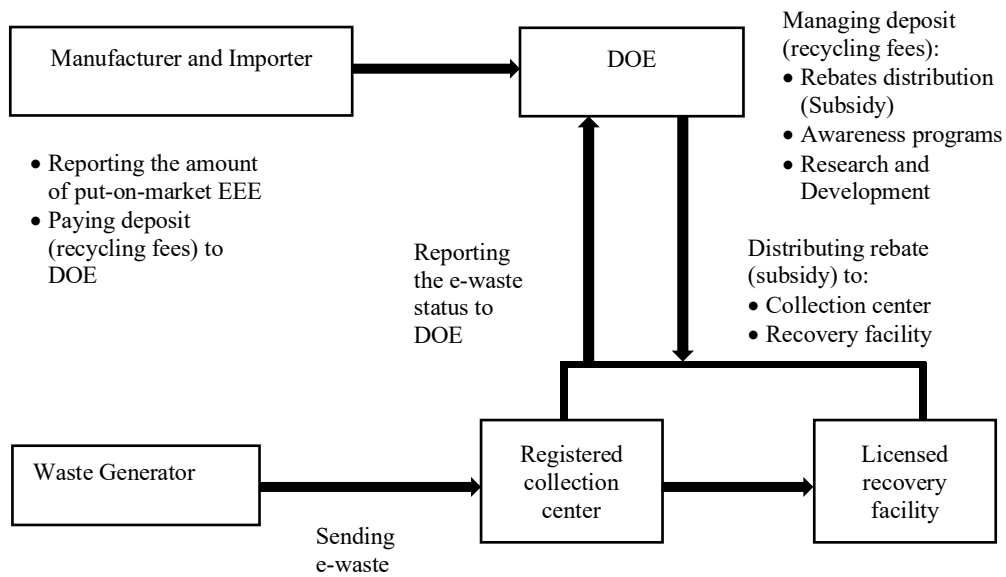


Figure 2.3
E-waste management mechanism framework in Malaysia
 Source: Department of Environment (2021)

Figure 2.3 illustrates the structured framework for managing e-waste in Malaysia as outlined by the DOE in 2021. The mechanism highlights the flow of responsibilities, reporting, and fund distribution among key stakeholders, including manufacturers and importers, waste generators (consumers), registered collection centres, licensed recovery facilities, and the DOE. Figure 2.3 encapsulates a multi-stakeholder, circular mechanism where each participant plays a specific role in managing e-waste efficiently. The integration of financial incentives, regulatory oversight, and formalized reporting ensures accountability, traceability, and environmental compliance. The system aims not only to manage e-waste but also to foster sustainable resource recovery and support the goals of a circular economy in Malaysia.

The system for recycling e-waste in Malaysia, as well as the management of e-waste overall, is yet to reach its earliest stages of development. Malaysians' inadequate attitude toward e-waste recycling is the most significant problem with the country's e-waste disposal (Tiep et al., 2015). In addition, even though there has been a rise in the usage of electrical and electronic devices in tandem with the growth of the population, there are still a significant amount of weaknesses in the disposal and management control systems that are in place for these things.

Malaysian household recycling activities are still sporadic, mainly concentrated in urban and suburban areas. Malaysia waste management system distinguishes between scheduled disposal and solid waste. The National Solid Waste Management Department is in charge of solid waste management, whereas the DOE is in charge of scheduled waste. However, the two departments cooperate in close collaboration since waste management often intersects, notably during the collection and disposal processes these two categories of waste (Haron, 2015). No precise department manages the e-waste management whole process. In more detail, no well-established separation, sorting, stacking, collecting, transport and disposal system has been developed.

According to the 2016 United Nations University Regional E-waste Monitor, e-waste in Malaysia arise by 39.7 % within the year 2010 to 2015. Malaysia has hazardous waste framework rules, including Environmental Quality Act, 1974, Public Cleansing Management Act 2007 and Environment Quality (Schedule Waste Regulations 2005)

(Honda et al., 2016). These regulations apply to the management and processing of e-waste in Malaysia.

In Malaysia, the informal sector is unfortunately involved in all stages of e-waste management, including collection, transportation, and disposal. Proper disposal of e-waste requires a more complex and specialized management system than that used for regular solid waste. The DOE is responsible for ensuring compliance with the Environmental Quality Act of 1974 when it comes to e-waste. Classified as scheduled waste under code SW 110, e-waste cannot be disposed of with other types of solid waste and must be handled through specific, regulated channels.

Although Malaysia has particular legislation controlling both municipal and scheduled trash, there is still a lack of comprehensive legislation and standards for e-waste in place. For example, with the support of Ministry of Environment in Japan, and cooperation with Pollution Control Department, Thailand, DOE Malaysia and The National Environment Agency Singapore an international mobile phone recycling network project has been launched in Asia (Tiep et al., 2015). This project is to established a cross-border transfer plan for old mobile phones produced in these countries and ensures that e-waste is carried out in a way that is beneficial to the environment. However, it is still doubtful that the general public is aware of this program.

Despite the fact that there exist e-waste management plans in Malaysia, issues continue, and the need to manage e-waste has become even more severe. Malaysia has

emerged as a preferred destination for imported e-waste from developed nations (Lehmann, 2011). According to Andeobu et al. (2021) despite the establishment of multiple material recovery facilities (MFR), Malaysia still confronts substantial challenges in controlling the ever-increasing volume of e-waste created.

On the contrary side, a significant number of EEE manufacturers in Malaysia have initiated a Take Back Program (TBP) on a modest scale in order to cut down on the quantity of e-waste that is dumped in landfills. This is done in order to protect the environment. In fact, the Ministry of Natural Resources and Environment (MNRE) urges TBP to properly dispose of e-waste, and some major EEE manufacturers have launched some programs. These programs and facilities, however, were shown to be insufficiently reaching the public, and their effectiveness remains unclear (Tiep et al., 2015). In the study, it was found that many households have stockpiled e-waste at their private residence or home. In general, stakeholders are not fully provide the information to the public about such a program to make them aware and are sometimes the public are typically confined to particular locations.

Moreover, the lack of information and inconvenience may thus impede members of the public who are planning to join in the program. Even though there are plans for the management of e-waste already in place, these strategies do not provide appropriate guidance to either the local consumers or the municipal authorities for how e-waste should be handled, repurposed, recycled, or disposed of. In short, stakeholders: local authorities, e-waste operators, NGOs and solid waste operators have been working hard to improve the recycling of e-waste among Malaysians, but

mainly on a temporary basis. The e-waste recycling and disposal are still typically disorganized at present. Therefore, a well-configured HERS is essential to guide the public to achieve efficient e-waste recycling. The engagement of stakeholders on this issue is essential to increase household participation and awareness of e-waste recycling.

2.4 E-waste Management Policies and Guidelines in Malaysia

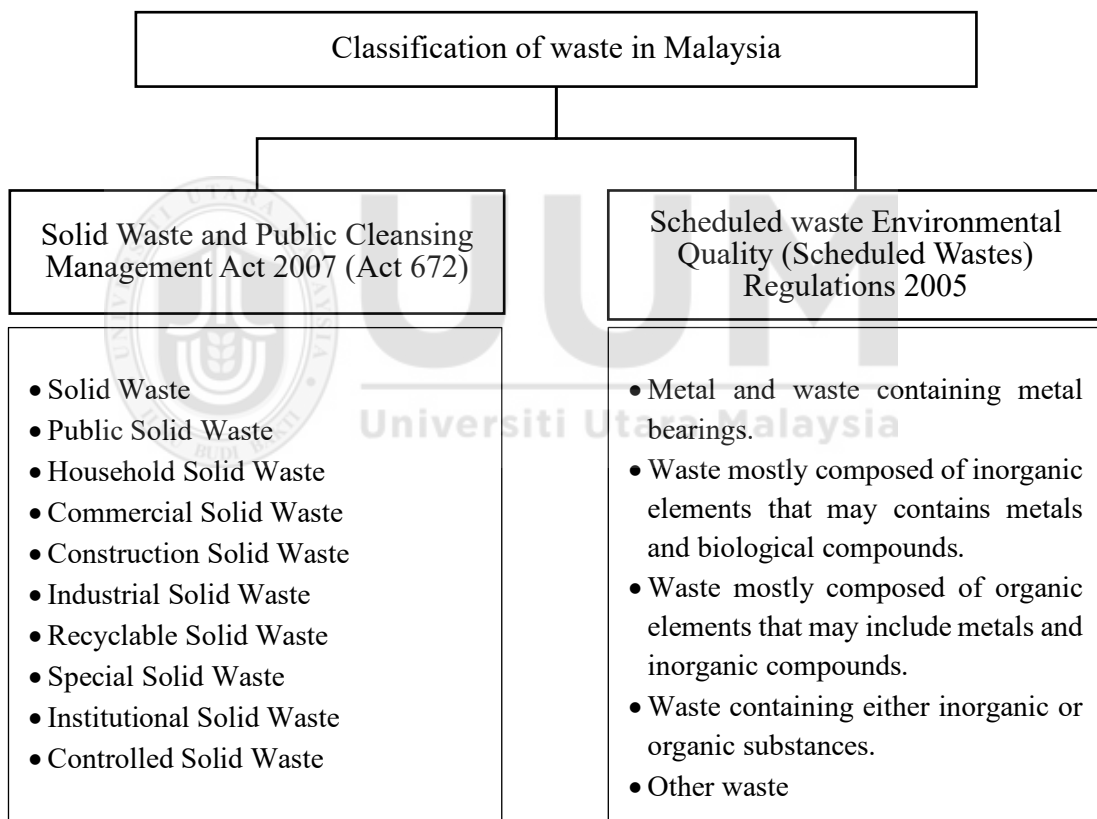


Figure 2.4
Waste classification in Malaysia,
 Source: Pariatamby (2017)

In Malaysia, the DOE operates under the MNRE and is in charge of formulating and enforcing e-waste laws and policies. Figure 2.4 illustrates the classification of waste

in Malaysia as governed by two principal legislative instruments: the Solid Waste and Public Cleansing Management Act 2007 (Act 672) and the Environmental Quality (Scheduled Wastes) Regulations 2005. This classification delineates waste into two major categories: solid waste and scheduled (hazardous) waste.

Under the Solid Waste and Public Cleansing Management Act 2007, waste is categorized into several subtypes, including public solid waste, household solid waste, commercial solid waste, construction solid waste, industrial solid waste, recyclable solid waste, special solid waste, institutional solid waste, and controlled solid waste. This Act primarily addresses municipal and non-hazardous waste streams, with particular emphasis on general household and commercial waste management.

In contrast, the Environmental Quality (Scheduled Wastes) Regulations 2005, under the purview of the Department of Environment (DOE), focuses on the regulation and management of hazardous waste, termed "scheduled waste." This category includes metal-bearing wastes, inorganic wastes containing metals and biological compounds, organic wastes potentially containing hazardous substances, and other toxic or environmentally sensitive waste materials, predominantly originating from industrial and manufacturing processes.

Despite the comprehensive nature of these classifications, Figure 2.4 highlights a critical regulatory gap on the absence of specific provisions for household electrical and e-waste. While industrial e-waste is likely to be classified as scheduled waste, household e-waste is neither distinctly identified nor managed under existing

frameworks. Consequently, household-generated e-waste often falls outside the scope of both Acts, resulting in its improper disposal through conventional municipal waste channels.

This legislative omission is particularly concerning given the increasing volume of e-waste generated by households due to rapid technological advancement and consumer electronics turnover. The lack of an official classification or dedicated policy framework for household e-waste not only impedes effective waste management practices but also poses significant environmental and public health risks.

Therefore, the analysis of Figure 2.4 underscores the urgent need for Malaysia to develop and implement a formal policy and regulatory mechanism for household e-waste management, thereby ensuring the safe, efficient, and sustainable handling of this growing waste stream. Both Mehmood Shad et al. (2020) and Pariatamby (2017) has agreed that, there are no official rules in place in Malaysia to deal with the issue of e-waste. Both the Environmental Quality (Scheduled Waste) Regulations 2005 and Solid Waste and Public Cleansing Management Act 2007 (Act 672) have provisions for the management of e-waste.

These provisions control the collection, treatment, recycling, and disposal of scheduled waste, which includes e-waste. DOE has emphasized a few of the most significant challenges that must be overcome in order to ensure the safe and sound management of e-waste generated by households in Malaysia. These challenges include the difficulty of collecting and transporting the waste, the high cost of utilising

formal methods for the treatment of e-waste, and the requirement of advanced technology that is typically unavailable in developing nations.

2.4.1 Scheduled Waste Environmental Quality (Scheduled Wastes) Regulations 2005

DOE included e-waste as a new waste category in accordance with the Environmental Quality (Scheduled Wastes) Regulations 2005 as a result of a significant rise in the amount of e-waste produced in 2006 (Department of Environment, 2021). The exponential growth in the amount of e-waste produced each year has become the primary impetus for the formulation of new waste and environmental management guidelines in Malaysia (Pariatamby and Victor, 2011). E-waste has been separated into a few different groups, according to the Environmental Quality (Scheduled Wastes) Regulations 2005. Table 2.1 lays out the classification in full.

Table 2.1
E-waste categorization based on environmental quality (scheduled wastes) regulations 2005

Categories	Details
SW 103	Expendable batteries that either included cadmium and nickel, mercury, or lithium as waste.
SW 109	Squandered materials that include mercury and its compound
SW110	Waste from electrical and electronic assemblies that contain components such as accumulators, mercury-switches, glass from cathode-ray tubes and other activated glass or polychlorinated biphenyl-capacitors, or waste that is contaminated with cadmium, mercury, lead, nickel, chromium, copper, lithium, silver, manganese, or polychlorinated biphenyls.

DOE and the MNRE in Malaysia are the entities responsible for managing e-waste, which is categorised as scheduled waste in accordance with the code SW 110 of the Environmental Quality Regulations 2005 (Alias et al., 2014; Junfeng et al., 2018). Despite the existence of e-waste management policies, neither local consumers nor municipal authorities are provided with sufficient guidance on how e-waste should be handled, whether for reuse, recycling, or disposal (Alias et al., 2014).

2.4.2 Solid Waste and Public Cleansing Management Act 2007 (Act 672)

The state and municipal governments were responsible for managing Malaysia's solid waste until to 2011, when the Act 672 came into effect (Pariatamby, 2017). Back then, municipalities contracted with independent firms were responsible to handle the overall waste collection and disposal (Moh and A.Manaf, 2016). Parliament approved the Act 672. On September 1, 2011, the federal government was given executive responsibility over solid waste management in eight states and federal territories when the Act was passed and put into effect.

According to DOE, municipal solid waste collection in Peninsular Malaysia was privatised, with three businesses being awarded concessions to collect waste in three distinct regions as clarified in Table 2.2. The National Solid Waste Management Department's is aiming to reduce landfill waste by 40% by the year 2030. This will have the double benefit of lessening the load on Malaysia's landfills and significantly reducing on the emissions of greenhouse gases that such facilities produce.

Table 2.2

Public cleansing service provider in Malaysia under Act 672

Service Provider	Region	States Covered
Southern Waste Management Environment Sdn Bhd	Southern Region	<ul style="list-style-type: none"> • Johore • Malacca • Negeri Sembilan
Environment Idaman Sdn bhd	Northern Region	<ul style="list-style-type: none"> • Perlis • Kedah
Alam Flora Sdn Bhd	Central and Eastern Region	<ul style="list-style-type: none"> • Kuala Lumpur • Putrajaya • Pahang

Act 672 established a uniform system for managing MSW and encouraged the mandatory separation and recycling of all MSW materials including household e-waste (Moh and A.Manaf, 2016). Act 672 mandates that the Department of National Solid Waste Management collaborate closely with the Solid Waste and Public Cleansing Corporation. This collaboration will take place in full compliance with the law. The National Solid Waste Management Department is in charge of proposing national solid waste management policy, plans, and strategies.

Apart from that, it is also in charge of developing plans for solid waste management facilities and establishing standards, specifications, and codes of practise (Pariatamby and Victor, 2013). Meanwhile, the Solid Waste and Public Cleansing Corporation is accountable for carrying out the department's policies and programmes. In addition to ensuring that standards and rules of practise are followed, it is responsible in raising public knowledge and encourages householders involvement in solid waste management (Yusop and Othman, 2019).

Local governments in Malaysia are responsible for solid waste management, with assistance from private firms such as waste consultants and operators that are hired by the government as stated in the above Table 2.2. Most of the time, the community gets involved in recycling activities on their own will, and the government can only urge the people to sort their garbage and recycle. To that purpose, there is currently no particular regulation requiring households to recycle especially in the context of e-waste (Abdullah et al., 2022).

2.5 Household E-waste Recycling Systems (HERS): Situational Factors

Stakeholder involvement in developing HERS is crucial to improve household recycling participation of e-waste. Due to the large amount of e-waste that must be processed each year, many stakeholders or institutions have initiated appropriate measures to monitor and manage e-waste. In this context, there are studies in Malaysia on the waste recycling system that look at different elements, and take different analytical levels. However, lack of studies were found that specifically evaluate the effectiveness of current actors in the management of HERS at the provincial level.

In Malaysia, HERS includes numerous situational elements which may help towards a productive involvement in household recycling. For a clearer view, researcher decided to portray the different situational factors and every elements discussed under each variables in Table 2.3, which are derived from previous literature.

Table 2.3
Situational factors to facilitate HERS

Situational Factors	Elements of Situational Factors
Accessibility and Availability	<ul style="list-style-type: none"> • Drop-off centres • Collection services • Recycling bins
Convenience	<ul style="list-style-type: none"> • Instructions • Collection frequencies • Distances
Engagement	<ul style="list-style-type: none"> • Incentives • Information • Recycling programmes
Advertising	<ul style="list-style-type: none"> • Media exposure • Advertisements • Public engagement
Education	<ul style="list-style-type: none"> • Curriculum systems • Pro-environmental psychology
Policy and Regulations	<ul style="list-style-type: none"> • Develop a specific e-waste national policy • Enforcement

Table 2.3 outlines the external, contextual conditions that influence household engagement in e-waste recycling. These situational factors play a crucial role in shaping behaviour by either enabling or constraining individuals' willingness and ability to participate in proper e-waste disposal practices. A comprehensive HERS framework must consider these elements in an integrated manner to foster a supportive system that transforms awareness into sustained action. Following subsections further explained and criticized the different situational factors that derived from stakeholders' engagement in managing the recycling systems which might affects household e-waste recycling participation.

2.5.1 The Importance of Accessibility and Availability in Recycling Infrastructure

Accessibility and availability of facilities and services are two fundamental factors in logistics theory to ensure the continuous product flow from the point of origin to the point of consumption (Tseng et al., 2005). It is reasonable to assume that the same principles would also apply to the context of reverse logistics flows as stated by A-Jalil et al. (2014), especially in managing HERS. A-Jalil (2015) agreed that these two combined elements were the main factors for householders to engage in recycling activities on a regular basis.

In a recent study, the accessibility of recycling facilities and services were considered correlated to household waste recycling behaviour (Rousta et al., 2020). They discovered that low participation rates among the householders arise when recycling facilities are not supplied in the householders' residential areas. Lacking e-waste drop-off centres, inadequate recycling bins and inaccessible recycling collection centres may contribute to a low percentage of household e-waste recycling. Therefore, access to appropriate recycling facilities is a critical factor in increasing recycling participation because it can contribute to the success of any recycling scheme provided by stakeholders (Oke and Kruijsen, 2016). They believed that if recycling facilities were widely available, it would eventually encourage recycling behaviour among recyclers. Although Malaysia has constructed a number of material recovery facilities, the country is still having considerable difficulties in handling the ever-increasing volume of e-waste that is being produced (Andeobu et al., 2021).

2.5.2 The Importance of Convenience in Recycling Infrastructure

E-waste infrastructure and services are the recycling facilities and services offered for the disposal of their electrical wastes to households. According to Senawi and Sheau-Ting (2016), the infrastructure and services for recycling e-waste have three components: e-waste recycling stations, e-waste recycling containers and e-waste pickup services. Many researches have demonstrated that poor recycling infrastructure and services will lower the rate of recycling participants. As according to Parameswaran et al. (2015), the number of persons who engaged in recycling increased directly proportional to the level of convenience offered by the recycling infrastructure.

Distances also play an essential part in the promotion of waste, in addition to convenience infrastructure. Community members will be more likely to recycle their e-waste if they are located in an area that is easily accessible (Senawi and Sheau-Ting, 2016). According to Shevchenko et al. (2019), the so-called household's transaction costs connected with the participation process are one way in which people are able to gauge how easy or difficult it will be for them to execute the appropriate behaviour for the recycling of e-waste.

According to Wagner (2013) and Dixit and Vaish (2015), the core of 'convenience' of the appropriate waste management from an EOL product process is determined by reducing all potential householder efforts in terms of transaction costs. Dixit and Vaish (2015) has discovered that customers use their individual resources such as time, effort and money in order to return e-waste. Research conducted by Best and Kneip (2011)

on household waste argued that the average cost of implementation was lower for the curb side recycling system than for the drop-off system.

Wagner (2013) identified five primary areas of convenience requirements in the provision of e-waste facilities and services. First, households need to spend as little time as possible identifying e-waste recycling facilities. Second, it is close to the collection point and householders able to travel a minimum distance to recycle their e-waste. Next, residents should be able to drop off items, allowing them to recycle e-waste in less time. Stakeholders must provide additional services at a drop-off location, and the general simplicity of the procedure must be ensured at all costs.

Prior study in a selected residential area in Kuala Lumpur, Malaysia has demonstrated the importance of recycling infrastructure in support of recycling habit (Zen and Chamhuri, 2015). The lack of recycling facilities will result in a decline in consumer preparedness to recycle, which in turn will bring to a reduction in the recycling rate. Furthermore, the authors Tiep et al. (2015) stated that the government of Malacca need to provide recycled infrastructure for its population so that residents would be aware of where they may recycle their e-waste and so increase the amount of e-waste recycled by Malacca residents.

2.5.3 Enhancing Systems through Stakeholders' Engagement

The establishment of a conversation between all of the involved stakeholders has been a significant contributor to the development of e-waste systems (Queiruga et al., 2012). According to Cahill et al. (2011), several nations have effectively developed constructive participation among all stakeholders, including local governments. Inclusion may be activated, for example, by creating a venue for transparent and regulated stakeholders' dialogue. The parties involved in implementing e-waste collection, classification and disposal alternatives have been found to be between the private sector, the public sector and civil society (Cahill et al., 2011; Ylä-Mella et al., 2014). This indicates that the engagement among stakeholders are crucial in ensuring the success of e-waste management systems.

According to Cahill et al. (2011) and Favot (2015) research, the likelihood of e-waste management success is improved when stakeholders from a variety of policy levels are engaged. The development of channels for communication, coordination, and assistance (financial and advisory) within the e-waste collecting infrastructure has been reported to have a good impact when both private and local authorities are responsible for its development.

Incentives for recycling waste are to provide incentives to people who recycle waste or to anyone in monetary or non-monetary forms. According to A-Jalil (2015) and Grilli and Curtis (2019) incentives can encourage good behavioural changes so that individuals start recycling their e-waste as it allows positive reinforcement to be generated. In current research, incentives are categorised into two groups: financial

incentives and non-financial rewards. Incentives, both monetary and non-monetary, play an essential part in encouraging the recycling of e-waste generated in households. Non-monetary incentives may appear in the form of gifts or coupons that cannot be redeemed for cash directly, while monetary incentives can take the form of cash bonuses, which can come in the form of direct payments, reduced rates, or even the possibility of winning the lottery (Rajapaksa et al., 2019).

These two incentives will stimulate e-waste recycling in the community when it is applied. The study conducted by Abila and Kantola (2019) on perceptions held by customers on the role of monetary rewards in Finland confirmed that monetary incentives is an effective attributes in promoting recycling thus boost household recycling behaviour. Wang et al. (2019) also revealed that the economic advantage of e-waste recycling favourably influenced customer inclinations.

On the other hand, Kianpour et al. (2017) discovered no significant relationship between monetary incentive and recycling intention. In spite of the fact that it is generally accepted that incentives are efficient for bringing about early changes in behaviour, the question of whether or not they are successful over the course of time is still up for discussion. Grilli and Curtis (2019) argued that the motivation to maintain pro-environmental behaviour decreases after the incentives are discontinued.

In a study that focused on the consumer electronics industry and was carried out by Janse et al. (2010) it was discovered that one of the most important factors in successfully managing reverse logistics is having a strategic alliance with all of the

partners in the supply chain. Queiruga et al. (2012) which focuses on the development of the e-waste system in Spain as well as the variables that are influencing that development, claimed that strategic choices on e-waste management takes time to have an effect on companies, but that collaboration among stakeholders is particularly important. Therefore, it is possible that a participatory governance approach, in which a wide range of stakeholders are involved from the beginning at the top levels of government and extending all the way down to the corporate sector and national institutions, will then encourage the participation of all stakeholders at subsequent phases, such as the design and the execution of the project.

An equal engagement of all associated parties based on legitimacy seems to be attainable. The success criterion might be deemed to be fulfilled, when the e-waste stakeholders have a pleasant and trustful connection (Börner and Hegger, 2018). This gives the impression that the stakeholders are working together to incorporate or coordinate themselves in the different e-waste techniques, such as implementation of a common waste management plan that addresses reducing, reusing, and recycling waste products.

2.5.4 The Role of Advertising in Influencing Public Behaviour

With the progress of technology, the rise of social media has become an important tool in the lives of many people since it includes interaction through creation, sharing, and exchange of information, ideas and user-generated material. Social media is seen as a revolution in the making, disrupting conventional communication. With the progress of technology, the rise of social media has become an important tool in the lives of many people since it includes interaction through creation, sharing, and exchange of information, ideas and user-generated material. Sujata et al. (2019) proposed that spreading information about recycling via a variety of different types of media is one strategy to enhance recycling behaviour, and the effect of social media was listed as one of the significant factors that plays a role when recycling attitudes are poor.

In addition, Huete-Alcocer (2017) acknowledged the use of the Internet as a beneficial and efficient instrument for provoking social awareness, participation, and mobilising social actions such as environmental activities of recycling. Specifically, they cited the Internet's ability to reach a large number of people at once. When people are asking for social benefits that need the initiative of a group, the Internet may help spread a variety of voices and translate those words into actions.

Consequently, Khelghat-Doost (2012) emphasized the significant role that the Internet played in making environmental movements more accessible to the general public; this was shown in the campaign that was waged against the Penang Global City Centre in Penang and to save Penang Hill. Particularly in Malaysia, there has been a

significant underutilization of the role and effect that social media may have in promoting environmental sustainability.

The use of social media is thus considered as an influencer that helps individuals to follow a specific behaviour via the contact with others in the social media network. This is because social media platforms encourage users to engage in conversation with one another. Therefore, Muniandy (2015) came to the conclusion that it has the potential to be an effective platform for communicating recycling messages to the general public and acting as a medium to impact recycling intentions and behaviours. To encourage an ever-increasing the amount of individuals that will take part in the recycling of e-waste, public awareness campaigns including various forms of the public sphere's media and communication institutions should be developed in an appropriate manner. This is due to the significance of social pressure in creating recycling practises among householders' e-waste.

To ensure that citizens have the information necessary to recycle and reuse e-waste in an appropriate manner, it is imperative that educational and communication initiatives be implemented (Nguyen et al., 2019), preferably with the assistance of the media. In the course of this study, advertising was taken into consideration as one of the factors that determine whether or not householders recycles their e-waste. Despite the fact that quite a few studies on many other recycling criteria have been conducted in the past, research on this particular aspect needed to be conducted and was relatively scarce.

2.5.5 Role of Education in Shaping Environmental Awareness

One of the most important aspects of efficient waste management is the formalisation and coordination of all actors at all levels, as well as the improvement of education quality via individualised course plans (Kihila et al., 2021). Waste reduction requires education and awareness. Without an education and awareness of environmental sustainability, the quantity of waste produced will continue to rise. Education beginning at an early age is the most effective long-term strategy for addressing the issue of waste management on a global scale (Zainu and Songip, 2017).

Cheng et al., (2022) published a paper on their research stating that the Penang City Council has organised many environmental awareness initiatives, including educational presentations, a campaign, and the distribution of “Say No to Single-Usage Plastics” banners portrayed at schools and shops on the island, all with the goal of decreasing the use of disposable plastics. The city council most likely keep up their efforts to educate the public especially students about waste reduction and recycling, particularly with regards to the Waste Segregation at Source Policy and the implementation of recycling banks in educational institutions (Cheng et al., 2022).

Due to the Covid-19 epidemic, all environmental campaigns and workshops that were supposed to take place in Penang have been forced to be shifted online and conducted via the use of a digital medium, such as by hosting an online lesson for the programme of ‘Virtual Green Adventure Series’ to educate students and other young people about the need of conserving the environment and engaging in sustainability practices (Penang Green Council, 2022).

The programme is a game-based educational technique that provides students and young people with engaging and participatory online sessions based on the United Nations Sustainable Development Goals. Through this initiatives, Penang recycling rates has improved to more than 50% above average. According to Wittstruck and Teuteberg (2012) it is of the utmost significance to be able to acquire an understanding of one another's knowledge of processes and techniques, for example, with respect to dangerous chemicals or working safety via learning and knowledge-sharing programmes that are implemented throughout e-waste networks. Stakeholders will eager to share their knowledge and believe that this condition for success is met if a particular platform for knowledge sharing about e-waste is available. In a further argument, Liu et al. (2019) stated that environmental education has to be encouraged in order to enhance consumer awareness of the need of recycling e-waste.

In addition to this, the implementation of a suitable success assessment and management system for e-waste and reverse logistics is needs to be implemented. The direction and kind of governance aspects such as objectives and targets may impact the ability to analyse and communicate current advancements, making them relevant to knowledge sharing on e-waste and suitable performance assessments (Börner and Hegger, 2018). To this day, it is not quite obvious what kinds of aims and targets public-private governance methods are striving to achieve in order to facilitate success of handling HERS.

2.5.6 The Importance of Policy and Regulation in Shaping Recycling Practices

In recent years, research on waste segregation have included the impact of policy intervention. In order to tackle the e-waste challenges in Malaysia, legislators might look to the recycling models of other nations. In Japan, for instance, the “Home Appliance Recycling Law” governs the country’s e-waste management system by outlining the obligations of all parties involved, from producers to retailers to end users (Nguyen et al., 2019).

Meanwhile, individuals are liable for the correct discharge of obsolete household appliances, the prohibition of the sale of e-waste to illegal operators, and the financial burden of collecting and recycling of such waste materials (Bo and Yamamoto, 2010). According to the results of Nguyen et al. (2019) research, there are a number of factors that affect people’s decisions to recycle e-waste, but the apprehensions about breaking the law possess the greatest impact. Due to the lack of a dedicated policy framework and governing body (Abdullah et al., 2022; Pariatamby, 2017), e-waste management in Malaysia is a pressing issue that has to be addressed as soon as possible via the introduction of laws.

In addition, evidence presented by Yu et al. (2014) demonstrated that citizens’ propensity to recycle e-waste increased as a result of the new rules and regulations. Relatively strict procedures should be put in place to regulate the e-waste problem at the point sources, and regulation is a good example of this; it may lead to a higher recycling rate as a result.

According to Wang et al. (2016), after the rules and restrictions were made public, householders were more environmentally conscious and prepared to recycle e-waste. Adequate regulations and standards, as well as their implementation, are necessary for promoting waste segregation and recycling practises among householders (Kihila et al., 2021). An effective e-waste recycling and management system may be aided by the establishment and implementation of laws and regulations that highlight the inclusion of the duties of all key parties. Nguyen et al. (2019) agreed that government-mandated rules and regulations play a significant role in the recycling of e-waste.

2.6 Household E-waste Recycling Behaviour (HERB): Personal Factors

Examining recycling behaviour has been the subject of research carried out in a wide range of academic subfields and from a wide diversity of specialised points of view. Each field of study investigates the factors that are unique to the domain in which it specialises. For instance, economists frequently investigate monetary incentives, such as pricing that is based on volume or weight, whereas environmental psychologists frequently investigate environmental concerns as the driving force behind recycling (Abila and Kantola, 2019; Grilli and Curtis, 2019; Rajapaksa et al., 2019).

Researchers in sociology, law, and legal studies examine the effects of legal mechanisms such as mandatory recycling, while researchers in engineering primarily investigate recycling technologies and organizational schemes. Sociologists study social pressure, which is the effect of external motivations (A-Jalil, 2015; A-Jalil et al., 2014). There have been several studies since the early 1970s focusing on

household recycling habits and the variables that influence their involvement in recycling activities. When recycling began in 1970 to 1980, economic incentives and demographic features were key factors in the belief that external financial rewards might encourage and reinforce recycling behaviour (Shi et al., 2021).

Ongoing research on social and psychological factors that influence people's long-term commitment to recycling is the focus of the next phase, which runs roughly from 1980 to 1993 (Miafodzyeva and Brandt, 2013). In order to maintain the value of the products and materials across the value chain, household behaviour is very important. Households decide the demand for a variety of items, whether or not to use and maintain those products, and whether or not to return those products to the reuse and recycling system when those products reach the EOL (Shevchenko et al., 2019). E-waste recycling awareness and understanding are major determinants of European consumer behaviour, particularly in western European nations. Increasing public awareness and understanding is the top priority at this time, according to all research (Bovea et al., 2018; Miliute-Plepiene et al., 2016; Pérez-Belis et al., 2015).

The purpose of this section is to offer an overview of the factors that influence HERB as a theoretical foundation for justifying present incentives targeted at boosting EEE collection rates. It provides insight into how incentives function and presents an alternate incentive to promote householders' pro-environmental recycling behaviour in terms of appropriate e-waste collection. The prediction of recycling behaviour comes mainly from the psychological state of individual households (A-Jalil et al., 2014).

Given the growing environmental concerns of householders and stakeholders in the disposal of products and subsequent operation of the reverse logistics process, it is necessary to determine how householders will act in response to certain actions taken by stakeholders. In essence, consumer awareness creates legislation, which in turn drives changes in consumer behaviour. Predictions of recycling behaviour are derived primarily from the household's individual state of mind.

The most important issue to consider in order to achieve high recycling rates is how to guarantee that customers are participating to the fullest extent possible in appropriate collections. There is no doubt that various determinants, such as demographic profiles, environmental knowledge, current habits, conveniences and motivations, influence consumer recycling behaviour in this regard (Colesca et al., 2014). The examination and categorization of recently published and pertinent research articles (Colesca et al., 2014; Shevchenko et al., 2019) indicated that several nations each have their own currently prominent factor that determines the recycling behaviour of householders with regard to e-waste.

In the context of Malaysia, the HERB framework includes several personal factors that may contribute to active participation in household recycling of e-waste. These personal factors are based on behavioural patterns observed within households and are considered essential in influencing recycling practices. To provide a clearer understanding, the researcher has presented the various personal factors along with the corresponding elements under each variable in Table 2.4. The classification and content of these variables are informed by findings from previous literature.

The concept of HERB is largely driven by personal factors as shown in Table 2.4, which refer to the internal, individual-level attributes that influence a person's decision-making and actions regarding e-waste disposal. These factors include psychological aspects such as attitude, social norms, knowledge and experience, awareness and psychological ownership. A comprehensive understanding of e-waste recycling behaviour must, therefore, account for these internal motivators, as they serve as the foundation upon which external interventions can effectively operate.

Table 2.4
Personal factors to facilitate HERB

Personal Factors	Elements of Personal Factors
Attitude	<ul style="list-style-type: none"> • Attitude of recycling • Pro-environmental behaviour • Responsibility towards environment
Social Norms	<ul style="list-style-type: none"> • Willingness to pay • Willingness to separate • Collection services
Knowledge and Experience	<ul style="list-style-type: none"> • Education system • E-waste recycling exposure • Values and beliefs
Awareness	<ul style="list-style-type: none"> • Environmental behaviour • Consequences of e-waste • Proper e-waste treatment
Psychological Ownership	<ul style="list-style-type: none"> • Sentimental values towards electrical items owned • Possessive feelings

The following subsections provide a detailed analysis and critical evaluation of the personal factors rooted in household behavioural patterns, which are believed to significantly shape and influence the level of engagement in household e-waste recycling practices.

2.6.1 The Influence of Attitude on Environmental Behaviour

According to the Theory of Planned Behaviour (TPB), one of the immediate factors that determines intention is an individual's attitude (Ajzen, 1985), and is indirectly related to behaviour. Attitude may filter information and create a person's worldview; it can also affect an individual's behaviour and capacity to change, in addition to knowledge, skills, and ambitions (Speake and Yangke, 2015). The majority of waste management attitudes and behaviours research focuses on household waste (Saphores et al., 2012; Siddiqi et al., 2020) there is, however, a rising research focusing on e-waste (Parameswaran et al., 2015; Pérez-Belis and Bovea, 2014).

Moreover, several prior research showed that attitude is a key determinant of the intention to recycle or recycling behaviour (Apinhapath et al., 2015; Gadiraju, 2016). It has been shown that individual's attitude has a substantial effect on the decision to participate in recycling activities. Current studies conducted by Nguyen et al. (2019) stated that people's attitudes about recycling successfully motivated their behavioural intention to recycle e-waste.

Consequently, it is not sufficient to have environmental awareness, a positive outlook on the goals of environmental protection, or a positive attitude toward recycling technology in order to participate in environmentally responsible waste management practises like recycling. An optimistic individual will recycle because he knows that his actions will help prevent pollution, enhance the efficiency with which landfills are used, and protect the natural world (Afroz et al., 2020). To successfully engage people,

it is necessary to have a feeling of personal efficacy as well as a sense of societal legitimacy for doing such acts.

Several studies have shown that one's attitude may significantly affect his or her actions to perform the act of recycling (Afroz et al., 2020; Akhtar et al., 2014). On the other hand, Dixit and Vaish (2015) found that preconceived notions about recycling did not influence participants' actual recycling behaviour. Understanding the forces that shape pro-recycling behaviours provides useful policy insights and aids in identifying crucial issues that the government, businesses, and grassroots groups may consider in order to better adequately address environmental challenges (Echegaray and Hansstein, 2017).

2.6.2 The Influence of Social Norms on Environmental Behaviour

Social responsibility and moral principles are reflected in people's recycling habits at home. Individuals create social norms as they come to accept responsibility for the repercussions of their actions and when they become aware of the implications of not engaging in a specific conduct (Khalil et al., 2017). A link between social norms and the desire to recycle has been documented in previous research (Khalil et al., 2017; Kianpour et al., 2017; Nguyen et al., 2019; Shaharudin et al., 2020). Having the necessary information and desire to recycle leads to the development of a personal norm for recycling.

In addition, individuals must be aware of, and accept as true, that their recycling efforts will benefit society as a whole and that their failure to do so would have negative implications for themselves and others. Interactional processes such as social learning under interactive governance might potentially impact the way used to improving HERB. The desire of householders to engage in recycling programmes for e-waste is one of the most essential parts of the design process for an e-waste management system (Nguyen et al., 2019). Thus, a recycling program's effectiveness is primarily reliant on the participation of local householder. Hence, it is miles critical to recognize the general householder perceptions on e-waste recycling to layout powerful guidelines that could assist to address e-waste issues.

2.6.3 Knowledge and Experience as Determinants of Sustainable Behaviour

If people are adequately informed on the relevance of recycling, they are more likely to be willing to engage in activities involving the recycling of e-waste (Saritha et al., 2015). This factor is the driving factor for recycling behaviour. On the other hand, when consumers unaware on the need to recycle, this factor becomes an obstacle. Many studies show that one of the main factors that leads to a lack of consumer participation in waste recycling is a lack of awareness. It is estimated that 75% of waste is retained due to lack of awareness (Saritha et al., 2015; Song et al., 2016). In brief, facts have proved that the role of knowledge is crucial to understanding the reasons consumers discharged their e-waste inappropriately.

Recycling is an efficient method that may conserve raw resources and cut down on the amount of energy that is used in industrial production. One of the key issues in waste recycling or disposal is consumer behaviour. There is impossible to build an efficient e-waste recycling system unless the householder returns a product that is currently considered e-waste (Condemi et al., 2019). Therefore, it is important to educate the community about e-waste treatment (Nguyen et al., 2019; Shevchenko et al., 2019).

A householder's exposure to e-waste recycling provides them with the necessary knowledge to properly dispose of their e-waste and encourages them to recycle their own e-waste, which in turn makes a positive contribution to the effective handling of e-waste recycling management. In addition, this study incorporated past experience into the conceptual framework along with householder knowledge to determine the impact of these variables on householder behavioural intention. Based on the logistics research on e-waste recycling, Nguyen et al. (2019) defined past experience as householders' actions and experiences with recycling, with which they are acquainted due to their current knowledge exposure to e-waste. Previous studies have shown that as individuals gain experience in recycling waste, they are more motivated to do so on a regular basis (L. Xu et al., 2017).

2.6.4 The Impact of Consequence Awareness on Individual Behavioural Intentions

Awareness substantially influences an individual's readiness to engage in waste sorting and recycling to determine if they believe the result of waste recycling would be beneficial to the environment (Labib et al., 2021). The examination of an individual's level of awareness regarding the procedures that are a part of the management of e-waste is one of the many steps that are involved in the process of determining whether or not a person is knowledgeable about the management of e-waste and whether or not they understand it (Mahat et al., 2019).

According to the findings of a study that was carried out in Shah Alam by Ahmad Kalana (2010) to determine the general population's degree of education and knowledge sensitivity between the local people, respondents had a comprehensive grasp of e-waste. However, the researchers found that the vast majority of respondents were clueless on how to dispose of old electronic items in an appropriate manner. This assertion is further confirmed by Supian et al. (2015), who argued that individuals were not aware of the appropriate approach to handle e-waste, despite the fact that local governments, including those in Selangor, have already established the separation of solid waste on September 2015, in accordance with the regulations formulated by the Act 672.

According to the findings of an investigation that was carried out by Nguyen et al. (2019), environmental consciousness and a positive outlook on recycling are the two most important factors that affect the outcome of the decision-making process on

whether or not householders want to recycle their electronic material in official collections. This was shown to be the case in the context of formal collections. This demonstrates the fact that individual who participate in recycling e-waste do so in large part because they are aware that such activity helps to the preservation of natural resources and the elimination of environmental problems.

Due to this, it is very necessary for the both private and public stakeholders to develop educational programmes that may increase householder's understanding and awareness the advantages of recycling in terms of protecting natural resources while simultaneously reducing waste deposited in landfills and the release of greenhouse gases. Householders would be more likely to recycle their unwanted EEE if they were aware of the many advantages associated with doing so, which in turn would help to cultivate the widespread of recycling practises for e-waste among householders.

2.6.5 The Role of Psychological Ownership in Motivating Pro-Environmental Behaviour

Within the realm of e-waste disposal, a number of academics have investigated, from the point of view of the TPB, the elements that influence an individual's propensity to recycle (Echegaray and Hansstein, 2017; Kianpour et al., 2017; Liu et al., 2019; Wang et al., 2019). Nevertheless, in contrast to owners of other forms of solid waste such as plastics and paper, owners of EEE may continue to exercise custody of the item even if it is no longer required (Ofori, 2020). These sensations are often the outcome of a connection and emotional relationships that have developed between the owner and the EEE during the course of the its existence.

In layman's terms, individuals are more likely to retain something because they feel emotionally attached to it, which in turn encourages them to hoard it and pass it forward only to their close friends and family. Household appliances and electronics like computers and mobile phones are common fixtures in most people's daily lives. Consequently, the mechanisms of attachment and how they affect reuse and recycling involvement must be taken into account.

Psychological Ownership Theory, proposed by Pierce et al. (2001), implies the formation of proprietary sentiments toward psychological adhesion priorities. This phenomenon has been mentioned as a source of possessive sentiments towards inanimate items and the retention of belongings when they are no longer required. Individuals who save items even after they are no longer useable often have a willingness to be frugal with economic resources, to consider new methods of reuse, and to be environmentally conscious (Ofori, 2020).

As long as individuals are emotionally tied to their belongings, they are more likely to treat the thing with care, delay its replacements or disposal, and fix it when it fails (Cole and Gnanapragasam, 2017). In contrast, one would generally anticipate that a high level of psychological ownership would slow down the process of redirecting undesirable objects toward recycling.

However, the study conducted by Ofori (2020) demonstrated that a sense of psychological ownership significantly enhances individuals' likelihood to engage in both reuse and recycling behaviours. The findings suggest that individuals who

perceive ownership over their electronic products are more inclined to view recycling as a responsible and appropriate means of preventing their e-waste from ending up in landfills. According to the knowledge of the researcher, the psychological ownership component has not yet been employed in the study on recycling e-waste in Malaysia.

2.7 Demographic Profiles and Recycling Participation

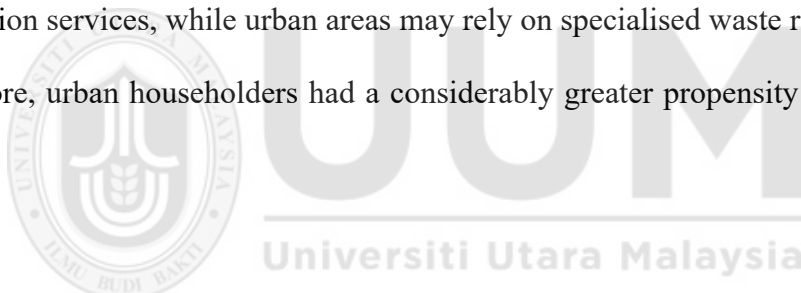
Demographic data on householders, such as age, gender, educational attainment, income, and the subclusters residency, was collected as part of this study in order to examine the influence of households' demographic profiles on their recycling intentions and participation for e-waste. This research was carried out in order to discover the effects of household demographic profiles. It was shown that demographic factors such as age and educational level had the highest influence when looking at householder's willingness to recycle (Nguyen et al., 2019), particularly in the context of e-waste.

In addition, gender and residential location also had a substantial impact on the recycling practises of the recyclers (Saphores et al., 2016). There is limited research that has been conducted as of yet that investigates whether demographic profiles may enhance, weaken, negate, or otherwise modify the link between HERB and HERS that may results in household e-waste participation.

The residential area of the households indicates that various demographic profiles are assigned to pre-defined householder groups. According to the findings of an empirical

research that was reviewed by Zhao and Chen (2021), both urban and rural households are willing to sort their waste and deposit it at predetermined recycling stations. They discovered that urban inhabitants had a considerably greater propensity to sort their waste and drop it at specified sites than rural residents did. This was the case when compared to urban dwellers.

There are a variety of public services available depending on the sort of neighbourhood in China (Zhao and Chen, 2021). There is a substantial disparity in access to public services between rural and urban areas. There are major regional variations in garbage collection as one of the many public services. Many rural areas lack regular trash collection services, while urban areas may rely on specialised waste removal services therefore, urban householders had a considerably greater propensity to recycle their waste.



Furthermore, in urban residential areas, the infrastructures and facilities for the collection, transportation, and disposal of waste and recyclables have evolved over the last few decades, and household waste may be promptly recycled after classification (Yu, 2014). In rural regions, however, government investments in infrastructure have been minimal. Amenities and waste management systems for rural areas remain undeveloped, and rural populations have limited access to facilities and services (Zeng et al., 2015).

All of these factors contribute to increased difficulty in implementing waste recycling in rural locations. In order to assess the demographic profiles impacts of the link

between HERB and HERS on the participation of household e-waste recycling in Malaysia, three subclusters were defined for the purposes of this study: (1) urban, (2) suburban, and (3) rural. The numerous findings of research on the influence of gender on recycling practises have been inconsistent. A research conducted by Rahman and Khondaker (2012) has shown no link between gender and recycling behaviour. In contrast, recent research has indicated that women are more likely than males to engage in environmental projects. Han and Hansen (2012) discovered that females were more inclined to recycle and believed that a lack of involvement in environmental projects would negatively affect them, the eco system, and community far more than males would.

More research is needed to validate the effect of gender in affecting recycling behaviour, specifically on e-waste recycling. Gender was used as a moderating variable in Kumar (2012) research to examine the relationships between predictor factors and residents' desire to engage in waste sorting and recycling. According to Labib et al. (2021), households' willingness to separate their waste for recycling varied according to the gender of the householder, where gender act as moderating variable in the study. Furthermore, demographic factors play significant role, as EcheGARAY and Hansstein (2017) discovered that in Brazil, females and middle-aged individuals with limited incomes had a favourable attitude about e-waste recycling, whereas those with high incomes were more likely to have already adopted this behaviour.

In the previous research, it was also hypothesised that income or wealth had an important influence in determining whether or not people intended to recycle their e-

waste. According to research conducted by Milovantseva and Saphores (2013), those with lower incomes were more inclined to keep their electronic garbage at home rather than recycle it. On the other hand, Echegaray and Hansstein (2017) and Wang et al. (2019) found that people's willingness to recycle e-waste decreased in proportion to their income, so they concluded that those with lower incomes were more likely to recycle e-waste than those with higher incomes. In other words, people with higher earnings had a lower likelihood of recycling their e-waste.

According to the results of research conducted by Marinescu et al. (2016), the age of a person has the greatest influence on the amount of e-waste that is collected. Instead, Zhang et al. (2019) hypothesised that younger individuals, namely those under the age of 30, were more engaged in the recycling of e-waste. In addition, Echegaray and Hansstein (2017) came to the same conclusion whereby people in their middle years are more likely to recycle their e-waste than those of a younger age. Furthermore, Jena and Sarmah (2015) found a correlation between higher levels of education and the likelihood that consumers would want to return previously used items.

Nguyen et al. (2019) found that consumers' recycling intentions were favourably impacted by their level of education, with greater levels of education correlating to a higher desire to execute e-waste recycling. However Zhang et al. (2019) discovered that higher-skilled people were more likely to recycle e-waste through online marketplaces. There is strong evidence from these research that individuals' recycling behaviours are influenced by their educational level.

2.8 Models and Theories Underpinning Household Recycling Behaviour and Stakeholder Participation in Reverse Logistics Symbiosis

Researchers are able to get a better understanding of behaviours and more accurately evaluate the potential causes and effects of certain issues with the assistance of models and theories (Miafodzyeva, 2012). It is critical to recognise that, although individuals should be included in the development of programmes designed to effect behavioural change, such models, and theoretical frameworks are not formulae for changing people's behaviours. The purpose of this study of relevant theories is not to locate a single "right" model that can account for e-waste recycling behaviour; rather, it is to uncover contributing elements that have an effect on that behaviour.

To establish a comprehensive and integrative perspective, this section examines a range of theoretical frameworks and models that collectively underscore the symbiosis effect, with particular emphasis on the dynamic interplay between situational factors and individual behavioural motivators. The discussion begins with a review of the TPB developed by Ajzen (1991), one of the most widely applied psychological models in explaining human behaviour. This is followed by Biel and Thøgersen (2007) theory of which offer nuanced views on pro-environmental action and consumer behaviour

Subsequently, attention is given to the drivers and constraints in reverse logistics as proposed by Carter and Ellram (1998) which provides foundational insights into logistical decision-making processes. Finally, the discussion incorporates the Symbiosis Effect Theory developed by A-Jalil (2015), which directly addresses the

concept of mutual interdependence in reverse logistics systems. Together, these frameworks and models are employed to explain how situational and personal factors interact to inform a holistic understanding of symbiotic effects within the context of reverse logistics and recycling behaviour.

2.8.1 Theory of Planned Behaviour (TPB)

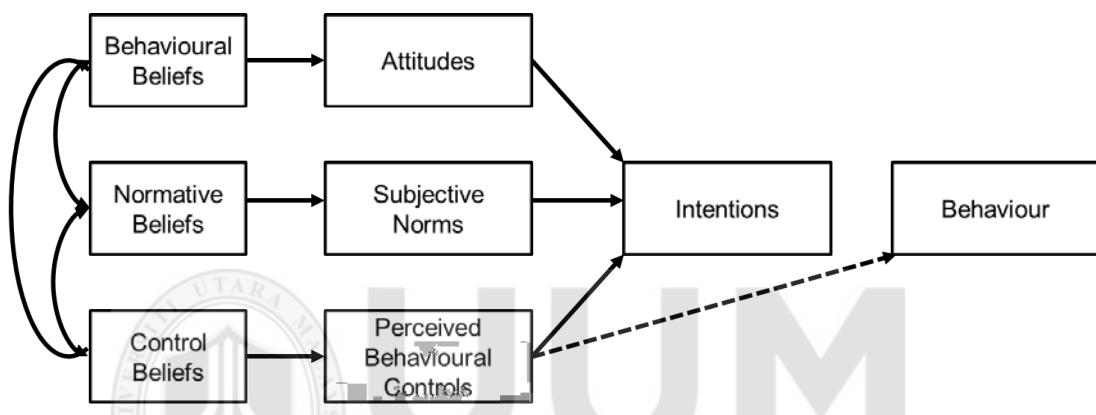


Figure 2.5
Theory of planned behaviour, Ajzen (1991)

Firstly, the conceptual framework developed in this study applies the TPB developed by Ajzen (1991) as illustrates in Figure 2.5 which explains that human behaviour is dependent on personal factors. TPB has been used to explain recycling behaviour more often than any other theories and models. According to this view, individuals always think about the consequences of their acts and have a good reason for the choices they make. Along the same lines as the Theory of Reasoned Action (TRA), TPB holds that a participant's willingness to participate or abstain from a certain behaviour is the primary factor in determining whether or not that behaviour will actually occur. TRA

builds on the foundation of deliberative choice theory by postulating that people have the freedom to engage in or abstain from a wide range of behaviour at will.

However, Miafodzyeva (2012) stated that not all behaviour can be changed only by making a conscious decision to do so. Liska (1984) claims that many behaviours cannot reach their full potential because to a lack of knowledge, experience, and access to desirable environments. Therefore, this shortcoming of the TRA was remedied by adding a third variable, “perceived behaviour control,” resulting in the TPB.

As stated by Ajzen (1985, 1991), there are three types of influences on one’s decisions through TPB:

- i. Behavioural Beliefs : Beliefs about the anticipated results of the behaviour and the judgments of these outcomes, which may be seen of as the individual’s positive or negative attitude toward engaging in the behaviour to perform specific action.
- ii. Normative Beliefs : Beliefs about and drive to conform with the normative expectations of others which may be seen of as the social pressure exerted on a person to engage in or refrain from a certain behaviour.
- iii. Control Beliefs : Beliefs regarding the existence of elements that may promote or hinder execution of the behaviour which may be seen of as the individual’s view of their own capacity to do the behaviour in question.

Figure 2.5 shows the TPB, which states that an individual’s actual execution of a behavioural patterns is influenced by the individual’s intention to undertake the behaviour. Attitudes toward the behaviour, subjective norms on participating in the

behaviour, and beliefs regarding the likelihood of success in engaging in the target behaviour all contribute to the formation of intent. An attitude toward behaviour, according to Ajzen (1985), is a favourable or negative judgement of executing that behaviour. Beliefs influence attitudes, norms influence normative views and willingness to conform, and perceived behaviour control influences beliefs about the individual's possession of the opportunities and resources required to participate in the behaviour (Ajzen, 1991).

Ajzen (1991) stated that TPB is a generic theory that may accommodate the addition of other variables, and it is fully up to the individual researcher to ascertain the specific beliefs that underlie the observed associations between behaviour. This is the model's selling point; which makes it intriguing and applicable to a broad range of behavioural studies. TPB has been utilised in many research to investigate recycling behaviour (Gadiraju, 2016; Labib et al., 2021; Mahat et al., 2019; Nguyen et al., 2019; Senawi and Sheau-Ting, 2016; Shaharudin et al., 2020). These studies have included a variety of other variables, including as moral standards, prior experiences, situational conditions, recycling implications, and socio-demographic characteristics.

In investigations of householder e-waste disposal behaviour, many theoretical techniques have been utilised. Ajzen's theory of TPB, which claims that an individual's behavioural intentions are impacted by their attitude toward conduct, subjective norms, and perceived behavioural control, is one of the most prevalent theories. The perceived behavioural control that occurs in e-waste recycling, according to this theory, reflects an individual's perceived ease or difficulty in completing this

action. Nonetheless, Ajzen's work does not fully mention the process of behavioural activation in explaining the reasons of the behavioural change.

The ABC-Model (ABC-Hypothesis) depicts this principle, revealing that if external circumstances are unfavorable, the influence of attitudes (A) on behaviour (B) will be weak (Guagnano et al., 1995). If the C-determinant demonstrates behaviour that allows appropriate involvement in e-waste recycling, then many will participate, and the attitude (A-determinant) will not be a significant element in behaviour (B-determinant).

Regardless of the A-determinant, if the C-determinant makes the activity excessively difficult, few people will engage in e-waste recycling (Shevchenko et al., 2019). However, it is important to keep in mind that people's beliefs about behaviour, norms and control of their behaviour are influenced by a variety of cultural, personal and contextual factors, which can vary depending on the setting (including cross-cultural) (Hanan, 2014). Therefore, it was essential to include other theories to explain behavioural changes.

2.8.2 Norm-Activation Model

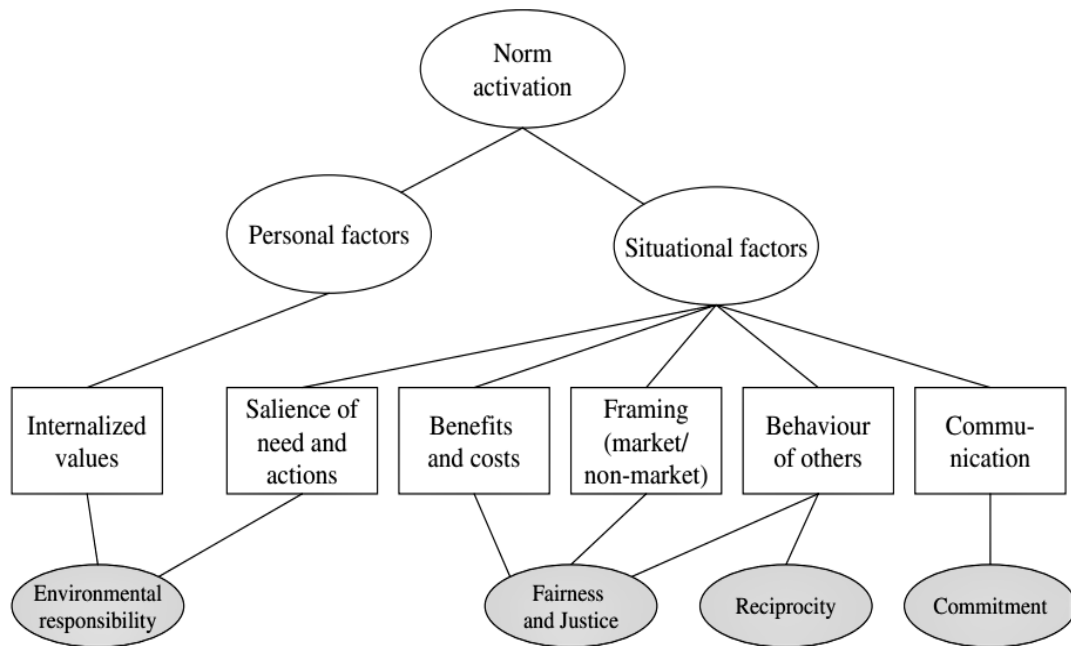


Figure 2.6
The Norm-Activation Model, Biel and Thøgersen (2007)

Figure 2.6 shows Norm-Activation Model constructed by Biel and Thøgersen (2007) which explains that personal factors are triggered into action by situational signals for instance the promotion of recycling initiatives. The personal factors under this model include internalized values whereas the situational factors are categorized in five different aspects: saliency of needs, costs and benefits, framing, individual's behaviour and communication. The two aspects: saliency of needs and actions and internalized values classified from both factors demonstrate the rationality of personal environmental responsibility through its interaction. This model articulates how an individual's behaviour are affected by situational and personal cues. However, this model does not describe the interaction process between both factors.

2.8.3 Model of the Drivers and Constraints in Reverse Logistics

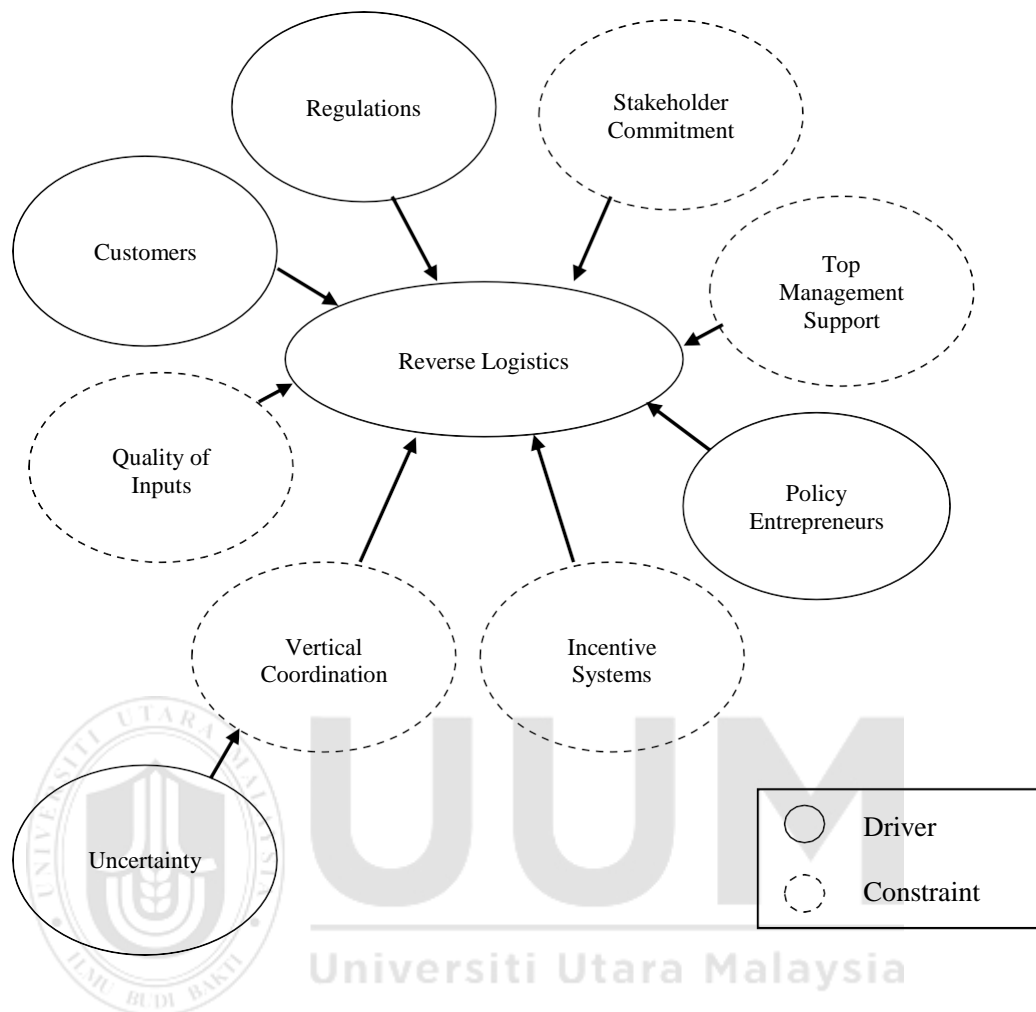


Figure 2.7
The Model of Drivers and Constraints in Reverse Logistics, Carter and Ellram (1998)

The model presented in Figure 2.7, developed by Carter and Ellram (1998), provides a foundational understanding of the systemic dynamics that either drive or constrain reverse logistics activities. Originally conceptualized to explain the enablers and barriers within organizational supply chain contexts, this model has since offered valuable insights when extended to the broader domain of municipal solid waste and e-waste management, particularly when viewed through the lens of reverse logistics

symbiosis. Carter and Ellram's model classifies reverse logistics factors into drivers (depicted by solid circles) and constraints (represented by dashed circles). It highlights the inherently interdisciplinary nature of the field, drawing upon diverse perspectives such as supply chain management, environmental policy, and organizational behaviour.

Additionally, the model facilitates the identification of key actors and driving factors that shape reverse logistics processes. Beyond its descriptive value, the framework provides a foundational reference for researchers aiming to construct comprehensive conceptual or theoretical models in future research endeavours. This model delineates the drivers and constraints that influence reverse logistics activities, which can be extended to conceptualise the interdependent relationships necessary between householders and local stakeholders, including governmental authorities, policymakers, and recycling service providers.

In the context of reverse logistics symbiosis, the drivers such as regulations, customers, and policy entrepreneurs are essential in catalysing household participation. For instance, regulatory frameworks, when clearly communicated and consistently enforced creates an enabling environment that legitimises recycling schemes and instils trust among citizens (Cahill et al., 2011; Zhang et al., 2019). The role of policy entrepreneurs, as posited by Carter and Ellram, parallels that of proactive local stakeholders and environmental waste operators who advocate for behavioural change and facilitate public-private collaboration, thereby nurturing a symbiotic ecosystem for waste recovery.

Moreover, customer influence; here interpreted as household behaviour, directly supports the operationalisation of reverse logistics through sorting, storing, and delivering recyclable materials. As highlighted in recent behavioural studies (Cao et al., 2018; Shi et al., 2021), the behavioural intent to recycle is strengthened when there is clear infrastructure, consistent messaging, and perceived convenience. Hence, households act as both contributors and beneficiaries within the reverse logistics symbiosis system.

Conversely, constraints such as uncertainty, quality of inputs, and lack of vertical coordination reflect the persistent challenges in mobilising and sustaining waste recycling. For example, quality of inputs, as constraint relates to the inconsistent or contaminated recyclable waste often collected from households which cause an issue that requires better sorting education and feedback mechanisms (Singh et al., 2022). Therefore, to foster a symbiotic relationship between households and stakeholders, this model emphasises the need for integrated policy coordination, stakeholder commitment, and context-aware behavioural interventions.

2.8.4 The Symbiosis Effect Theory for Waste Recycling Management

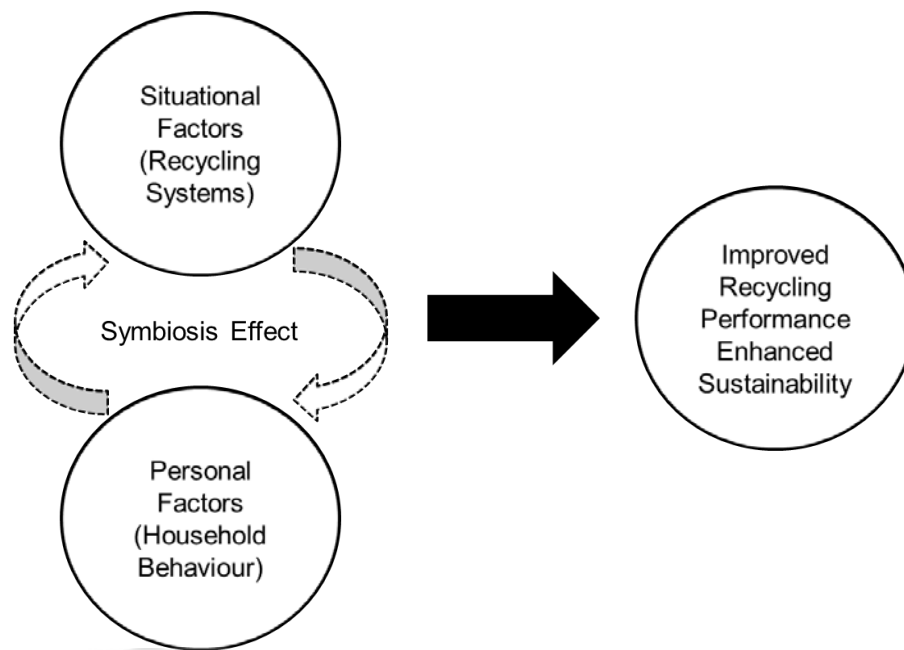


Figure 2.8
The Symbiosis Effect Theory, A-Jalil (2015)

Figure 2.8 conceptualises the Symbiosis Effect Theory developed by A-Jalil (2015), which posits that sustainable recycling outcomes emerge from the dynamic, mutualistic interaction between situational factors (systemic elements of recycling logistics) and personal factors (individual household behaviours). This theoretical lens suggests that neither local municipalities support nor individual action alone is sufficient to drive systemic recycling improvements; rather, it is the interplay and reinforcement between both dimensions that leads to improved recycling performance and enhanced sustainability.

Interaction between HERS and HERB is crucial to improve household e-waste recycling participation. A-Jalil (2015) investigated the household waste systems and

recycling behaviour within the reverse logistics domain and revealed that there are reciprocal interactions existing between situational and personal factors. HERB is influenced by both personal and situational variables in behavioural literature (A-Jalil, 2015; A-Jalil et al., 2014; Thøgersen, 2007). So far, the comprehensive investigation of situation and personal factors, recognizing the interaction between these two factors and exploring the interdependence between these two factors is still quite vague.

The role of behaviour serves an essential part in the household waste recycling system, and the householder works with local authorities to determine the effectiveness or sustainability of the reverse logistics campaign in HERS. A consistent understanding of the relationship therefore reveals that the two elements, both situational and personal, must have a symbiotic impact.

The two previous theory and model: TPB and Norm-Activation Model only focuses on either personal factor or situational factor for the study in behavioural change without concerning about its interactions. Thus, this study incorporates the Theory of Symbiosis Effect developed by A-Jalil (2015), which describes the interaction between two key factors: situational and personal factors driving the recycling participation of local household waste.

In the context of reverse logistics symbiosis, this theory serves as a robust framework to understand how households and stakeholders. This framework was used to investigate the roles of two major players in a sustainable household waste recycling system: recycling systems and household behaviour. The two-way arrows in the

diagram represent feedback loops where each party influences and responds to the other which the institutional systems shape household behaviours while aggregated household actions and participation inform the optimisation and legitimacy of these systems.

According to A-Jalil et al. (2014), the perspective of symbiotic effects theory is conceived as a powerful framework for strengthening both sustainability and economy by codifying the considerations of effective household waste recycling systems and sustainable development. As mentioned by A-Jalil (2015), the Symbiosis Effect Theory framework may be used for future replication or expansion to various areas of knowledge in the future, and it functioned as a starting point to converge multiple lenses of preconceptions.

Consequently, this theoretical framework may be put to the test in order to improve its resilience and flexibility in tackling multidisciplinary research concerns. Therefore, this study adapting the Symbiosis Effect Theory by providing empirical evidence that examines household conditions and personal factors, as well as the involvement of stakeholders in handling e-waste management, specifically in the context of the household e-waste from the source among Malaysians.

2.9 Research Gap

Most behavioural waste recycling studies (Hanan, 2014; Kumar, 2012; L. Xu et al., 2017) have adopted the TPB as their primary framework. The determinants identified in these studies typically focus on the infrastructure and facilities of recycling systems, such as attitudes, awareness, perceived norms, and perceived behavioural control, to explain household recycling behaviour.

To add novelty to the field of recycling behaviour research, this study introduces additional determinants specific to e-waste recycling systems, drawn from past waste management studies through recycling (Colesca et al., 2014; Haron et al., 2018; Mwanza and Mbohwa, 2017; Senawi and Sheau-Ting, 2016; Siddiqi et al., 2020; Yusop and Othman, 2019). These factors include accessibility, availability, convenience, engagement, advertising, education, and policy regulations. While past studies often examine these factors separately, this research combines them to offer deeper insights into developing more effective and efficient recycling systems.

In addition to situational factors, this study introduces a new personal factor adapted from Ofori (2020), psychological ownership, in relation to household e-waste. This factor is explored alongside other personal determinants such as attitude, social norms, knowledge, experience, and awareness. As a result, this study broadens the behavioural recycling research framework by expanding beyond the TPB-based factors, offering a more comprehensive understanding of the complexities involved in e-waste recycling.

Currently, only a limited number of studies have empirically examined the interaction between situational and personal factors. Notably, the research on situational factors (Aksan and Çelikler, 2019; DiGiacomo et al., 2018; Pérez-Belis et al., 2015; Rajapaksa et al., 2019; Yusop and Othman, 2019) explores the design of effective recycling systems, primarily addressing situational factors. However, it does not fully account for the influence of personal factors in shaping household recycling behaviour.

Numerous studies have examined personal factors influencing household recycling participation (Attia et al., 2021; Islam et al., 2016; Lu et al., 2022; Mahat et al., 2019; Saritha et al., 2015; Song et al., 2016; Speake and Yangke, 2015). However, these studies predominantly emphasises individual behaviour, often neglecting the influence of situational factors within recycling systems. This oversight restricts the discourse surrounding situational factors, which exert comparable effects to personal factors.

Effective recycling systems should be developed through the active engagement of local stakeholders in waste management to create a more comprehensive and sustainable approach in improving household recycling participation within the stakeholders' jurisdiction. Most behavioural recycling studies tend to examine either situational or personal factors in isolation, rather than exploring their interaction.

A holistic approach is essential, considering both stakeholders and householders as key players in enhancing recycling participation. These two major actors, who share the same environment, can contribute to a mutually beneficial relationship that fosters sustainable living conditions through recycling initiatives (A-Jalil, 2018). Relying

solely on one group, whether stakeholders or householders, makes it challenging to achieve efficient and effective progress. Instead, both must take responsibility for their respective roles while actively supporting and engaging with each other to ensure a more effective and sustainable recycling system.

The norm-activation theory, as articulated by Biel and Thøgersen (2007) and Park and Ha, (2014), proposes that a reciprocally beneficial relationships, as suggested in this study, can be conceptualised as a symbiosis effect. The mutual benefit arises when householders acknowledge and embrace the expectations of local stakeholders, engaging in recycling efforts to enhance an effective reverse logistics system, contingent upon the stakeholders providing convenient and easily accessible household recycling waste facilities and services.

The current investigation extends the framework established by A-Jalil (2015), which formulated a comprehensive Symbiosis Effect Theory specifically within the realm of solid waste management. This research adapts and evaluates the theory within the specific context of household e-waste, offering a focused examination of this waste stream across three distinct subclusters: urban, suburban, and rural areas. Currently, there is an absence of research that explores the application of the Symbiosis Effect Theory in the context of e-waste management, underscoring the novelty and significance of this investigation.

In waste recycling management, end-users play a pivotal role in supplying recycled materials to the backward stream (Alnuwairan, 2021; Grabara and Man, 2014). Reverse logistics functions as a reactive process, predominantly influenced by end-users, necessitating collaboration with waste management stakeholders to facilitate an efficient flow (Isernia et al., 2019; Islam and Huda, 2018; Li and Tee, 2012). Therefore, it is essential for local municipalities and reverse logistics operators to thoroughly understand the significant importance of household involvement in sustaining both the level of quality and the amount of recyclables. Acknowledging this relationship is crucial for enhancing the overall effectiveness and sustainability of recycling systems.



2.10 Chapter Summary

This chapter reviewed all the relevant literature of previous researchers studying the household behaviour of e-waste recycling. In summary, the applicability of the interdisciplinary approach to understanding a wide range of areas is discussed, involving the two main topics: household e-waste recycling behaviour and household e-waste recycling system (stakeholder involvement). This study further examine the greater impact of personal and situational factors on the participation of household e-waste recycling.

There is limited literature regarding the interaction of the two factors in household waste recycling behaviour. Research shows that it focuses only on situational or individual factors without combining the two indicators. More researchers preferred to focus more on the MSW without explaining in detail in the area of e-waste. The application of multiple knowledge from many disciplines influences current research methods to use a mixed methodology approach, which can clarify and provide a better understanding on the two main factors: situational factors and personal factors in explaining e-waste recycling participation and the influence of the moderating factor of households' demographic profiles.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Introduction

This chapter addresses how the mixed-method approach was used for this study, and how the data and analysis phases as well as the concepts were supported. This chapter highlights the research approach and design framework and illustrates how the selected design was used to address the research questions behind it. As one of the hallmarks of the mixed methodological approach, the research questions play a crucial role in steering the direction of the study frame, and the justifications for the questions' selection are made clear. The following topics are discussed in this chapter: research design, population and sampling, instrumentation, data collection procedures, data analysis techniques and ethical considerations.

The approach that is chosen has to be compatible with the nature of the research topic as well as the overall objective of this study. According to Creswell and Creswell (2018), researchers choose a methodology depending on a number of factors, including the specifics of the research topic or issue at hand, as well as the personal experiences of the researchers and the needs of the target respondents. The single method study design has been employed in a number of studies that have been undertaken on recycling behaviour. As a result, this study proposed more appropriate approaches for answering and realising the research questions and goals. This study employed a mixed methodology approach, specifically by conducting both quantitative and qualitative study to attain a comprehensive understanding of the diverse viewpoints pertaining to household e-waste issues.

3.2. Conceptual Framework

This study builds on two distinctive elements of symbiotic effects, supported by the work of A-Jalil (2015). The two independent variables involved in this study are situational and personal factors. Situational factors are the factors that are derived from recycling systems managed by the stakeholders which affects household e-waste recycling participation. Whereby personal factors are the factors that derived from household behaviour which affects household recycling participation to recycle their e-waste.

Personal factors in the form of attitude, social norms, knowledge and experience, awareness and psychological ownership were primarily proposed to be necessary to influence households' recycling behaviour, and situational factors in the form of accessibility and availability, convenience, engagement, advertising, education and policy and regulations were considered to be indicative of households' recycling behaviour whereby demographic profiles act as the moderating variable in this research.

By considering the symbiosis effect, the interactions between both major factors can be understood more clearly. It helps to determine effective ways to deal with household e-waste problems by cultivating more favourable behaviour toward household e-waste recycling with the existence of recycling systems. According to A-Jalil (2015), the theory of symbiotic effects complements each other and is supported by several theories that are suitable for understanding the study of reverse logistics in waste management. Therefore, it is possible to address the research questions developed in this study and achieve the research objectives more effectively.

Furthermore, using the same symbiotic approach, there is a possibility to further investigate the household recycling behaviour domain or scope depending on nations and cultural variations. Previously, the Symbiosis Effect Theory was examined among the householders inside the two municipalities of the United Kingdom; thus, this research was carried out within the residence of Malaysia under household e-waste. A-Jalil (2015) also suggested that an empirical investigation should be expanded to investigate the primary facilitators of the symbiotic effect in detail.

As a result, this research conducted a cross-sectional study to investigate recycling behaviour for household e-waste in relation to household demographic profiles, based on resident profiles, and the extension of elements of household personal characteristics between HERS and HERB. For the purposes of this investigation, three subclusters were established so that the demographic profiles implications could be evaluated on the link between HERB and HERS towards household e-waste recycling participation in Malaysia: (1) urban, (2) suburban and (3) rural.

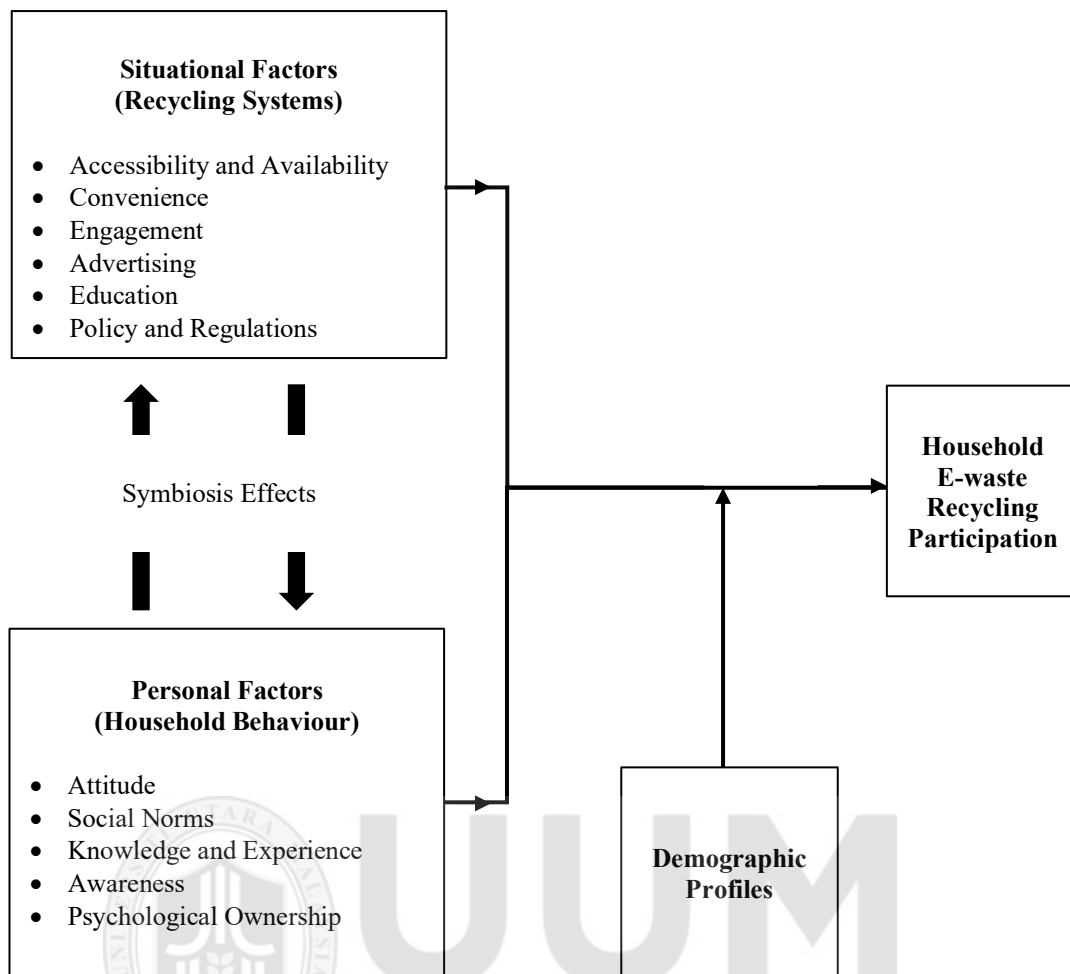


Figure 3.1
 Conceptual framework adapted and modified from A-Jalil, 2015

Figure 3.1 presents the research framework, which visually encapsulates the key relationships derived from the formulated research questions. The Symbiosis Effect Theory provided a platform upon which to converge divergent points of view and suggested that the framework may be utilised for future replication or extension to diverse fields of knowledge (A-Jalil, 2015). As a consequence of this, this theoretical framework was put to the test in order to strengthen its robustness and adaptability in the face of challenges posed by interdisciplinary research. Specifically, this research focuses primarily on the management of household e-waste from its source, in contrast to the A-Jalil (2015) case study, which focused on the management of solid waste.

Previous research conducted by A-Jalil (2015) examined the Symbiosis Effect Theory in a case study using two United Kingdom municipalities (the East Riding of Yorkshire Municipality and the City of Hull Municipality), whereas this current research tested this theory within the context of Malaysia.

In addition, the scope of this study was expanded to investigate in more detail other determinants for both situational and personal aspects. When researching the tendency of Malaysian households to recycle e-waste, two new criteria were added to the theory's initial list of considerations: policy and regulations, as well as psychological ownership. A-Jalil (2015) also recommended carrying up a cross-sectional study to delve deeper into the differences in recycling practices based on residency profiles and the incorporation of other elements of individual characteristics, such as cultural context.

As a result, this research expanded the original Symbiosis Effect Theory by including demographic profiles as a moderating variable to test whether the interactions between both factors (situational and personal) and household e-waste recycling participation vary depending on demographic profiles. The details of the new variables were covered in the previous chapter.

3.3. Investigating the Symbiotic Relationship between HERS and HERB: The Research Paradigm

This research is underpinned by the pragmatic research paradigm, which offers an appropriate philosophical foundation to explore the complex and context-dependent interactions between HERS and HERB. Given the study's aim to investigate the symbiotic relationship between situational and behavioural domains influencing household recycling participation, pragmatism serves as a bridge between differing epistemological and ontological perspectives.

According to (Creswell & Creswell, 2018), pragmatism is not committed to any one system of philosophy or reality. Instead, it focuses on the research problem and uses all available approaches to understand it. Pragmatism views knowledge as both constructed and grounded in experience, making it suitable for studies that require both subjective interpretation and objective generalisation. This aligns with the current study's use of quantitative survey data to generalise behavioural patterns and qualitative FGD to uncover deep, contextual insights from stakeholders and households.

The research adopts a pluralist epistemology, recognising that knowledge about e-waste recycling participation can be both measurable and experiential. Surveys were used to examine statistically significant relationships among personal, situational, and demographic factors, while focus groups helped interpret how these factors interact symbiotically at the community and institutional levels. This blend of epistemologies enables a nuanced analysis of way HERS mutually influence and are influenced by HERB.

From an ontological perspective, pragmatism acknowledges that reality is complex, dynamic, and constructed through the interaction of multiple agents and systems (Morgan, 2007). This suits the conceptual model that highlights bidirectional influence or symbiosis between HERS and HERB. Such a model necessitates a research philosophy that does not reduce phenomena to singular causes but embraces interdependence and multi-dimensionality.

Moreover, pragmatism is especially relevant for sustainability and behavioural research in real-world contexts, such as environmental waste management. As highlighted by (Johnson & Onwuegbuzie, 2004), pragmatism enables researchers to draw from both qualitative and quantitative traditions, thereby enhancing the robustness and practicality of findings. In this study, the mixed-methods approach allows the researcher to integrate measurable behavioural constructs with stakeholders' contextual understanding of system limitations and opportunities.

The methodological pluralism encouraged by pragmatism not only legitimises the coexistence of positivist and interpretivist tools but also supports the goal of improving behavioural practice and systems engagement. In conclusion, the pragmatic paradigm provides the flexibility and philosophical coherence necessary to investigate the symbiotic effects between stakeholders' engagement and household behaviour in e-waste recycling. It supports a methodologically integrative, problem-centred, and outcome-oriented approach that well aligned with the study's conceptual framework and empirical goals.

3.4. Research Design

This research employed a mixed methods research design. Both qualitative and quantitative were deployed to address the ROs and RQs. In this study, both qualitative and quantitative research methods were appropriate to be utilised in order to understand the interactions between householders and stakeholders towards e-waste recycling. Recycling studies have been approached quantitatively or qualitatively in previous literature (Rubio et al., 2008), while both techniques have utilised together a small number of similar research (A-Jalil, 2015; Castro et al., 2014). Barr et al. (2013) suggest an integrated approach that uses mixed methods to further explain recycling behaviour among householders. This study investigated recycling behaviour among distinct subclusters of householders, namely urban, suburban and rural. The issues presented concerned which variables impact recycling behaviour, as well as the experience, or character of various groups of households' recycling behaviour.

The objective of this study is to examine the impact of two independent variables: situational factors (accessibility and availability, convenience, engagement, advertising, education, policy and regulations) and personal factors (attitude, social norms, knowledge and experience, awareness and psychological ownership) on the intention to recycle e-waste equipment and the proper recycling behaviour. This research analysed the existence of a symbiotic relationship between the two factors. Furthermore, this research also focuses on examining the effect of household demographic profiles moderating the relationship between both situational and personal factors towards household e-waste recycling in Malaysia. This study was based on one of the six e-waste subcategories (Forti et al., 2020) that belongs to the category of small computer and telecommunications equipment, including small portable electrical and

electronic devices such as mobile phones, portable and digital video recorders, batteries, chargers and other integrated electrical or electronic accessories connected to the device. In this study, the survey was strategically utilised to obtain primary sources from selected respondents (householders) and informants (local stakeholders).

Nevertheless, the study clearly identified individual factors in the householder's attitude toward recycling and ignored the possibility of an interaction between individual factors and situational factors. Thus, Barr's study found that current situational factors were the strong predictors for improving householders' recycling attitudes. Furthermore, the nature of this study requires the use of both quantitative and qualitative research methods. Almalki (2016) argues that mixed methods are suitable for any research project, as the use of mixed methods provides more insights that cannot be obtained with a single approach. In addition, researchers should use mixed method design to solve complex problems in research projects (Halcomb and Hickman, 2015). It is obvious that a mixed approach can be used to capture both the objective and subjective viewpoints of reality in order to provide a complete explanation of the interaction between two elements of behavioural and operational knowledge.

Recognizing that all methods have limitations and that relying on a single data source is not enough, a mixed method design is beneficial to reduce and overcome flaws and constraints of a single research technique and for a better understanding of research problem or issues (Creswell and Creswell, 2018). This study agreed with the relevancy of a mixed-methodological approach to addressing research questions, as it can be used quantitatively or qualitatively to understand meanings and nuances when a subject requires an objective account of a worldview. Therefore, in this study, researcher

proposed an integrated approach to describe household e-waste recycling participation using a mixed methodology because it is an optimal approach to address the developed research question. The motivation of this research is the need to explain the existence of symbiosis effect, as depicted in Figure 3.1, between the recycling systems by the stakeholders and the household behaviour, in order to achieve sustainability in the context of household e-waste recycling management, thereby explaining the possible interactions between both factors and household e-waste recycling participation with the household demographic profiles.

3.4.1 Mixed-Methods Explanatory Sequential Design

In the past, recycling studies have been addressed quantitatively or qualitatively (Jena and Sarmah, 2015; B. Wang et al., 2019; Yusop and Othman, 2019; Zen and Siwar, 2014), but only a small number of comparable studies have applied both techniques simultaneously (A-Jalil, 2015; Castro et al., 2014). Dominantly, research on households' attitudes views towards recycling focused only on personal factors rather than recognising the potential for interplay between both personal and situational variables. The empirical results of the A-Jalil (2015) research postulate the interplay of the two separate factors; personal and situational influences. However, the study only looked at two localities in the United Kingdom, focusing on MSW. Therefore, this study proposed an integrated strategy using mixed methodology to understand household recycling behaviour as proposed by Barr et al. (2013) in the context of household e-waste by adapting the A-Jalil (2015) theoretical framework.

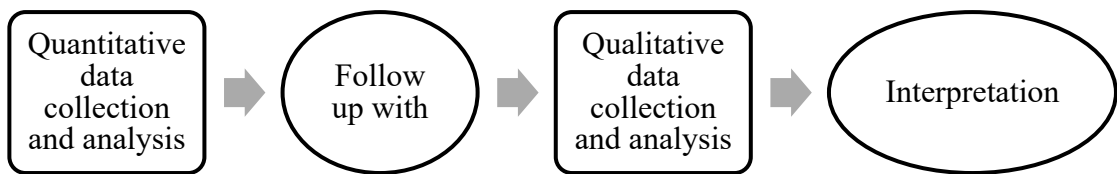


Figure 3.2
Flowchart of explanatory sequential mixed method design (Creswell and Clark, 2018)

Figure 3.2 illustrates the flowchart of the explanatory sequential mixed methods design, as adapted from Creswell and Clark (2018). In an explanatory sequential design, a two-phase research approach is employed, where quantitative data is collected and analysed first. The results of this initial phase inform the subsequent qualitative data collection and analysis, which aims to provide deeper insights and explanations for the quantitative findings (Creswell and Clark, 2018). This design is particularly useful for identifying patterns or relationships within numerical data and subsequently exploring respondents' perspectives to explain these patterns in greater depth (Ivankova et al., 2006). The objective of the second qualitative phase is typically to elucidate the findings obtained in the first quantitative phase. Researcher added triangulation phase three to further explain the final interpretation. A visual representation of this process is depicted as a flowchart in Figure 3.3, illustrating the sequential of the research phases conducted in this study.



Figure 3.3
Flowchart of research design based on explanatory sequential mixed method design adapted from Creswell and Clark, 2018

The study population and sampling strategy were identified before the discussion of the explanatory sequential phases. The next sections explain the sampling strategy used before the measures conducted in the explanatory sequential design for this mixed methodology research.

3.5. Target Population

In Malaysia, various residential areas or clusters of homes might qualify for a plethora of different forms of public services. Access to public services is drastically different in rural residential areas compared to urban residential areas. This disparity is significant. The collection of waste is one of the public services that differs greatly from one region to another, most noticeably concerning e-waste. While many rural residential areas do not even have normal waste disposal services, urban residential areas often have specialised e-waste collection centres and drop-off or disposal services. Urban residential areas also tend to have more recycling options. The participants in this research were drawn from a population of stakeholders and householders in the two states of Northern Region Malaysia namely, Kedah and Penang. In order to assess the participation of household e-waste recycling in Malaysia, for the purposes of this study, three subclusters were defined for the above-mentioned states: (1) urban, (2) suburban, and (3) rural. This thesis addressed the three subclusters of Kedah and Penang in terms of enhancing the understanding to supplement knowledge as well as highlighted of any shortcomings in comprehending the recycling behaviour of householders residing in separate clusters.

3.5.1 Geographic and Demographic Profiles of Kedah



Figure 3.4
Map of Kedah State

The state of Kedah as shown in Figure 3.4 can be found in the far north-western part of Peninsular Malaysia., which has a total area of 9,492 km² and is inhabited by an estimated population of 2.19 million people (Department of Statistics Malaysia, 2022). Kedah shares its borders with the neighbouring state of Perlis to the north, the Straits of Malacca to the west, and Penang and Perak to the south. The state of Kedah contains twelve major districts named Kota Setar, Pokok Sena, Kubang Pasu, Padang Terap, Pendang, Sik, Baling, Kulim, Bandar Baharu, Kuala Muda, Yan and Langkawi. After Penang, one of the cities in the northern area that is seeing rapid growth is Alor Setar, which serves as the state capital of Kedah. Malays, Chinese, and Indians are the three largest ethnic groups in Kedah's population, along with certain Malaysian Siamese ethnic groups. Kedah's population is highly diverse due to its composition, which

includes these three main ethnic groups. The majority of residential areas in Kedah are made up of a variety of dwelling styles, including traditional houses, single-story homes, terraced homes, and low-density multi-story buildings (Department of Statistics Malaysia, 2020). The territories that makeup Kedah are diverse geographically, consisting of a combination of urban, suburban, and rural settings.

3.5.2 Geographic and Demographic Profiles of Penang

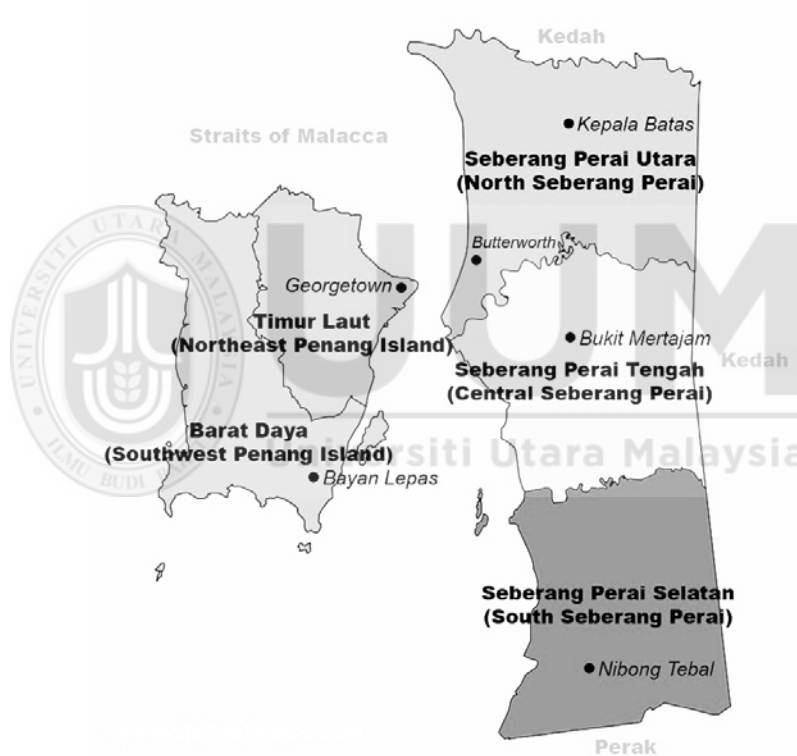


Figure 3.5
Map of Penang State

The location of the state of Penang as shown in Figure 3.5 places it in the north part of West Malaysia. Georgetown and Butterworth are the two areas that make up this region's division. Butterworth is situated on the West Malaysian mainland, while Georgetown is located on the island and act as the capital city of Penang. The state of Penang, which encompasses both the island and the mainland, has an estimated

population of 1.77 million people and spans a total area of 1,049 km² in north-western Peninsular Malaysia (Department of Statistics Malaysia, 2022). The state's administrative and economic activities are mostly concentrated at Georgetown, which is located in the most north-eastern point of the island. According to Department of Statistics Malaysia (2022), Penang's population consists of a harmonious blend of Malaysia's main ethnicities, with Malays accounting for 32%, Chinese for 59%, and Indians for 7%. The proportion of the population living in urban areas has been growing at a faster pace in Malaysia. In point of fact, Malaysia was one of the nations in East Asia with the highest urbanisation rates.

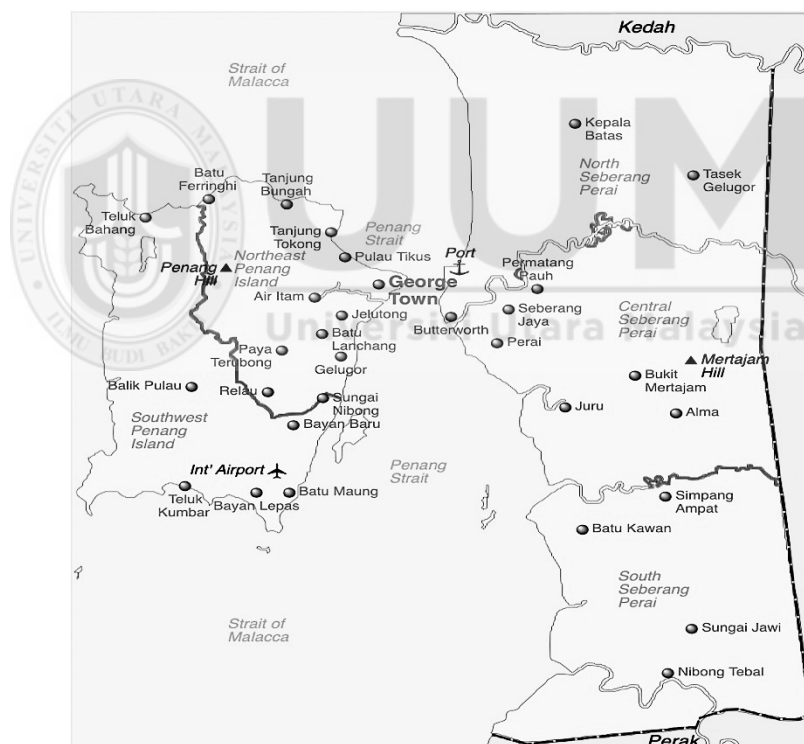


Figure 3.6
A map of Penang showing the locations of the main cities of Georgetown, its suburbs, and other major localities

According to the statistics, the percentage of the Malaysian population that lives in urban areas has expanded from 66 % in the year 2004 to 71 % in the year 2010 and then to 75.5 % in the year 2017. Malaysia's urban population growth was among the quickest in the area, with an average annual growth rate of 4% of the country's total population. According to a current report by Department of Statistics Malaysia, Penang, has a degree of urbanisation of 90.8%, which exceeds the national urban rate and makes it one of the most urbanised states in the whole nation.

Penang is Malaysia's second smallest state by geographical mass. The capital city of Georgetown consists of thirteen districts and 137 subdistricts. Despite being Malaysia's second smallest state, it is one of its most populous and is the second largest metropolitan area in Malaysia after Kuala Lumpur. Penang is a sprawling metropolitan region that consists of various towns and the suburbs of a core metropolis that have merged together. George Town, Bayan Lepas, Butterworth, and Bukit Mertajam and Nibong Tebal are the primary urban centres in the conurbations (Samat and Mahamud, 2019). As shown in Figure 3.6, the map of Penang illustrates the locations of the main city of George Town, its surrounding suburbs, and other major localities relevant to the study area. Penang's shifting demographics are both remarkable and baffling.

The households in the states of Kedah and Penang made up the population that was selected for this study. The following are the primary factors that led to the selection of these two areas:

i. Increase Recycling Rates

The reason these two states of communities had been selected as these states had previously led to low recycling participation (Department of Environment, 2021), but in recent years, both states’ recycling rates have increased. As shown in Table 3.1 below, Penang currently records a recycling rate that exceeds 50%, significantly higher than the national average of 32% in 2021. This makes Penang the leading state in Malaysia in terms of recycling performance.

Table 3.1
Recycling participation rates for Kedah and Penang

States	Recycling Rates (%)			
	2009	2013 – 2015	2017 – 2019	2020 – 2021
Kedah	N/A	5	15	28.1
Penang	23.6	32.7	43.3	56.8

Source: Department of Environment (2021)

ii. Different Waste Management Strategy

The implementation of Act 672 began on September 1, 2011. There are six states and two federal territories in Malaysia that have recognised and conformed with Act 672. These states are Perlis, Kedah, Pahang, Negeri Sembilan, Melaka, and Johore. The federal territories of Kuala Lumpur and Putrajaya are also included in this list. Kedah was chosen as one of the study areas for this research because it is located in one of the

states that started the implementation of Act 672. According to Act 672, the federal government is in charge of the management of solid waste and the privatisation of concessionaires that were formerly handled by the municipal authorities (Moh and A.Manaf, 2016). Municipal solid waste has established the National Solid Waste Management Department as the regulatory agency and the Solid Waste and Public Cleansing Management Corporation (SWCorp) to handle operations under the Ministry of Housing and Local Government. Local governments, on the other hand, would constantly monitor and enforce plastic and waste disposal procedures that may be developed with the application of policy regulations and fines imposed on the public (Puluhulawa and Puluhulawa, 2021).

Under the provisions of Act 672, the states began implementing the waste segregation at source code in September of 2015. Meanwhile, beginning in 2016, the programme is obligatory, with non-compliance punishable by a fine of up to RM1000. The program's goals include increasing recycling rates, reducing waste disposal in landfills, and protecting the environment and human health. In addition, the 2 + 1 system, a new garbage collecting method, was established. The method enables for non-recyclable items to be collected twice per week and recyclable goods to be collected once per week (Rangga et al., 2022). Private concessionaires, Environment Idaman Sdn. Bhd., conduct waste collection and transportation services in Kedah under the supervision of SWCorp.

Penang is one of the states that does not embrace Act 672 and instead follows the Local Government Act of 1976 (Act 171). Apart from Penang, Act 672 does not govern the administration and enforcement of its provisions in the other seven states of Malaysia, namely Selangor, Perak, Kelantan, Terengganu, Sabah, and Sarawak, as well as the

Federal Territory of Labuan. This law gives the local authority the capacity for the purpose of waste management and the provision of sanitary services, and it distinguishes itself from the federal level by cooperating with local authorities (Cheng et al., 2022). The use of landfills continues to be the standard practise for the management of solid waste on both the island and the mainland. The Pulau Burung Sanitary Landfill in Nibong Tebal is where waste is sent to be disposed of (Penang Green Council, 2022). Since June 2017, the state of Penang has been enforcing the Waste Segregation at Source Policy, which requires the separation of solid waste into recyclable waste and general waste. The goals of this policy are to increase the percentage of waste that is recycled and to extend the amount of time that waste can be stored in landfills. Given that both states utilise distinct waste management strategies, it is empirical for this study to examine whether differing household e-waste management practises in each location proposed a different impact on the participation of the household e-waste recycling participation.

iii. Unique Demographic Background

The selected municipalities, Kedah and Penang, exhibit distinct demographic characteristics, making them ideal case studies for examining variations in household e-waste recycling participation. These states were chosen due to their differing levels of urbanization, allowing the research to encompass a broad spectrum of demographic settings, including urban, suburban, and rural communities. Despite their geographical proximity, Kedah and Penang demonstrate significant differences in their socio-economic composition, infrastructure development, and environmental policies, all of which can potentially influence recycling behaviours.

Kedah, characterized by a mix of rural, suburban, and urban areas, represents a more heterogeneous landscape with varying degrees of economic development, accessibility to waste management services, and public awareness regarding e-waste recycling. In contrast, Penang is largely urban and suburban, featuring higher population density, greater technological penetration, and more established recycling initiatives. These disparities provide a robust framework for investigating how situational (e.g., availability of recycling facilities, government policies) and personal (e.g., environmental awareness, socioeconomic status) factors interact to shape household participation in e-waste recycling.

By incorporating these demographic subclusters; rural, suburban, and urban, within the Malaysian context, this study aims to offer a comprehensive analysis of the facilitators and barriers to e-waste recycling across diverse socio-environmental settings. The findings contribute valuable insights for policymakers and stakeholders in designing targeted interventions that enhance e-waste recycling participation across different community profiles.

iv. Accessible Fieldwork

The selected research locations provided a practical and feasible setting for fieldwork, ensuring accessibility despite the researcher's logistical constraints. The suitability of the population parameters allowed for efficient data collection, enabling the researcher to conduct the study effectively within the available resources and capabilities.

3.6. PHASE 1: Quantitative Phase

3.6.1 Data Collection Method: Survey

In the quantitative phase of this study, data were collected using a structured questionnaire administered through an online survey platform. Survey-based data collection is widely recognised as a fundamental method in quantitative research due to its ability to generate standardised data that can be statistically analysed to test hypotheses, examine relationships, and identify patterns across a large sample (Creswell and Creswell, 2018). The structured nature of surveys enhances the reliability and validity of responses, particularly when the aim is to generalise findings to a broader population (Saunders et al., 2019).

There are several established types of questionnaires, each with specific strengths and limitations namely; self-administered paper-based surveys, postal questionnaires, and online surveys (Blaikie, 2010). After a careful evaluation of these formats, the researcher selected the online survey method. Online surveys offer several advantages, including cost-effectiveness, broad geographical reach, faster data collection, automated data entry, and increased convenience for respondents (Evans & Mathur, 2005).

The questionnaire was distributed among the stakeholders and households in the two Northern Region states of Kedah and Penang using stratified sampling method. The respondents were primarily householders who have utilised reusable, repairable and recyclable electronic devices. Participants were asked to complete an online self-report survey through Google Forms. The link of the questionnaire were generated and shared during the FGD and individual interview sessions. The questionnaire link were also

distributed through several groups in social media platforms with the involvement of participants from both study states. Data collection for the quantitative phase was conducted over a period of approximately seven months.

Online surveys have grown in popularity in recent years, and they allow for a bigger number of participants since they simply need the participant to have internet connection (Peeta and Ramos, 2006). Furthermore, further data shows that online surveys are beneficial in terms of lowering research expenses, permitting shorter response times, and perhaps improving response rates (Jansen et al., 2007). These advantages stem from the fact that online surveys allow participants to participate at their own schedule.

3.6.2 Sampling Strategies

This study conducted in the northern region of Malaysia which comprises the two northernmost states of Kedah and Penang. According to a current statistical report by Department of Statistics Malaysia, the approximate residents of Kedah is 2,190,000 whereas Penang is 1,770,000. Using stratified method of selecting samples from the population, a proportional balance of demographic background is vital to generalize the Malaysians' views on household e-waste recycling system. The method of stratification was based on geographical location whereby a proportionate of urban, suburban and rural areas were selected. In accordance with Sekaran Technique for sampling size, the estimation for each state is based on the population size (National Census, 2010). Using 95% confidence level and margin error of 5%, the target sample size for this study were 385 samples of households.

3.6.3 Demographic of the Respondents

The research commences by conducting a descriptive analysis, which involves examining the demographic characteristics of a population as constructed below in Table 3.2. This is achieved by analysing a sample of the population to create a descriptive demographic profile, specifically focusing on their socio-economic background. Therefore, it was imperative for the present study to ascertain the demographic background of the participants, as it constitutes a crucial component of the personal factor. This personal factor is recognised as one of the key constructs for conducting inferential statistical analysis in subsequent sections of the study.

Table 3.2
Demographic breakdown of respondents

Demographic Profile	Number of Respondents (N=364)	Percentage (%)
Gender		
Male	160	44.0
Female	204	56.0
Age		
20 years old and below	9	2.5
21 to 30 years old	139	38.2
31 to 40 years old	138	37.9
41 to 50 years old	46	12.6
51 years old and above	32	8.8
Marital Status		
Single	137	37.6
Married	227	62.4
Nationality		
Malaysian	355	97.5
Other	9	2.5
Academic Qualification		
High school	29	8.0
University	318	87.4
Professional certificate	14	3.8
Other	3	0.8
Employment Status		
Student	48	13.2
Government sector	114	31.3
Private sector	178	48.9
Unemployed	13	3.6
Retiree	11	3.0

Household Number	61	16.8
Single occupants	72	19.8
Double occupants	175	48.1
3 to 4 occupants	56	15.4
Other		
Residing State	160	44.0
Kedah	204	56.0
Penang		
Residing Area	168	46.2
Urban	143	39.3
Suburban	53	14.6
Rural		
Years Living in Residing State	6	1.6
Less than a year	52	14.3
1 to 5 years	69	19.0
6 to 10 years	237	65.1
More than 10 years		
Type of Dwelling	17	4.7
Flat	56	15.4
Apartment or condominium	176	48.4
Terrace or super link	107	29.4
Bungalow or lot house	8	2.2
Other		
Household Income	101	27.7
B40 (RM4,850 and below)	232	63.7
M40 (RM4,851 – RM10,970)	31	8.5
T20 (RM10,971 and above)		
Frequency of Buying New EEE	8	2.2
Once in less than 12 months	61	16.8
Once a year	178	48.9
Once in 2 to 3 years	117	32.1
Once in more than 3 years		
Main Reason for Purchasing New EEE	80	22.0
Loss of function	74	20.3
Physical damage	79	21.7
Need for greater functionality	131	36.0
Desire for latest technology		
Reaction to Unused Functioning EEE	127	34.9
Kept at home	155	42.6
Given or sold to informal system (family, friends, acquaintances on social media, etc.)	49	13.5
Sold to formal system (Shopee, electrical shops, cash converters, etc.)	33	9.1
It goes straight to the bin		
Reaction to Not Functioning EEE	133	36.5
Kept at home	27	7.4
Try to repair it	47	12.9
Sold to second hand shops	92	25.3
Throw away together with daily trash	65	17.9
Disposed it at recycling centre		
	205	56.3

Received Information on EEE Handling	159	43.7
Yes		
No	319	87.6
Prior Knowledge on E-waste	45	12.4
Yes		
No	310	85.2
E-waste Danger Awareness	54	14.8
Yes		
No	224	61.5
Scheduled Residential Waste Collection	140	38.5
Yes		
No		

Upon conducting an initial examination of the data, it is evident that the samples primarily consisted of individuals aged between 21 and 40 years old. This age group accounted for a significant proportion of the total sample, amounting to 76.1%. The participants were drawn from both government and private sectors, representing three distinct sub-clusters: urban, suburban, and rural regions. Furthermore, the female respondents constituted 56.0% of the sample, while the male respondents comprised 44.0%.

Prior research has demonstrated that individuals who possess knowledge about recycling waste tend to exhibit a favourable inclination towards sorting and separating e-waste at the source (Islam et al., 2016; A. Mahat et al., 2019; Pariatamby and Victor, 2013; Senawi and Sheau-Ting, 2016; Z. Wang et al., 2016). In line with these findings, the present study observed that a majority of the participants (87.6%) possessed previous knowledge and experience in the domain of e-waste recycling.

The data indicates that a significant majority of respondents, specifically 88%, reported having engaged in voluntary recycling practices despite the absence of scheduled residential waste collection services in their respective residential areas. A significant

proportion of the properties examined were situated in urban and suburban areas, making up approximately 86% of the total. Furthermore, the majority of the survey participants reported residing in their current property for a duration exceeding 10 years, with a notable percentage of 65.1%.

It is significant to acknowledge that the aforementioned observations exhibited a high degree of consistency, thereby establishing a robust pattern across the geographical regions of both Kedah and Penang. Nevertheless, it is imperative to acknowledge the significance of including residents from rural regions in this study, as they made a substantial contribution, accounting for approximately 15.0% of the total percentage. Both municipalities exhibit unique demographic characteristics. Given that both states exhibit differing degrees of urbanisation, it is important to consider the implications of this factor.

Although the Kedah localities and the Penang state are adjacent to each other, they exhibit distinct geographical characteristics. The Kedah localities encompass a diverse range of landscapes, including rural, suburban, and urban areas. In contrast, the Penang state is predominantly characterised by urban and suburban environments. Hence, the results of this study explained in further the dynamics of the subclusters, namely rural, suburban, and urban areas through the act of their households' recycling behaviour.

Furthermore, a majority of the residential properties in the area consisted of terrace or lot houses, accounting for a cumulative percentage of 77.8%. Additionally, a substantial proportion of the households were occupied by more than two individuals, with a prevalence rate of 48.1%. The data reveals that a significant proportion of the sample

population, specifically 56.0%, originated from Penang State, while a slightly lower proportion of 44.0% hailed from Kedah. The data collected indicates that a significant majority, specifically over 80% of the respondents, were currently engaged in employment. The remaining individuals were found to be either pursuing further education or were beneficiaries of a pension scheme.

Previous studies have examined the relationship between household recycling behaviour and performance by measuring the level of deprivation using income as the unit of measurement (Echegaray and Hansstein, 2017; Milovantseva and Saphores, 2013). Recent study into household recycling behaviour have yielded findings that highlight the influence of demographic factors, specifically income level, as a prominent determinant of recycling behaviour (Al Mamun et al., 2018). Thus, the present study conducted a comprehensive analysis of the impact of demographic profiles on household e-waste recycling behaviour.

3.6.4 Questionnaire Development

The questionnaire items were systematically developed based on an extensive review of relevant literature to ensure content validity and alignment with the study's conceptual framework. Acknowledging the critical role of rigorous questionnaire design in enhancing data accuracy and improving response rates (Creswell and Creswell, 2018), meticulous attention was dedicated to developing a well-structured and logically sequenced in accordance with the studied variables. This approach was intended to minimise ambiguity, promote consistency in responses, and ultimately support the collection of high-quality empirical data.

The quantitative phase of this study employed a structured questionnaire to assess the factors influencing household participation in e-waste recycling. The questionnaire was developed following rigorous academic protocols and adapted from established and validated instruments to ensure reliability and validity of measurement. The instrument focused on two broad categories of independent variables; situational factors (HERS) and personal factors (HERB) and one dependent variable, household e-waste recycling participation.

A five-point Likert scale was employed across all items, ranging from Strongly Disagree (1) to Strongly Agree (5). The questionnaire was divided into four parts:

Part A : Demographical information

Part B : A set of questions about different situational factors (recycling systems) influencing household e-waste recycling participation.

Part C : A set of questions about different personal factors (household behaviour) influencing household e-waste recycling participation.

Part D : A set of questions about household e-waste recycling participation

Part E : Suggestions and recommendations (open ended questions)

The development of the questionnaire was informed by the principles of the sequential explanatory design, where the quantitative instrument must be methodologically sound to drive valid interpretation of the initial phase (Creswell and Clark, 2018). To enhance content validity and alignment with the context of Malaysian households, the items were primarily adapted from prior empirical studies in environmental behaviour, recycling participation, and reverse logistics. These sources include works by Afroz et

al. (2020); Saphores et al. (2012); Vassanadumrongdee and Kittipongvises, (2018); Z. Wang et al. (2016) and others, which were chosen due to their established use in assessing behavioural and structural determinants of e-waste recycling in various settings. All adapted instruments had undergone prior psychometric evaluation, ensuring they meet thresholds for construct reliability (Cronbach's alpha > 0.70) and factorial validity. Table 3.3 presents a summary of the adapted sources from which the questionnaire items were derived.

Table 3.3
Summary of sources for questionnaire items

Questionnaire Section	Factors	No. of Items	Source(s)
PART B: Situational Factors (HERS)	Accessibility and Availability	5	Saphores et al. (2016); Zeng et al. (2015)
	Convenience	5	Afroz et al. (2020); Z. Wang et al. (2016)
	Engagement	5	A-Jalil (2015); Vassanadumrongdee and Kittipongvises (2018)
	Advertising	5	Z. Wang et al. (2016)
	Education	5	Ajzen (1991); Ylä-Mella et al. (2015)
	Policy and Regulations	5	Biswas (2018); Nnorom and Osibanjo (2008)
PART C: Personal Factors (HERB)	Attitude	5	Ajzen (1991); Saphores et al. (2012); Wan et al. (2017)
	Social Norms	5	Thøgersen (2009); B. Wang et al. (2019)
	Knowledge and Experience	5	Haron et al. (2018); Rahardyan et al., (2004)
	Awareness	5	Afroz et al. (2020); Vassanadumrongdee and Kittipongvises (2018)
	Psychological Ownership	4	Ofori (2020); Pierce et al. (2001)
PART D: Dependent Variable	Recycling Participation	4	Afroz et al. (2020); B. Wang et al. (2019); Zeng et al. (2015)

Adaptation involved modifying contextual language to reflect Malaysia's recycling system and local government practices. Where necessary, additional items were formulated based on the underpinning theoretical grounding of the TPB and the Symbiosis Effect Theory to address variables like psychological ownership and stakeholder engagement, which are relevant to the unique socio-cultural dynamics of household recycling in Malaysia. The sample questionnaire administered through online channels (refer to Appendix A).

3.6.5 Quantitative Data Analysis

This research utilised a pre-coding method in which all question items were assigned numerical values. An analysis is performed on each variable to check for any values that are outside the expected range. The out-of-range values present in the data file were rectified by cross-referencing them with the original questionnaire. The implementation of these specific procedures is critical in order to guarantee that the data is suitable for subsequent analysis as part of the comprehensive research framework (DiLalla and Dollinger, 2006).

Data screening is an essential step in the research process as it serves the purpose of verifying the accuracy of data entry and assessing the normality of the distribution of variables that are intended for analysis (Coakes, 2006). By conducting data screening, researchers can ensure the reliability and validity of their findings by identifying any potential errors or anomalies in the data. This step was taken to detect any missing values, outliers, or other data quality issues that may impact the integrity of the analysis.

As mentioned by Zikmund (2003), it has been established that editing is recognised as an integral component of the data processing and analysis phase.

In the process of analysing the aspects of the project that influence its quality, the Structural Equation Modeling (SEM) under software SPSS Analysis of Moment Structures (AMOS) version 29 were used for this research and a structural model was designed for this study. The data were analysed to identify the descriptive analysis on households' attitude and their knowledge on e-waste recycling. Both measurement and structural models analysis were made to identify whether HERS and HERB influence household e-waste recycling participation; and reciprocal loops analysis of variance to identify the symbiosis relationship between HERS and HERB.

Finally, the moderating influence of household demographic profiles on the links between the two independent variables (situational and personal) and household recycling participation were investigated using structural moderating model analysis. Structural moderating model analysis in AMOS is an effective method for evaluating moderation across many variables in a research model, particularly when a study aims to explore heterogeneity impacts (demographic profiles) in behavioural research (Byrne, 2010).

SEM with Confirmatory Factor Analysis (CFA) were conducted to address the research questions. This comprehensive analysis allows for the simultaneous investigation of all proposed relationships, including the interconnections among multiple dependent variables within a given study (Byrne, 2001). Therefore, the interdependent relationship between HERS and HERB was analysed using SEM with the software AMOS as it

suiting the purpose of this analysis was to validate the existence of a symbiotic effect between these variables in the context of e-waste recycling.

3.7. PHASE 2: Qualitative Phase

3.7.1 Data Collection Method: Interviews and Focus Group Discussion

In the qualitative phase of this study, semi-structured interviews and FGDs were employed to explore in-depth perceptions, experiences, and attitudes of participants regarding their engagement in e-waste recycling. Interviews have been widely recognised as one of the most frequently used methods in qualitative research, particularly in organisational and social sciences, as they provide a direct means to access participants' lived experiences and subjective meanings (Bryman, 2016; King & Horrocks, 2010).

The primary aim of this phase was to gain contextual understanding of the factors that influence householders' recycling behaviour and their interactions with situational structures. As such, semi-structured interviews were deemed appropriate due to their flexibility in allowing pre-determined questions while enabling the interviewer to probe deeper into emerging themes (Longhurst, 2003). Compared to structured interviews, this format allowed participants to express their views more freely, thereby yielding rich and nuanced data (DiCicco-Bloom & Crabtree, 2006).

A total of three semi-structured interviews were conducted face-to-face with selected householders across various demographic profiles and residential areas in Kedah and Penang. These participants were purposively sampled based on their varying levels of

e-waste recycling participation, ensuring the inclusion of both active and passive recyclers. The face-to-face format facilitated rapport building and enabled the observation of non-verbal cues, which are often essential in qualitative interpretation (Gill et al., 2008). In addition to the interviews, three FGDs were conducted in online settings using video conferencing platforms. FGDs were chosen to complement the individual interviews by promoting group dynamics and discussion, which often generate ideas and perspectives that may not emerge in one-on-one settings (Krueger & Casey, 2014). The online medium was chosen due to its logistical convenience and wider accessibility, especially given the participants' geographic distribution.

Each FGD consisted of 3-4 participants. Both interviews and FGDs were conducted in the preferred language of the participants (Malay or English) to ensure comfort and clarity. All sessions were recorded with consent, and subsequently transcribed for thematic analysis. Each semi-structured FGD session was conducted over a duration of approximately two hours, allowing sufficient time for in-depth discussion while maintaining participant engagement. The sessions followed a pre-determined FGD agenda (refer Appendix B6), which guided the flow of topics and ensured consistency across all group discussions.

At the start of each session, the researcher briefly introduced the study and reiterated the ethical research protocol (refer Appendix B3), including participants' rights to anonymity, confidentiality, and voluntary withdrawal at any time without consequences. Following this, participants were asked to complete a brief demographic survey and sign the informed consent form (refer Appendix B2) prior to engaging in the interview. These procedures ensured that all participants were fully informed and

had voluntarily agreed to participate, in accordance with ethical guidelines recommended by Creswell and Clark (2018) and the institutional ethical review standards.

3.7.2 Sampling Strategies

A purposive sampling strategy was used to select expertise involving waste management stakeholders or key informants of government and private agencies associated with waste management in Malaysia. In qualitative research, the sampling procedure is very malleable, and there is no one set formula for establishing the appropriate size of the sample (Fusch and Ness, 2015). It has been stated that the size of the sample that is able to answer the research questions is an adequate measure to use when determining the sample size for a qualitative study (Ogden and Cornwell, 2010). The goal of recruiting for a qualitative approach is to recruit enough informants who are knowledgeable and experienced in the field to ensure that rich and dense data is collected to answer the research questions.

The assessments of the researchers were employed in order to arrive at an adequate sample size, which was based on the quality and breadth of the data that was obtained (Ogden and Cornwell, 2010) and the analysis of the data did not provide any new ideas. Hence, this study used purposive sampling particularly 'stakeholder sampling' that includes the significant stakeholders who are engaged in the program's creation, providing, receiving, or administration (Palys and Atchison, 2008). The sample for this approached were 20 sample size that included a total of 17 respondents from different

waste management local stakeholders and the remaining three householders from the three different subclusters.

3.7.3 Demographic of the Respondents

Table 3.4
Demographic background of respondents

The respondents	Total	Age (years old)	State	Recycling Experience (years)
Stakeholders				
Local government / authorities	8	35 – 55	3 from Kedah Authorities 3 from Penang Authorities 2 from Federal Government	> 10
Private e-waste recycling operators / centres	4	30 – 50	2 from Kedah 2 from Penang	> 10
Licensed waste management NGOs	2	30 – 40	1 from Penang 1 covered all around Malaysia	> 10
Total	14			
Householders				
Urban resident	1	25	Penang	5
Suburban resident	1	30	Kedah	< 5
Rural resident	1	42	Kedah	2
Total	3			

Table 3.4 provides a summary of the demographic background of the respondents involved in the qualitative approach. The study categorized participants into two groups; stakeholders and households, who were interviewed in separate sessions using distinct data collection methods. Households were interviewed through face-to-face sessions to eliminate communication barriers and facilitate more direct, personal discussions regarding their adoption of waste recycling practices in daily life. This

approach enabled a more informal and relatable interaction, aligning with the households' living contexts.

Conversely, in-depth interviews with stakeholders were conducted using the FGD approach to elicit detailed insights. The FGDs were organized into three distinct sessions based on the stakeholders' professional backgrounds: Session 1 included local authorities, Session 2 involved private recycling operators, and Session 3 comprised licensed waste management NGOs. The segregation of FGD sessions allowed the researcher to mitigate potential biases or conflicts that could arise from interactions between private operators and local or federal authorities.

A purposive sampling technique was strategically implemented to identify and select stakeholders for the study, with a deliberate focus on individuals possessing extensive expertise and over a decade of practical experience in managing e-waste systems within the Malaysian context. This approach ensured the inclusion of participants who could provide deep, informed insights into the operational, policy, and practical dimensions of e-waste management.

Similarly, purposive sampling was employed to identify household respondents, who were systematically categorized into subclusters based on their residential typologies: urban, suburban, and rural areas. These subclusters allow researcher to account for variations in socioeconomic, cultural, and infrastructural factors that influence households' behaviour on waste recycling practices, across different residential contexts. This stratification was designed to capture the heterogeneity of household behaviours and attitudes towards waste recycling across diverse socio-economic and

geographical settings, thereby enhancing the comprehensiveness and contextual relevance of the study findings.

3.7.4 Development of Semi-structured Interview Questions

As the second phase of this explanatory sequential mixed methods study, the qualitative data collection aimed to further explore and explain the findings obtained from the earlier quantitative phase. Hence, the development of semi-structured interview questions was guided directly by the results and variables identified in the survey questionnaire. A comprehensive note was first created to map out all relevant variables, key themes, and significant patterns that emerged from the quantitative findings. This served as a foundational framework to identify areas requiring further exploration. The original survey questions were then translated into broader, open-ended questions that allowed for deeper insight into participants' views, behaviours, and underlying motivations.

Two distinct sets of interview guides were developed to address the different perspectives of two participant groups: local stakeholders and householders. For householders, the semi-structured questions were carefully derived from the survey instrument but expanded with probing and follow-up questions to elicit more comprehensive insights into their recycling habits, personal motivations, perceived barriers, and social influences. These questions were designed to unpack specific behavioural patterns influencing household e-waste recycling participation. The full guideline for household interview questions is provided in Appendix B4.

For local stakeholders, a separate set of questions was developed and organised into three focused FGD sessions, each targeting a distinct cluster of stakeholders:

Session 1: Operations and Waste Management Experts

Session 2: Local Government and Regulatory Authorities

Session 3: Media Representatives, Recycling Service Providers, and NGOs

Each session was tailored to the expertise and institutional role of the participants. The FGD questions primarily examined the stakeholder's perceived role and responsibilities in promoting household recycling, the effectiveness of existing recycling systems, and opportunities to enhance public participation. These questions are outlined in Appendix B5. In addition to core discussion prompts, role-specific follow-up questions were introduced to gain deeper insights from individual stakeholders. For example, local authorities were asked about the enforcement and implementation challenges of e-waste policies at the grassroots level, while NGOs and media representatives were asked to share their experiences in raising public awareness and engagement. These targeted probes enabled a more nuanced understanding of the symbiotic relationship between stakeholders and householders in the context of reverse logistics and e-waste recycling.

Although a structured guide was developed for consistency, the interviews maintained flexibility. The semi-structured format allowed the researcher to adapt the order of questions, probe further into relevant responses, and explore emerging topics of interest during the conversations. This flexibility was particularly useful in uncovering unexpected themes and deeper explanations, thus enhancing the richness and contextual relevance of the data collected.

3.7.5 Qualitative Data Analysis

For the second phase, qualitative approach was designed to address RQs. The information that was gathered is an amalgamation of themes gleaned through semi-structured interviews conducted utilising a phenomenological interview procedure (Roulston, 2010). The phenomenological interview method basically requires respondents who have experience in recycling waste and apply probes developed from a priori topics. Interviews were prepared in semi-structured questionnaire, and both householders and stakeholders were asked about their experiences and expertise in the recycling and waste management.

Qualitative component of the explanatory sequential mixed methods design aimed to address and support the proposed research questions. The data collection included the integration of respondents and informants based on a phenomenological interview approach using semi-structured interviews. The phenomenological interview approach involved the five stakeholders namely from the local authorities, e-waste operators, NGOs and solid waste operators, who, in a general sense, engaged with waste management experience and the implementation of research generated from a preconceived themes. The interviews were designed in a partially structured and semi-structured, that allows for intensive collection of attitudes, convictions and anecdotal information from respondents (Longhurst, 2003).

The thematic analysis consists of grouping all findings into main themes, which were concentrated in two main topics with regard to situational or personal aspects for this study. The thematic analysis technique was used to systematically code, categorise, and interpret the qualitative data (Braun and Clarke, 2006). Themes were developed both

deductively, based on the quantitative variables (e.g., situational and personal factors), and inductively, from emergent patterns during the interview discourse. The coding process was conducted using ATLAS.ti version 8.4 which facilitated the organisation, comparison, and visualisation of coded segments across transcripts (Friese, 2012). Each transcript was read multiple times to ensure accuracy, and key quotations were coded into relevant thematic networks. Two overarching themes were used as coding categories, reflecting the theoretical constructs of the study and supporting the integration of quantitative and qualitative findings.

Additionally, an ethnographic analysis approach was employed to explore the symbiotic relationship (RQ3) between HERS and HERB. Ethnography, traditionally used to examine cultural and behavioural patterns within a specific context, was adapted in this study to analyse the semantic relationships between respondents' roles, environmental contexts, and their expressed behaviours and meanings (Spradley, 1979). By examining the interplay between the subject (householders or stakeholders) and the subject matter (e-waste recycling), the ethnographic lens helped uncover deeper structural and relational dynamics within the reverse logistics ecosystem.

This ethnographic approach enabled the conceptualisation of symbiosis as a behavioural and systemic interaction, grounded in real-world experiences and institutional practices. The triangulation of phenomenological understanding, thematic organisation, and ethnographic interpretation provided a robust and multidimensional analytical framework to address all three research questions. Moreover, the semi-structured format of the interviews allowed flexibility for the researcher to probe deeper based on participants' responses, leading to a richer dataset. The integration of

ATLAS.ti further enhanced the rigour and transparency of the coding and theme development process, ensuring traceability and consistency across data sources.

3.8. Ethical considerations

According to Punch (2005), both qualitative and quantitative studies should consider ethical issues whereby qualitative research should consider ethical issues more. This is because this method involves the privacy of many respondents and participants which the data provided often to be classified as private and confidential. A research methodology is not complete if the ethical considerations involved in the design of the study are disregarded or neglected. In accordance with Parveen and Showkat (2017), a research ethics procedure is one that should be followed both during and after the research. It must communicate effectively with stakeholders and ensure that they realize that its impact is only for the betterment of society.

3.8.1 Informed Consent

The procedure of obtaining informed permission prior to any data collection was guaranteed by providing appropriate information about this research to both local stakeholders and householders. Respondents were advised of the risks and advantages of participating in this study, as well as the potential hardship of participating in this research. Participants were advised that their involvement was entirely voluntary and of their own volition. They were free to withdraw from the research at any moment. Additionally, experts were cautioned and told that they would not be penalised in any way if they chose not to engage in this study, their organisation or nominator would not be informed.

3.8.2 Privacy and Confidentiality

The project is prepared to proceed at a moderate rate as interviews with participants were recorded, even though the study was conducted in a casual social context and its subjects were not in the sensitive category. A notified consent form were primarily distributed prior to FGD and interview sessions. The form identify specific rights for participants, consent to engage in the study and accept the protection of their rights. The informed declaration of consent was included in the online survey and indicate participation compliance. A digital encryption of each questionnaire returned and secrecy of the answers were ensure the anonymous of participants. Interviewees code were assigned to characterize and report the outcome in FGD and individual interviews with both local stakeholders and householders.

Participants were made aware that summarized data were made accessible to the professional body, but it was not possible to trace individual replies in any way. This study concerned two coexisting respondents (local stakeholders and householders), where the stakeholders had a pre-set set of perceptions about their households' settings, and vice versa. Therefore, the interviews for the two respondents were not conducted at the same time, in the same location. The question was structured to be more honest about recycling issues and none of the major issues that could have impacted either side emerged.

3.9. Chapter Summary

This chapter presents a comprehensive discussion of the mixed methodological approach adopted in this study, underpinned by relevant epistemological and ontological perspectives drawn from diverse worldviews of reality. The selection of a mixed-methods approach is particularly well-suited for an interdisciplinary investigation, as it allows for a more holistic exploration of the complex interactions between HERS and HERB. Given that the study examines the symbiotic effects between these two entities, within a body of knowledge that is inherently multifaceted and shaped by differing philosophical paradigms, it is imperative to employ a methodological framework that accommodates both qualitative and quantitative dimensions.

To achieve this, an explanatory sequential mixed methods design has been utilized, enabling the integration of data from multiple sources to provide a more comprehensive and nuanced understanding of the research problem. This chapter outlines the systematic steps undertaken in the implementation of the explanatory sequential design, detailing how data collection and analysis were conducted in parallel before being synthesized to generate meaningful insights. Additionally, critical considerations regarding the reliability and validity of the study are addressed, ensuring the robustness of findings. Practical and ethical concerns have also been carefully examined, with appropriate measures implemented to uphold research integrity and participant welfare. By rigorously applying these methodological principles, this chapter lays the foundation for a credible and well-substantiated analysis of the RQs at hand.

CHAPTER FOUR

RESULTS AND ANALYSIS

4.1. Introduction

This chapter presents a detailed account of the research methodology utilized to evaluate the proposed conceptual framework and address the research questions of this study. The primary objective of this chapter is to provide a thorough exposition of the findings obtained from the analysis of the collected data and to assess the robustness of the symbiosis effect theory within the context of e-waste recycling. It outlines the application of the mixed-method approach employed in this research, encompassing the major findings from both the quantitative phase (Phase 1) and the qualitative phase (Phase 2) of the explanatory sequential mixed-methods design, as depicted in Figure 3.2. This section is dedicated solely to reporting the results from the quantitative and qualitative analyses, with an in-depth discussion and interpretation of these findings provided in Chapter 5 (Phase 3).

This chapter is organized into two distinct sections, with each section focusing on the outcomes of specific research phases. The first section details the quantitative phase of the research design. The analytical process begins with preliminary data analysis, encompassing data cleaning, normality assessments, response rate evaluation, and bias testing through an independent samples t-test. This is followed by a demographic analysis of the survey participants. Subsequently, the unidimensionality and CFA are performed to examine the measurement model, which focuses on situational factors, personal factors, and the dependent variable of household e-waste recycling participation.

The reliability and validity of the measured items are then evaluated, ensuring the robustness of the findings. The subsequent analysis delves into the structural models, specifically Model A and Model B. Model A investigates the symbiotic relationship between situational and personal factors and their collective influence on household e-waste recycling participation. Model B expands upon this by incorporating demographic profiles as a moderating variable into the analysis conducted in Model A.

Next, the second phase, the qualitative phase of the research design. The description of qualitative findings begins by thematic analysis that compares and consolidates the a-priori themes. A priori themes derived from previous empirical studies and those derivations of themes from this study have been grouped into two major factors to illustrate the symbiosis effect (situational and personal). Those themes were modified until all key themes were included and reached a saturation point.

Thematic approaches are commonly used in qualitative data analysis to identify patterns in seemingly random information, derived from the collected data and then organized into themes. The process of data analysis begins with coding. It is through the process of looking at the variations and similarities across different codes to identify and organize themes that are embedded in the data. The analysis were then continued with the graphical networks between HERS, HERB and household e-waste recycling participation to shows the interconnectivity between them, as well as identifying the connection with the demographic profiles to the networks. The graphical illustration and analysis through the network of linkages portrays different kinds of exploration that includes the symbiosis relationships between themes and codes to further answer the research questions.

4.2. PHASE 1: Quantitative Results

Upon addressing the underlying assumptions for multivariate analysis, the groundwork is established for the implementation of multivariate analysis as explained in the subsequent subsections. A multi-step SEM approach is employed to ensure a comprehensive analysis of the research framework. The process begins with a CFA to assess the adequacy of both the measurement and structural models, evaluating their validity, reliability, and overall model fit. Following this, a reciprocal loops analysis is conducted to explore the dynamic symbiotic relationships embedded within the research model. Additionally, a structural moderating model is applied to examine the influence of demographic profiles on household e-waste recycling participation, providing deeper insights into potential variations across different population segments. This methodological approach enhances the robustness of the analysis, offering a nuanced understanding of the interrelationships within the study.

4.2.1 Preliminary Data Analysis

4.2.1.1 Assessment of the Normality

After replacing missing data with the means of the respective variables, an assessment was conducted to determine the normality of distribution for the scale data. The acceptable range for skewness is between -3 and +3, whereas kurtosis is considered adequate within the range of -10 to +10 when using SEM (Brown, 2006). Values that fall outside the established thresholds may introduce some degree of uncertainty; however, SEM remains a robust analytical technique, and minor deviations do not necessarily constitute significant violations of its assumptions.

To further assess data normality, skewness and kurtosis values were examined. As presented in Table 4.1, analysis conducted using SPSS indicates that the skewness values for the selected dependent and independent variables fall within the acceptable range of -3 to +3, while kurtosis values are within the range of -10 to +10. These results confirm that the data satisfies the assumption of univariate normality, ensuring its suitability for subsequent multivariate analysis.

Table 4.1
Descriptive statistics for assessment of normality

Variables and Items	Mean	SD	Skewness	Kurtosis
Accessibility and Availability				
AccessibilityAvailability1	4.43	0.722	-1.560	3.809
AccessibilityAvailability2	4.41	.796	-1.865	4.717
AccessibilityAvailability3	4.42	.797	-1.886	4.763
AccessibilityAvailability4	4.46	.736	-1.724	4.394
AccessibilityAvailability5	3.38	1.287	-.394	-.940
Convenience				
Convenience1	4.23	.767	-1.145	2.205
Convenience2	4.12	.890	-1.000	.657
Convenience3	4.25	.957	-1.642	2.884
Convenience4	4.34	.838	-1.628	3.347
Convenience5	4.40	.756	-1.546	3.349
Engagement				
Engagement1	4.37	.687	-1.308	3.322
Engagement2	4.33	.768	-1.185	1.748
Engagement3	4.02	1.000	-.987	.320
Engagement4	3.46	1.227	-.595	-.691
Engagement5	4.38	.756	-1.293	2.073
Advertising				
Advertising1	4.000	.955	-.826	.080
Advertising2	3.77	1.068	-.531	-.739
Advertising3	3.31	1.154	-.243	-.850
Advertising4	3.96	1.009	-.781	-.305
Advertising5	3.68	1.154	-.643	-.337
Education				
Education1	4.25	.833	-1.325	2.201
Education2	4.42	.698	-1.092	.978
Education3	4.51	.674	-1.478	2.818
Education4	4.50	.678	-1.501	2.991
Education5	4.38	.764	-1.061	.505
Policy and Regulations				
PolicyRegulations1	2.60	1.207	.341	-1.003
PolicyRegulations2	4.09	.946	-1.091	.681
PolicyRegulations3	4.11	.960	-1.117	.731
PolicyRegulations4	2.91	1.369	.064	-1.302

PolicyRegulations5	4.34	.761	-1.272	2.135
Attitude				
Attitude1	4.26	.813	-.939	.330
Attitude2	4.33	.814	-1.233	1.435
Attitude3	4.11	.809	-.799	.374
Attitude4	4.27	.788	-1.020	.972
Attitude5	4.46	.754	-1.557	3.045
Social Norms				
SocialNorms1	3.69	1.098	-.753	.064
SocialNorms2	3.72	1.155	-.716	-.289
SocialNorms3	3.78	.979	-.528	-.382
SocialNorms4	3.87	.937	-.680	-.048
SocialNorms5	4.13	.838	-.727	-.077
Knowledge and Experience				
KnowledgeExperience1	4.39	.762	-1.580	3.487
KnowledgeExperience2	4.49	.649	-1.346	2.759
KnowledgeExperience3	4.48	.640	-1.172	2.038
KnowledgeExperience4	4.10	.902	-1.073	1.215
KnowledgeExperience5	3.82	1.006	-.811	.451
Awareness				
Awareness1	4.45	.754	-1.696	3.803
Awareness2	4.52	.644	-1.396	2.714
Awareness3	4.47	.682	-1.386	2.653
Awareness4	4.52	.666	-1.891	6.138
Awareness5	4.37	.801	-1.377	2.332
Psychological Ownership				
PsychologicalOwnership1	4.27	.806	-1.194	1.471
PsychologicalOwnership2	4.22	.816	-.938	.620
PsychologicalOwnership3	4.39	.717	-1.420	2.925
PsychologicalOwnership4	4.36	.850	-1.582	2.675
Household E-waste Recycling Participation				
RecyclingParticipation1	4.35	.644	-.782	1.363
RecyclingParticipation2	4.39	.736	-1.172	1.481
RecyclingParticipation3	4.37	.679	-.943	1.277
RecyclingParticipation4	4.45	.712	-1.136	1.001

Note N = 364 for all items. All items were measured using 5-point Likert scale. SD = standard deviation

4.2.1.2 Response Rate

A cumulative total of 409 respondents successfully filled out an online survey. A total of 45 questionnaires were excluded from the dataset. Among these, 34 were completed by residents who were not within the designated study areas, while 11 were “straightlining” when the respondents consistently provide identical choices across parts B, C, and D. When survey respondents provide the same or very similar answers to a series of questions using the same response scale, it can lead to a phenomenon known as straightlining. This has the potential to compromise the quality of the data collected (Kim et al., 2018). Hence, a total of 364 questionnaires were deemed valid, including 160 respondents from Kedah and 204 from Penang.

Table 4.2 provides an illustration of the summary of the rate of return, which pertains to the questionnaire. As to Vriesema and Gehlbach (2021) findings, straight-line answering had a greater impact on the total number of survey items compared to other forms of satisficing, and it also influenced the overall outcomes of the datasets. Consequently, the researcher opted to exclude the defective questionnaires to guarantee the acquisition of high-quality data in this study.

Table 4.2
Summary of the questionnaires response rate

Items	Number of questionnaires	Percentage (%)
Total answered questionnaires	409	100
Total excluded questionnaire	45	11
• Total questionnaires answered by respondents outside of Kedah / Penang	34	8
• Straightlining questionnaires	11	3
Usable questionnaires	364	89

Questionnaires are often used in several research within the management and behavioural sciences to gather information and collect data. In order to carry out research and disseminate noteworthy findings, researchers rely on the cooperation of individuals to respond to these surveys (Baruch, 1999). The use of a questionnaire as a research tool for gathering information may seldom provide a comprehensive dataset, unless in instances when there is a 100% response rate. Precise reporting of the denominator in research studies is crucial for calculating response rates and enabling readers to evaluate possible bias, especially about causes for non-response. There is no universally agreed-upon standard for determining a high response rate, but, a rate of 80% or over is often regarded as outstanding (Booker et al., 2021). The response rate in this study was deemed satisfactory with a total response rate of 89%, surpassing 80%.

4.2.1.3 Non-Response Bias

Non-response bias is an issue of concern when dealing with survey methodology (Armstrong and Overton, 1977). Non-response bias could threaten the validity of the survey (Tse et al. 2003). Tests for non-response bias are performed to ensure that the responses obtained are devoid of bias; otherwise, the conclusions drawn from the study's results may be called into question or deemed invalid. In order to assess the appropriateness of pooling the sample groups, a t-test was performed on the constructs to investigate the presence of any significant differences between the means of the specified groups for each variable, utilising a grouping factor.

In this research, non-response bias was checked using the Armstrong and Overton (1977) method of comparing the responses of Kedah's respondents with those of Penang's respondents on responses on the principal constructs. For this analysis, the Kedah's respondents (44% of the sample), refers to those that residing within the state of Kedah were compared with Penang's respondents (56% of the sample) using an independent samples t-test. The findings presented in Table 4.3 indicate that the group effect does not reach significance at the 0.05 level, suggesting that there are no significant differences among the groups concerning the items and constructs analysed. Consequently, it can be inferred that the utilisation of diverse respondent state backgrounds does not influence the outcomes, suggesting that, overall, there is an absence of bias. Therefore, the t-test provides evidence that the responses of those surveyed are typical of the target population.

Table 4.3
Independent samples t-test

		Independent Samples t-test						
		Levene's Test for Equality of Variances				t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2tailed)	Mean Difference	Std. Error Difference
Accessibility Availability	Equal variance assumed	.290	.590	1.427	362	.154	.459	.322
	Equal variances not assumed			1.425	339.596	.155	.459	.322
Convenience	Equal variance assumed	.284	.595	.937	362	.349	.289	.309
	Equal variances not assumed			.935	339.423	.350	.289	.309
Engagement	Equal variance assumed	2.149	.144	.693	362	.489	.216	.311
	Equal variances not assumed			.689	333.935	.491	.216	.313

Advertising	Equal variance assumed	.001	.981	.872	362	.384	.368	.421
	Equal variances not assumed			.870	328.150	.385	.368	.423
Education	Equal variance assumed	.162	.687	.527	362	.598	.155	.294
	Equal variances not assumed			.522	328.150	.602	.155	.297
Policy and Regulations	Equal variance assumed	2.611	.107	.830	362	.407	.327	.394
	Equal variances not assumed			.836	350.704	.404	.327	.391
Attitude	Equal variance assumed	3.975	.047	.708	362	.480	.249	.352
	Equal variances not assumed			.694	312.052	.488	.249	.359
Social Norms	Equal variance assumed	.141	.707	1.124	362	.261	.655	.583
	Equal variances not assumed			1.122	328.165	.263	.655	.584
Knowledge and Experience	Equal variance assumed	.128	.721	.512	362	.609	.148	.290
	Equal variances not assumed			.508	332.220	.612	.148	.291
Awareness	Equal variance assumed	1.086	.298	1.622	362	.106	.505	.311
	Equal variances not assumed			1.608	329.107	.109	.505	.314
Psychological Ownership	Equal variance assumed	3.338	.069	-.118	362	.906	-.030	.254
	Equal variances not assumed			-.116	314.451	.908	-.030	.259
Recycling Participation	Equal variance assumed	.438	.508	2.118	362	.035	.533	.252
	Equal variances not assumed			2.102	331.103	.036	.533	.253

4.2.2 Analysis and Results of the Measurement Model: Assessment of the Unidimensionality and Confirmatory Factor Analysis (CFA)

The methodology employed under quantitative approach in this study involves the utilization of a two-stage modelling approach, as suggested by Anderson and Gerbing (1988). This approach entails the initial development of a measurement model, followed by the subsequent testing of the structural model. The adoption of this approach is motivated by two primary reasons. First, the approach discussed in this study has gained significant acceptance within the research community, as evidenced by its inclusion in the work of Hair (2006). Furthermore, this approach has also been successfully implemented in other behavioural studies (Akhtar et al., 2014; Al Mamun et al., 2018) that share similar characteristics and objectives.

Typically, the majority of recycling behavioural studies employ PLS-SEM to analyse their quantitative data such as Muniandy (2015). However, in this study, the decision was made to conduct further analysis of the data using AMOS. This involved utilizing both measurement and structural models to assess the robustness of the symbiosis effect theory in relation to e-waste recycling behaviour. Furthermore, as stated by Hair (2006), it is recommended to assess the reliability of the items within each construct in two separate stages in order to prevent any potential interaction between the measurement and structural models. The measurement model is constructed to quantify the extent to which the observed variables are influenced by the unobserved or latent variables. A measurement model pertains to the segment of a model that precisely outlines the relationship between the observed variables and unobserved, composite, or latent variables (Hair, 2006). In other words, a measurement model is the portion of the structural model.

The assessment of models can be accomplished through three distinct approaches: the exploratory factor analysis (EFA) approach, the CFA approach, and the hybrid approach (Ahire and Devaraj, 2001). According to Hair (2006), there exists a distinction between the CFA approach and the EFA approach. The CFA approach involves the extraction of factors based on theoretical considerations, while the EFA approach relies on statistical findings. Furthermore, the EFA approach can be carried out without any prior knowledge regarding the number of factors or the assignment of items to specific constructs. Unlike other factor analysis techniques, such as EFA, CFA allows the researcher to have prior knowledge about the number of factors in a set of variables and the expected loading of each item on a specific factor. This means that the researcher can specify the factor structure before computing the results, providing a more directed and hypothesis-driven approach.

CFA serves as a valuable tool for researchers, allowing them to assess the validity of a preconceived theory. By analysing the relationships between observed variables and latent constructs, CFA provides a statistical framework to evaluate the fit between the observed data and the theoretical model. Researchers can utilise CFA to determine whether the collected data supports or contradicts their initial research objectives, thereby aiding in the confirmation or rejection of the preconceived theory. Moreover, CFA technique offers a comprehensive evaluation of the model fit, whereas the EFA method does not incorporate such an assessment.

In comparison, CFA is limited to detecting only unidimensionality problems and does not provide indications of the dimensions present. Based on the results of their empirical testing, the authors suggest the adoption of a hybrid approach when utilising the two

measurement scales. One approach that combines both EFA and CFA is often favoured due to its numerous advantages. This approach begins with EFA, which allows for an initial exploration of the underlying factor structure of the data. Following this, CFA is employed to confirm and validate the factor structure identified in the EFA stage. By utilising both EFA and CFA, researchers can benefit from the strengths of each method and obtain a more comprehensive understanding of the data.

This section provides a comprehensive analysis of the measurement model specifications for each underlying construct, accompanied by a detailed discussion of the path diagram. Subsequently, the utilisation of multi-item scales is expounded upon in order to assess each factor within the measurement model.

The constructs in the proposed model, namely HERS (Accessibility and Availability, Convenience, Engagement, Advertising, Education and Policy and Regulations), HERB (Attitude, Social Norms, Knowledge and Experience, Awareness and Psychological Ownership), and Household E-waste Recycling Participation, were individually evaluated for unidimensionality. Each of these constructs was individually analysed in a distinct measurement model.

The subsequent section provides a comprehensive account of the methodologies employed to alter the measurement model. In order to achieve the objectives of this study, for the first phase, researcher employed the use of CFA with the assistance of AMOS 29.0 software. CFA is a statistical technique commonly used in research to assess the validity and reliability of a measurement model (Hair, 2006). The statistical technique known as CFA is employed to assess the extent to which the number of

factors and the loadings of measured variables on these factors align with the anticipated theoretical framework (Kline, 2005). It has been suggested by Anderson and Gerbing (1988) that CFA is a method that is characterised by its rigour, as it enables researchers to thoroughly investigate the factorial properties of the measurement models or constructs that are utilised in SEM.

The rationale for the process encompasses two primary considerations, as suggested by Kline (2005). Initially, it is imperative that indicators designated to assess a proposed underlying factor exhibit standardised loadings of relatively high magnitude on indicated factor. The value for this parameter is usually equal to or greater than 0.50, as reported by Hair et al. (1998). Furthermore, it is important to note that according to Kline (2005), the estimated correlations between the factors should not exceed a value of 0.85.

It has been observed that when the estimated correlation between the items in each factor surpasses the threshold of 0.85, there is a possibility that the items are not effectively measuring two distinct factors. Essentially, it can be stated that there exists a certain degree of overlap between these two factors, resulting in their empirical indistinguishability. Each of the constructs was individually examined in a distinct measurement model.

Upon encountering instances where the obtained results did not align with the initially specified measurement model, the measurement model was subsequently re-evaluated and reanalysed. These two considerations are taken into account alongside the overall goodness-of-fit indices in order to propose the acceptance of unidimensionality for each

model. Table 4.4 shown the recommended value for each fit indices in testing CFA that was computed using AMOS to test the measurement models.

Table 4.4
Recommended value for good fit indices

Fit Indices	Recommended Value	Sources
P-value	significant ($P < 0.001$)	Bagozzi and Yi (1988)
Chi-square to Degree of Freedom (χ^2/df)	3 - 5	Schumacker and Lomax (2004); Ullman (2001)
Goodness-of-Fit Statistic (GFI)	> 0.90	Hair et al. (2009)
Comparative Fit Index (CFI)	> 0.90	Bentler (1990)
Tucker-Lewis Index (TLI)	> 0.90	Bentler (1990)
Standardised Root Mean Square Residual (SRMR)	< 0.08	Hu and Bentler (1998)
Root Mean Square Error of Approximation (RMSEA)	< 0.08	Hu and Bentler (1998)

4.2.2.1 HERS: Situational Factors

4.2.2.1.1 Accessibility and Availability

Table 4.5

Accessibility and availability items and their description

Original Items	Item Label	Item Deleted
I would do all that is needed to recycle my personal electronic and electrical waste if the collection centre is closer to my residential area.	AccessibilityAvailability1	
I would do all that is needed to recycle my personal electronic and electrical waste if periodic collection services were available in my residential area	AccessibilityAvailability2	
I would do all that is needed to recycle my personal electronic and electrical waste if the e-waste recycling bins were available in my residential area.	AccessibilityAvailability3	
I would do all that is needed to recycle my personal electronic and electrical waste if the e-waste collection services were made available by my residence.	AccessibilityAvailability4	
If necessary, I would be willing to pay extra for e-waste collections or drop-off centres to be provided by my residential area.	AccessibilityAvailability5	Deleted

The findings from the CFA reveal important insights into the measurement model's validity and reliability. Although the standardized parameter estimates were all statistically significant ($P < 0.001$), the results indicated that the initial measurement model required respecification to improve its fit to the data. The initial chi-square value was significant ($\chi^2 = 78.079$, $df = 15.616$, $P = 0.000$, $N = 364$), and the chi-square to degrees of freedom ratio ($\chi^2/df = 5$) exceeded the commonly accepted threshold of 3, suggesting suboptimal model fit. Other fit indices, including GFI (0.923), CFI (0.909),

TLI (0.817), SRMR (0.042), and RMSEA (0.201), were also evaluated. While GFI and CFI were within acceptable ranges (Bentler, 1990; Hu and Bentler, 1998; Ullman, 2001), the TLI (0.817) and RMSEA (0.201) fell outside recommended thresholds, indicating areas for improvement. Model-fit measures such as χ^2/df , GFI, CFI, TLI, SRMR, and RMSEA were employed to assess the overall goodness of fit.

Although some indices met their respective acceptance levels, the TLI and RMSEA values highlighted the need for respecification. TLI values below 0.90 and RMSEA values above 0.08 indicate poor model fit, suggesting a potential issue with the model's structural assumptions or item loadings. To address these concerns, individual factor loadings for each item were examined as part of the CFA process. Items with factor loadings below the threshold of 0.50 were considered for removal, following the recommendations of Hair et al. (2009).

One item, AccessibilityAvailability5, was removed due to its low factor loading (< 0.50), which violated the assumption of convergent validity based on average variance extracted (AVE) as proposed by Fornell and Larcker (1981). Low factor loadings indicate that the item does not sufficiently contribute to the construct being measured and may compromise the validity of the model.

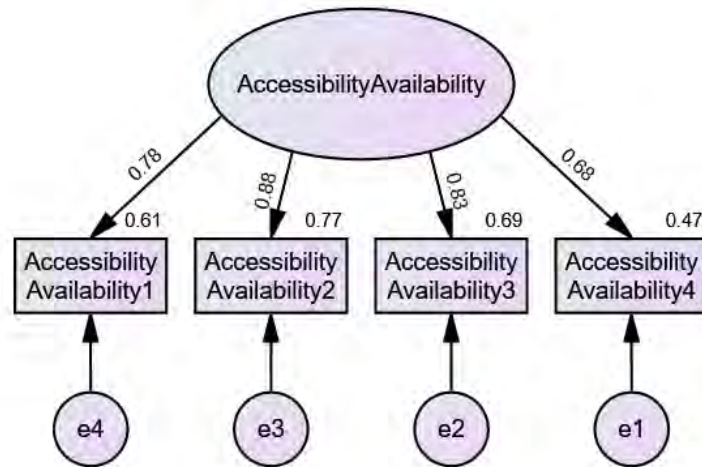


Figure 4.1
A CFA measurement model of accessibility and availability

After respecifying the model and removing the problematic item, the final measurement model for the Accessibility and Availability construct demonstrated improved fit indices. The revised model yielded $\chi^2/df = 3$, GFI = 0.929, CFI = 0.924, TLI = 0.972, SRMR = 0.027, and RMSEA = 0.086. Most fit indices, including GFI, CFI, TLI, and SRMR, indicated a good fit, while the RMSEA, though reduced, remained slightly above the commonly accepted value of 0.08. In SEM, RMSEA is a widely used fit index to assess how well a model approximates the data. Traditional guidelines suggest that RMSEA values below 0.05 indicate a close fit, values between 0.05 and 0.08 represent a reasonable fit, and values between 0.08 and 0.10 are indicative of a mediocre fit. These guidelines underscore that RMSEA values between 0.08 and 0.10 are considered marginal, indicating that while the model may not fit the data poorly. Values exceeding 0.10 have often been considered indicative of poor fit. However, some researchers have proposed that RMSEA values up to 0.10 can still be acceptable, depending on the context of the study and the complexity of the model.

The acceptability of RMSEA values can also be influenced by factors such as sample size and model complexity, both of which are particularly relevant in the context of investigating intricate reciprocal relationships such as the symbiosis effect between situational and personal factors. In models that aim to validate such dynamic interdependencies, the interaction between multiple latent constructs inherently increases the complexity of the model, which can influence fit indices, including RMSEA. For example, MacCallum et al. (1996) highlighted that RMSEA values up to 0.10 may be acceptable for models that involve high complexity or smaller sample sizes, as these factors tend to inflate RMSEA values due to the challenges associated with estimating a large number of parameters. Similarly, Kenny et al. (2015) emphasize that when assessing complex models, such as those integrating reciprocal relationships and moderating variables, fit indices should be interpreted in conjunction with theoretical justification and other supporting indices (e.g., CFI, TLI, and SRMR) to evaluate the model holistically.

In the case of the symbiosis effect model, which investigates the reciprocal relationships between situational and personal factors while incorporating demographic profiles as a moderating variable, the model's complexity necessitates a nuanced interpretation of RMSEA values. The inclusion of moderating effects adds additional layers to the structural paths, increasing the degrees of freedom and the potential for RMSEA values to slightly exceed the traditional threshold of 0.08. This is not indicative of poor model fit but rather reflects the robust nature of the model in capturing intricate relationships and interactions that mirror real-world dynamics in household e-waste recycling participation. Furthermore, the theoretical robustness of the symbiosis model and the coherence of other fit indices (e.g., GFI, CFI, TLI, and SRMR) lend support to the

acceptability of RMSEA values slightly above 0.08. This aligns with the argument that fit indices must be interpreted within the context of the research objectives and the complexity of the model, particularly when addressing multifaceted constructs that aim to explain and enhance behavioural outcomes.

In summary, while RMSEA values below 0.08 are generally preferred, values marginally above this threshold can be considered acceptable in the context of complex structural models. This is particularly relevant when the model seeks to validate intricate relationships, as is the case in this study, where the reciprocal interactions between situational and personal factors and the moderating role of demographics are central to advancing theoretical and practical understandings of e-waste recycling behaviour. Despite this, the substantial improvement in the TLI and the removal of low-loading items supported the validity and reliability of the final measurement model. These findings underscore the iterative nature of CFA, where model respecification and the evaluation of factor loadings play a critical role in refining the measurement model. The process ensures that the final model is both statistically robust and theoretically aligned with the constructs under investigation, enhancing its utility in subsequent structural modeling analyses.

4.2.2.1.2 Convenience

Table 4.6

Convenience items and their description

Original Items	Item Label	Item Deleted
I would do all that is needed to recycle my personal electronic and electrical waste if I can walk to the drop-off centre.	Convenience1	
It is convenience for me to perform e-waste recycling if the e-waste recycling and drop-off centres are less than 5 kilometres away from my residential area.	Convenience2	
I often find it difficult to recycle larger household electronic and electrical waste (television, refrigerator, washing machine etc.)	Convenience3	Deleted
I would do all that is needed to recycle my larger electronic and electrical waste if there were periodic collection services in my residential area.	Convenience4	
I would do all that is needed to recycle my personal electronic and electrical waste if the collection and drop-off centres closer by my residence.	Convenience5	

The findings from the CFA highlight key aspects of the measurement model's validity and its overall adequacy. While all standardized parameter estimates were statistically significant ($P < 0.001$), the results indicated that the initial measurement model required respecification to enhance its fit to the data. The chi-square statistic for the initial model was significant ($\chi^2 = 32.480$, $df = 6.496$, $P = 0.000$, $N = 364$), with a chi-square to degrees of freedom ratio ($\chi^2/df = 5$). This ratio exceeded the commonly accepted threshold of 3, suggesting that the model's fit to the observed data was suboptimal. Other fit indices included GFI (0.966), CFI (0.925), TLI (0.851), SRMR (0.037), and RMSEA (0.123). While GFI and CFI fell within acceptable ranges as per established

benchmarks in Table 4.4, the TLI (0.851) and RMSEA (0.123) values did not meet the recommended thresholds, indicating the need for further refinement of the measurement model.

The evaluation of model-fit measures, including χ^2/df , GFI, CFI, TLI, SRMR, and RMSEA, serves as a critical step in assessing the model's overall goodness of fit. Although some indices satisfied their respective acceptance levels, others, such as TLI and RMSEA, pointed to areas requiring improvement. A TLI value below 0.90 and an RMSEA value exceeding 0.08 indicate potential issues with the model's construct structure, necessitating closer examination of individual item loadings and their contribution to the constructs being measured.

This step ensures that the model aligns both statistically and theoretically with the underlying conceptual framework. As part of the CFA procedure, the factor loadings of each item were rigorously assessed to evaluate their individual contributions to the latent constructs. Items with factor loadings below 0.50 were flagged for removal. One item, Convenience3, was excluded due to its low factor loading (< 0.50), which failed to meet the threshold for convergent validity. Factor loadings below this level are indicative of weak correlations between the item and its associated construct, violating the assumption of convergent validity based on AVE. The removal of such items is necessary to ensure the construct validity of the measurement model.

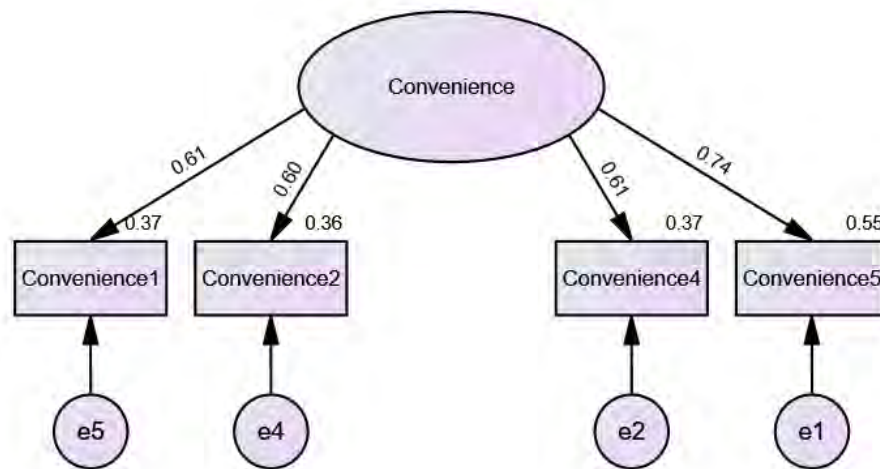


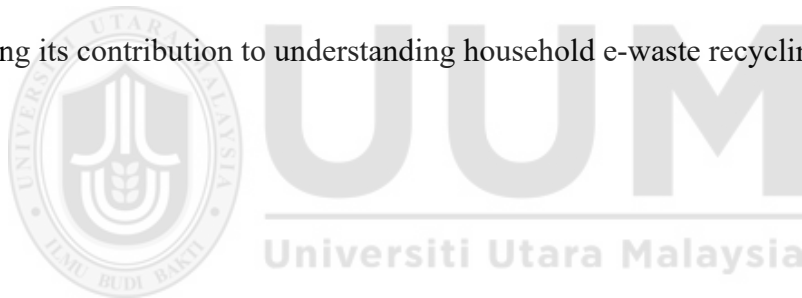
Figure 4.2
A CFA measurement model of convenience

Following the removal of the low-loading item and the respecification of the model, the final CFA measurement model for the Convenience construct demonstrated a substantial improvement in fit indices, reflecting enhanced alignment between the theoretical structure and the observed data. The refined model yielded fit statistics as follows: $\chi^2/df = 3$, GFI = 0.974, CFI = 0.942, TLI = 0.927, SRMR = 0.029, and RMSEA = 0.06. Each of these indices indicates a considerable enhancement in the model's overall fit, adhering to established thresholds for goodness-of-fit in structural equation modeling.

Notably, the TLI improved to 0.927, surpassing the widely accepted threshold of 0.90, which indicates a strong fit and confirms the construct's theoretical coherence (Hu and Bentler, 1998). The SRMR value of 0.029 falls well within the threshold of 0.08, suggesting that the model has minimal residual error, thus further supporting the robustness of the revised measurement model. The RMSEA, reduced to 0.06, is within

the range typically interpreted as indicating a close fit to the data (Browne and Cudeck, 1992; MacCallum et al., 1996), reinforcing the reliability of the measurement model in representing the construct under investigation.

The improvement in these indices demonstrates the efficacy of the iterative refinement process in CFA, where theoretical justification is balanced with empirical evidence to optimize model fit. These results confirm that the respecified model provides a reliable and valid framework for measuring the Convenience construct, enabling robust conclusions to be drawn about its role within the broader symbiosis model. This level of refinement ensures that the model not only adheres to statistical conventions but also aligns closely with the theoretical constructs underpinning the research, thereby enhancing its contribution to understanding household e-waste recycling participation.



4.2.2.1.3 Engagement

Table 4.7

Engagement items and their description

Original Items	Item Label	Item Deleted
I would do all that is needed to recycle my personal electronic and electrical waste if the government really enforce the laws and regulations related to e-waste recycling.	Engagement1	
I would do all that is needed to recycle my personal electronic and electrical waste if government or non-governmental organizations provides all the necessary facilities by my residential area.	Engagement2	
Awareness programs on household e-waste recycling held by government or non-governmental organizations influenced me to recycle my personal electronic and electrical equipment.	Engagement3	Deleted
My local authority provides detail collection and drop-off centres about household e-waste recycling on their websites (location, periodic timetable, e-waste categories and etc.)	Engagement4	Deleted
I would do all that is needed to recycle my personal electronic and electrical waste if government or non-governmental organizations provides monetary or non-monetary rewards upon e-waste recycling (coupons, cash vouchers and etc.)	Engagement5	

Although all standardized parameter estimates were statistically significant ($P < 0.001$), the results of the initial CFA indicated that the measurement model required respecification. The chi-square statistic was significant ($\chi^2 = 80.977$, $df = 16.195$, $P = 0.000$, $N = 364$), with fit indices suggesting suboptimal model fit. Specifically, the relative chi-square (χ^2/df) was 5, while the GFI was 0.920, CFI was 0.426, TLI was

0.706, SRMR was 0.101, and RMSEA was 0.205. The RMSEA value exceeded the acceptable threshold of 0.08 and other key indices (CFI, TLI, and SRMR) similarly fell short of recommended guidelines, indicating that the model did not adequately fit the observed data. Model fit measures as shown in Table 4.4, including χ^2/df , GFI, CFI, TLI, SRMR, and RMSEA, were used to assess the overall goodness of fit of the measurement model. Despite the significance of the standardized parameter estimates, specific fit indices such as the CFI (0.426), TLI (0.706), SRMR (0.101), and RMSEA (0.205) were outside acceptable ranges, necessitating a reassessment of the model's construct validity and dimensional structure. In response, individual factor loadings were evaluated for each item, with particular attention to the threshold criterion of ≥ 0.50 for convergent validity (Hair et al., 2009). Two items, Engagement3 and Engagement4, were removed from the model due to factor loadings below 0.50, as values below this threshold indicate a violation of convergent validity assumptions based on the AVE (Fornell and Larcker, 1981). These modifications were theoretically and empirically justified to improve the measurement model's alignment with the data.

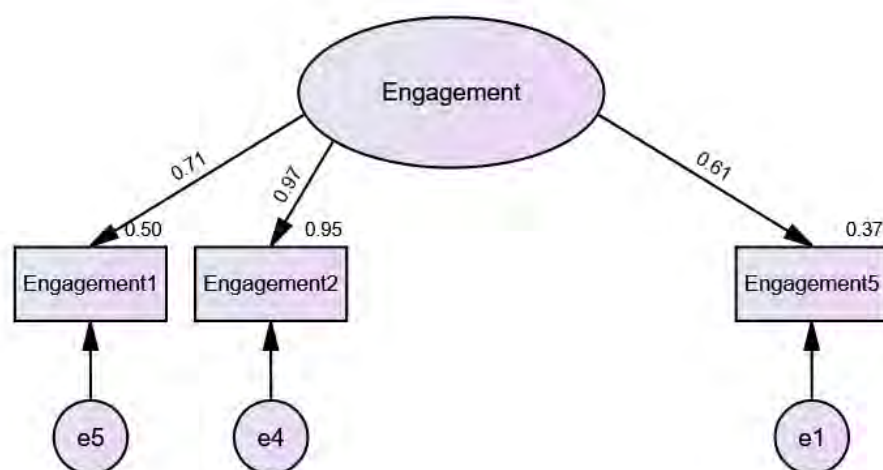


Figure 4.3
A CFA measurement model of engagement

Following the removal of low-loading items and subsequent respecification, the final CFA measurement model for the Engagement construct achieved a significantly improved fit. The revised model produced fit indices of $\chi^2/df = 3$, GFI = 1.000, CFI = 1.000, TLI = 0.980, SRMR = 0.050, and RMSEA = 0.000, all of which exceeded recommended thresholds for acceptable or good model fit. These results indicate a robust measurement model with strong construct validity and reliability, providing a solid foundation for the subsequent structural model analysis.

4.2.2.1.4 Advertising

Table 4.8

Advertising items and their description

Original Items	Item Label	Item Deleted
I would do all that is needed to recycle my personal electronic and electrical waste if the media provides information on e-waste recycling (televisions, radio, social media etc.)	Advertising1	
The media influences me to recycle my household electronic and electrical waste.	Advertising2	
I can find out all details on e-waste recycling through my local council's webpage.	Advertising3	Deleted
I would do all that is needed to recycle my personal electronic and electrical waste if the government held an awareness campaign on household e-waste recycling.	Advertising4	
Non-governmental Organizations (NGO) are my major sources of information if I were to find out about detail information on household e-waste recycling.	Advertising5	

While all standardized parameter estimates were statistically significant ($P < 0.001$), the initial CFA results indicated that the measurement model required refinement and

respecification. The chi-square statistic was significant ($\chi^2 = 70.346$, $df = 14.069$, $P = 0.000$, $N = 364$), with a χ^2/df value of 5. The initial model fit indices included a GFI of 0.934, CFI of 0.901, TLI of 0.802, SRMR of 0.078, and RMSEA of 0.190.

The evaluation of model-fit measures, such as χ^2/df , GFI, CFI, TLI, SRMR, and RMSEA, served to assess the overall adequacy of the measurement model. While the GFI and CFI values approached acceptable thresholds, the TLI (0.802) and RMSEA (0.190) fell outside the recommended ranges, as presented in Table 4.5. These indices suggested that the model's fit to the data was suboptimal and required further refinement to achieve theoretical and statistical acceptability. In order to improve the measurement model, the factor loadings of individual items were thoroughly assessed. Items with factor loadings below 0.50 were identified as candidates for removal, as such loadings violate the assumption of convergent validity based on the AVE. Consequently, one item, Advertising3, was excluded from the model due to its low factor loading (< 0.50). This step was necessary to enhance the validity and reliability of the construct.

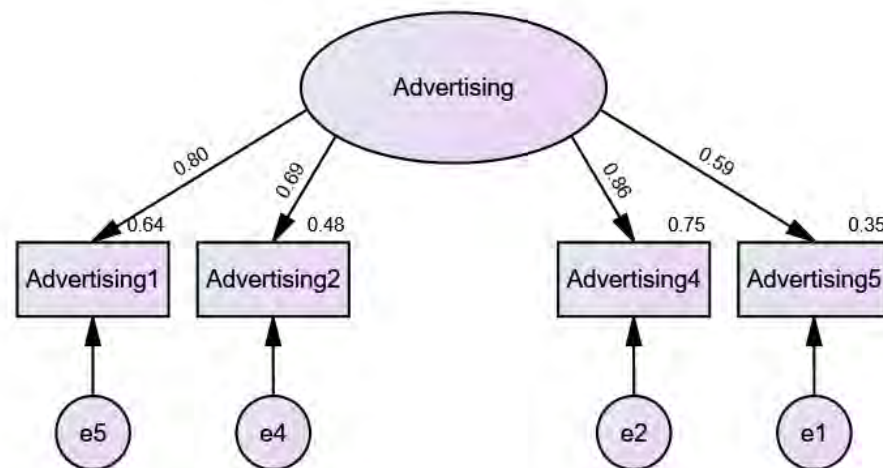


Figure 4.4
A CFA measurement model of advertising

After the removal of the low-loading item and subsequent model respecification, the final CFA measurement model for the Advertising construct exhibited significant improvements in fit indices. The revised model achieved a χ^2/df value of 3, with GFI = 0.997, CFI = 0.999, TLI = 0.997, SRMR = 0.017, and RMSEA = 0.0219. All indices now exceeded the recommended thresholds for acceptable or good model fit, confirming the robustness of the revised measurement model. These results affirm that the refined model is both theoretically sound and statistically valid, thereby providing a reliable basis for further analysis in this study.

4.2.2.1.5 Education

Table 4.9

Education items and their description

Original Items	Item Label	Item Deleted
I would do all that is needed to recycle my personal electronic and electrical waste if I have received primary knowledge on e-waste recycling from my school years.	Education1	
Lack of knowledge about household e-waste recycling procedure is the reason householders did not recycle their personal electronic and electrical waste.	Education2	
Government should introduce a specific program on handling household e-waste to educate the youngsters.	Education3	
Recycling awareness should be commenced during the school curriculum.	Education4	
Parents are responsible to indicate a good household e-waste recycling behaviour towards their children.	Education5	

The results of the Confirmatory Factor Analysis (CFA) indicated that the initial measurement model for the Education construct exhibited satisfactory fit and did not require further respecification. All standardized parameter estimates were statistically significant ($P < 0.001$), demonstrating the robustness of the model's hypothesized relationships. The chi-square statistic was significant ($\chi^2 = 63.968$, $df = 12.794$, $P = 0.000$, $N = 364$), with a relative chi-square value (χ^2/df) of 5. Key model-fit indices were carefully examined to evaluate the overall goodness of fit of the measurement model, including the GFI = 0.933, CFI = 0.909, TLI = 0.918, SRMR = 0.031, and RMSEA = 0.080. All these indices met or exceeded established thresholds for acceptable model fit as outlined in prior methodological guidelines in Table 4.5.

The GFI value of 0.933 and the CFI value of 0.909 indicated that the model adequately explained the observed data, reflecting a strong degree of congruence between the hypothesized measurement structure and the actual data. The TLI value of 0.918 exceeded the recommended threshold of 0.90, further substantiating the model's structural validity. Additionally, the SRMR value of 0.031, which falls well below the recommended maximum of 0.08, indicated minimal residual discrepancies between the observed and predicted covariance matrices. The RMSEA value of 0.080 was within the range of marginal acceptability, indicating a reasonable approximation of the model to the data.

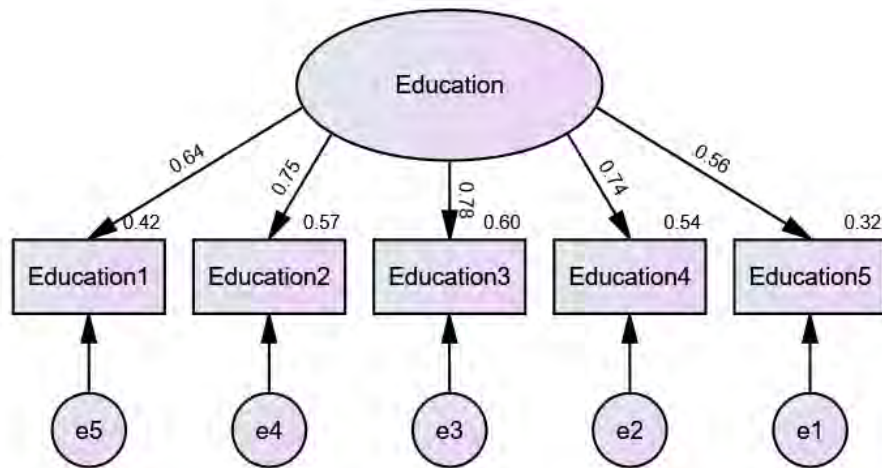


Figure 4.5
A CFA measurement model of education

Collectively, these results confirmed that the measurement model for the Education construct was well-specified, valid, and reliable, requiring no additional modifications. The final CFA measurement model demonstrated a good fit to the data, providing a robust foundation for subsequent structural model analysis and supporting the theoretical framework underlying the construct. This well-fitting model ensures that the Education construct can be effectively integrated into the broader research framework, contributing to the investigation of its role in enhancing household e-waste recycling participation.

4.2.2.1.6 Policy and Regulations

Table 4.10
Policy and regulations items and their description

Original Items	Item Label	Item Deleted
I am aware about the existing state law concerning the issue of e- waste recycling.	PolicyRegulations1	Deleted
I think intervention by the government is necessary to curb the e-waste issues.	PolicyRegulations2	
I think intervention by the non-government is necessary to curb the e-waste issues.	PolicyRegulations3	
I am aware of the sanctions and penalties from local authorities about improper disposal of e-waste.	PolicyRegulations4	Deleted
Rather than citizens, authorities are the one whom responsible to manage e-waste issues.	PolicyRegulations5	

While all standardized parameter estimates were statistically significant ($P < 0.001$), the results of the CFA revealed that the initial measurement model for the Policy and Regulations construct required respecification. The chi-square test yielded a significant result ($\chi^2 = 241.895$, $df = 48.379$, $P = 0.000$, $N = 364$), with a relative chi-square value (χ^2/df) of 5. However, the initial model fit indices demonstrated suboptimal performance, as indicated by the GFI = 0.827, CFI = 0.699, TLI = 0.399, SRMR = 0.258, and RMSEA = 0.361. These model-fit indices were evaluated based on established guidelines for assessing the goodness of fit, including χ^2/df , GFI, CFI, TLI, SRMR, and RMSEA (Bentler, 1990; Hu and Bentler, 1998; Ullman, 2001). Despite the significance of the parameter estimates, the initial fit indices were largely outside the acceptable thresholds, as presented in Table 4.5, underscoring the need for further refinement of the model.

In order to strengthen the reliability and validity of the measurement model, a detailed examination of the factor loadings for each individual item was conducted. Factor loadings are critical indicators of how well each observed variable represents its underlying latent construct. According to established guidelines Hair et al. (2009), items with factor loadings below the threshold of 0.50 are considered insufficient in contributing to the convergent validity of the construct. This threshold ensures that each item has a substantial correlation with the factor it is intended to measure.

Following this assessment, two items, PolicyRegulations1 and PolicyRegulations4, were identified as having factor loadings below the recommended level (< 0.50). These items were removed from the model, as their inclusion would compromise the measurement's theoretical soundness and statistical robustness. Low factor loadings typically indicate weak relationships between the item and its associated latent construct, suggesting that these items may introduce noise or diminish the model's ability to represent the construct accurately. The decision to remove these items aligns with the principle of convergent validity, which requires that indicators of a construct exhibit strong inter-correlations (Fornell and Larcker, 1981). Convergent validity is further assessed through the AVE, which measures the amount of variance captured by the construct in relation to the variance due to measurement error. Items with insufficient factor loadings can reduce the AVE below acceptable levels, thereby undermining the construct's validity.

Moreover, the removal of these low-loading items is a common and necessary step in refining measurement models, particularly in complex research contexts. By ensuring that all remaining items meet the required statistical criteria, the construct achieves a higher degree of internal consistency and reliability. This refinement process also contributes to improved model fit indices, providing greater confidence in the validity of the structural relationships to be tested in subsequent analyses. This process not only enhanced the model's statistical rigor but also ensured that the latent construct of Policy and Regulations was accurately and reliably represented, thereby reinforcing the theoretical foundation of the research.

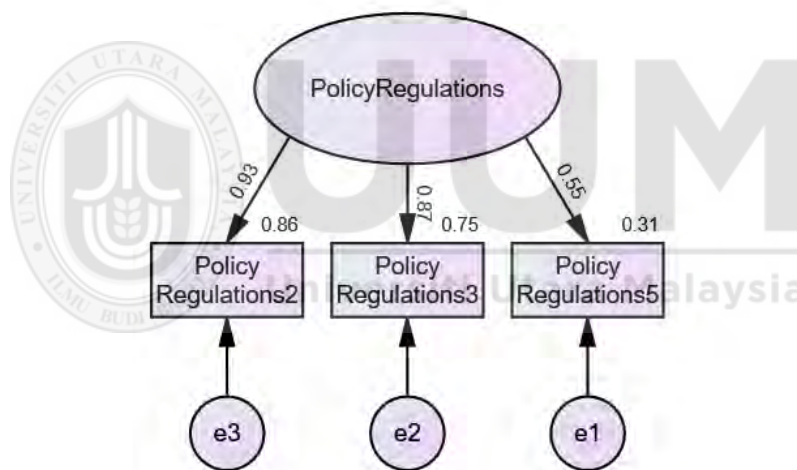


Figure 4.6
A CFA measurement model of policy and regulations

Following the removal of the problematic items and the subsequent respecification, the revised CFA measurement model for the Policy and Regulations construct demonstrated an exceptional fit. The final model achieved a χ^2/df value of 3, with GFI = 1.000, CFI = 1.000, TLI = 0.997, SRMR = 0.000, and RMSEA = 0.073. These fit indices exceeded commonly accepted thresholds, indicating that the refined model not

only met but surpassed expectations for statistical and theoretical rigor. The results affirm the reliability and validity of the construct, providing a robust foundation for its inclusion in the overall structural model and further analysis within the broader research framework.

4.2.2.2 HERB: Personal Factors

4.2.2.2.1 Attitude

Table 4.11

Attitude items and their description

Original Items	Item Label	Item Deleted
It makes me very satisfied if I do all that is needed to recycle my personal electronic and electrical waste.	Attitude1	
I believed that everyone is responsible to recycle their personal electronic and electrical waste.	Attitude2	
I believed that I must contribute my energy in managing my personal electronic and electrical waste properly.	Attitude3	
I believed that both stakeholders and I are responsible managing household electronic and electrical waste (government and non-governmental organizations).	Attitude4	
Generally, e-waste recycling is beneficial for both society and the environment.	Attitude5	

The results of the CFA provided robust evidence supporting the acceptance of the proposed model. As illustrated in Table 4.4, the standardized parameter estimates indicated that all measured indicators were statistically significant, with P-values less than 0.001, underscoring the reliability of Attitude towards the conceptual framework.

Key fit indices further reinforced the validity of the model. Specifically, the chi-square statistic was significant ($\chi^2 = 35.063$, $df = 7.013$, $p < 0.001$, $N = 364$), and the relative chi-square (χ^2/df) yielded a value of 5.

Additionally, other critical fit indices demonstrated acceptable thresholds for model fit: the GFI was 0.956, the CFI was 0.699, the TLI was 0.942, the SRMR was 0.020, and the RMSEA was 0.029. These values collectively indicate that the model aligns well with the observed data. The evaluation of model fit was guided by established criteria, where the χ^2/df ratio, GFI, CFI, TLI, SRMR, and RMSEA were examined to assess the overall goodness of fit. All reported values fell within the commonly accepted thresholds, suggesting that the model not only satisfies statistical significance but also meets the practical standards of model adequacy. This provides confidence in the structural integrity and theoretical underpinnings of the research framework.

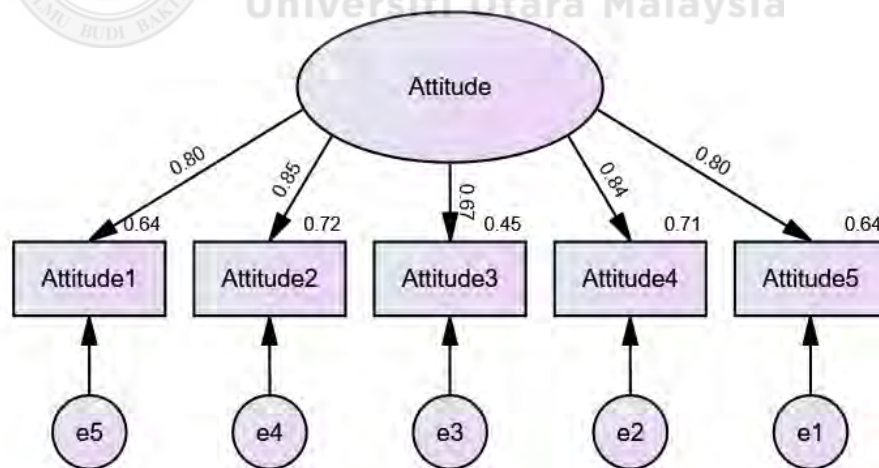


Figure 4.7
A CFA measurement model of attitude

4.2.2.2.2 Social Norms

Table 4.12

Social Norms items and their description

Original Items	Item Label	Item Deleted
I would do all that is needed to recycle my personal electronic and electrical waste once a week.	SocialNorms1	
I usually recycle my household electronic and electrical waste in the exact same location.	SocialNorms2	
It makes me feel weird and uncomfortable if I do not do all that is needed to recycle my personal electronic and electrical waste.	SocialNorms3	
I do all that is needed to recycle my household electronic and electrical waste without needing to think about it.	SocialNorms4	
I would do all that is needed to recycle my personal electronic and electrical waste if the people around me involved in e-waste recycling.	SocialNorms5	Deleted

Although the standardized parameter estimates were all statistically significant ($P < 0.001$), the results of the initial CFA indicated that the measurement model required respecification to improve its fit to the data. The chi-square test yielded significant results ($\chi^2 = 79.799$, $df = 15.960$, $p = 0.000$, $N = 364$), and the relative chi-square (χ^2/df) was calculated at 5. While some fit indices were within acceptable thresholds (GFI = 0.913, CFI = 0.920, SRMR = 0.056), others, particularly the TLI = 0.840 and the RMSEA = 0.203, fell outside the acceptable range, indicating the need for model refinement. Table 4.4 provides a detailed summary of these indices. To address these issues, the overall goodness of fit of the model was reassessed using standard fit measures, including χ^2/df , GFI, CFI, TLI, SRMR, and RMSEA. While some indicators suggested a reasonable fit, the suboptimal TLI and RMSEA values highlighted specific

areas for improvement. This required a closer examination of the factor loadings associated with individual items. As part of the CFA, items with factor loadings below the recommended threshold of 0.50 were evaluated for removal, as low factor loadings indicate potential violations of convergent validity assumptions (Fornell and Larcker, 1981).

One item, SocialNorms5, was removed due to a factor loading below 0.50, as it failed to meet the criterion for convergent validity. The exclusion of this item enhanced the model's alignment with theoretical and statistical standards. The removal of SocialNorms5 was justified because factor loadings below 0.50 imply insufficient shared variance, undermining the construct's validity as defined by AVE.

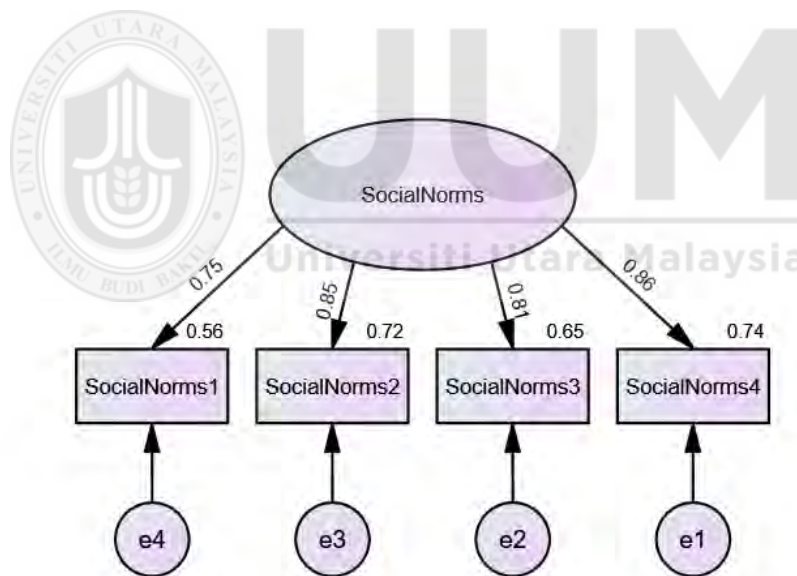


Figure 4.8
A CFA measurement model of social norms

After respecification, the final CFA measurement model for the Policy and Regulations construct demonstrated a near-perfect fit to the data. Key fit indices improved substantially, with $\chi^2/df = 3$, GFI = 0.929, CFI = 0.943, TLI = 0.928, SRMR = 0.048, and RMSEA = 0.026, all well within their respective acceptable ranges. These results

indicate a robust measurement model that adequately captures the underlying theoretical structure. A detailed summary of the final fit indices is presented in Table 4.4, underscoring the improved model performance after refinement.

4.2.2.2.3 Knowledge and Experience

Table 4.13

Knowledge and experience items and their description

Original Items	Item Label	Item Deleted
Recycling household electronic and electrical items is the main way to reduce the use of landfills and emissions of greenhouse gasses.	KnowledgeExperience1	
Recycling household electronic and electrical items is very much useful to create a better community environment.	KnowledgeExperience2	
Recycling household electronic and electrical items can help to improve the quality of the environment.	KnowledgeExperience3	
I am knowledgeable about the electronic and electrical items that were suitable for recycling.	KnowledgeExperience4	Deleted
I believe valuable materials from recycled e-waste could be used to make new products.	KnowledgeExperience5	Deleted

Although the standardized parameter estimates were all statistically significant ($p < 0.001$), the results of the CFA indicated that the initial measurement model required further refinement. The chi-square statistic was significant ($\chi^2 = 41.747$, $df = 8.349$, $p = 0.000$, $N = 364$), with a relative chi-square (χ^2/df) of 5. While some fit indices met the acceptable thresholds ($GFI = 0.913$, $CFI = 0.957$), others fell short, particularly the $TLI = 0.889$ and the $RMSEA = 0.142$, suggesting potential inadequacies in the model's structure. A detailed summary of these initial results is presented in Table 4.4.

To evaluate the overall adequacy of the measurement model, standard fit measures were examined, including χ^2/df , GFI, CFI, TLI, SRMR, and RMSEA. While certain indices supported the model's validity, the TLI and RMSEA values indicated the need for refinement to achieve an acceptable level of fit. Consequently, the factor loadings of individual items were assessed to identify any potential violations of convergent validity. Items with factor loadings below 0.50 were flagged for removal, as they fail to contribute sufficiently to the shared variance of the construct and violate the assumption of convergent validity, as per the guidelines established by Fornell and Larcker (1981). Two items, KnowledgeExperience4 and KnowledgeExperience5, were excluded from the measurement model due to their low factor loadings (< 0.50). Removing these items improved the construct's validity and the overall fit of the model. Items with factor loadings below 0.50 undermine the theoretical coherence of the construct by failing to meet the threshold for AVE (Fornell and Larcker, 1981), thus justifying their exclusion.

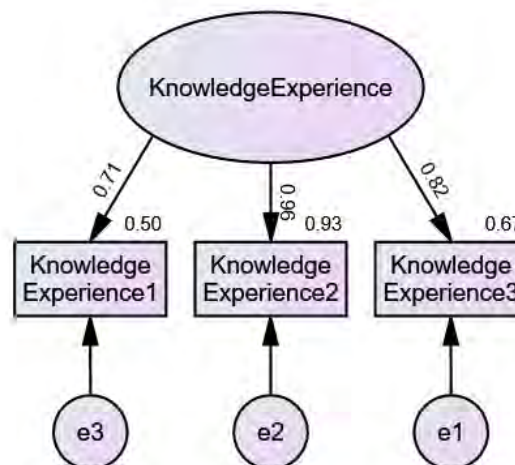


Figure 4.9
A CFA measurement model of knowledge and experience

After refinement, the final CFA measurement model for the Knowledge and Experience construct demonstrated an excellent fit to the data. Fit indices for the revised model showed substantial improvement: $\chi^2/df = 3$, GFI = 1.000, CFI = 1.000, TLI = 1.000, SRMR = 0.000, and RMSEA = 0.073. These results affirm that the modifications to the model were successful in enhancing its alignment with theoretical and statistical expectations. The refined model is portrayed in Figure 4.9, confirming its robustness and suitability for further analysis.

4.2.2.2.4 Awareness

Table 4.14
Awareness items and their description

Original Items	Item Label	Item Deleted
I believed that performing e-waste recycling imposed positive environmental impacts.	Awareness1	
I believed that performing e-waste recycling helps to protect human health and the environment.	Awareness2	
I believed that performing e-waste recycling helps to reduce carbon footprint and reduces the dependency of landfills.	Awareness3	
Improper management in e-waste disposal is harmful to the environment.	Awareness4	
All electronic and electrical waste contains harmful substances.	Awareness5	

The results of the CFA provided compelling evidence to support the acceptance of the proposed measurement model. As illustrated in Table 4.4, the standardized parameter estimates demonstrated statistical significance for all indicators ($p < 0.001$), underscoring the reliability of the relationships among the Awareness and household e-

waste recycling participation. The chi-square test for model fit yielded a significant result ($\chi^2 = 6.409$, $df = 7.013$, $p = 0.000$, $N = 364$), a common outcome for large sample sizes due to its sensitivity to sample size (Byrne, 2010; Kline, 2015). However, the relative chi-square ($\chi^2/df = 5$) remained within an acceptable range, providing further support for the model's adequacy. Additional fit indices were examined to assess the overall goodness of fit, including the GFI = 0.993, the CFI = 0.989, the TLI = 0.998, the SRMR = 0.077, and the RMSEA = 0.028. All indices indicated an excellent model fit, which fell well within their respective acceptable ranges.

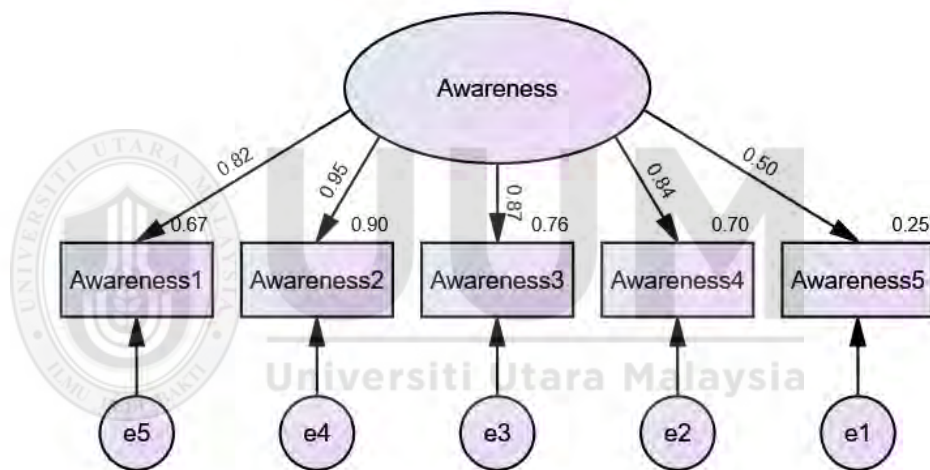


Figure 4.10
A CFA measurement model of awareness

4.2.2.2.5 Psychological Ownership

Table 4.15

Psychological ownership items and their description

Original Items	Item Label	Item Deleted
I prefer to keep my electronics and electrical items that are no longer in used for sentimental/nostalgic reasons.	PsychologicalOwnership1	
I prefer to recycle my old electronics and electrical items to ensure it will be treated in appropriate way.	PsychologicalOwnership2	Deleted
I prefer to give my old electronics and electrical items to my close family/friends so I can still see it sometimes.	PsychologicalOwnership3	
I prefer to keep my broken electronic and electrical items as a collection.	PsychologicalOwnership4	

While the standardized parameter estimates were all statistically significant ($p < 0.001$), the results of the initial CFA suggested that the measurement model required respecification to achieve better fit. The chi-square statistic was significant ($\chi^2 = 39.926$, $df = 19.963$, $p = 0.000$, $N = 364$), with a relative chi-square (χ^2/df) value of 3. Although some fit indices met acceptable thresholds (GFI = 0.953, CFI = 0.903), others, particularly the TLI = 0.708 and the RMSEA = 0.229, were outside the acceptable range, indicating potential issues with the model's adequacy. Table 4.4 provides a detailed summary of these findings. To evaluate the model's overall performance, multiple fit indices were used, including χ^2/df , GFI, CFI, TLI, SRMR, and RMSEA. While some metrics suggested reasonable fit, the suboptimal TLI and RMSEA values highlighted areas that required refinement. A detailed item-level analysis was subsequently conducted to assess factor loadings, which serve as indicators of each

item's contribution to its respective construct. Items with factor loadings below 0.50 were considered for removal due to their inability to meet the criteria for convergent validity, as defined by AVE. One problematic item, PsychologicalOwnership2, exhibited a factor loading below the threshold of 0.50 and was therefore excluded from the measurement model. Items with such low loadings compromise the theoretical and empirical integrity of the construct by failing to account for sufficient shared variance among the observed variables. This decision was consistent with best practices in CFA and ensured the validity and reliability of the refined model.

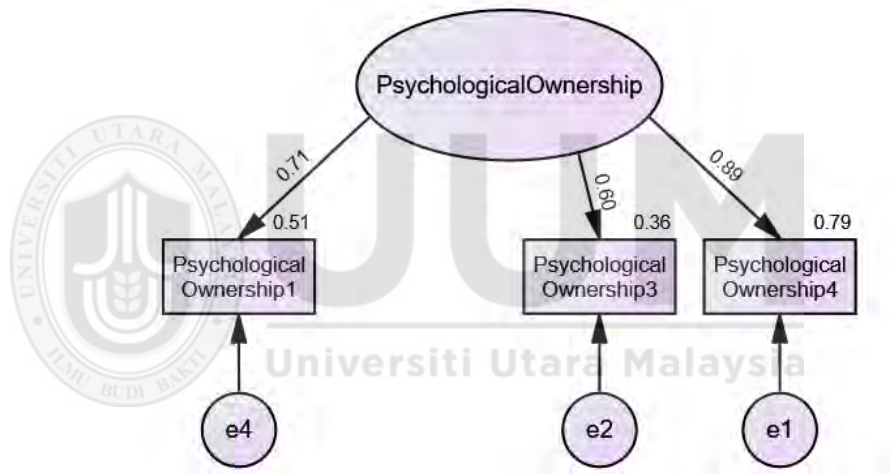


Figure 4.11
A CFA measurement model of psychological ownership

Following the respecification, the final CFA measurement model for the Policy and Regulations construct exhibited an excellent fit. Key indices improved significantly, with $\chi^2/df = 3$, GFI = 1.000, CFI = 1.000, TLI = 0.988, SRMR = 0.000, and RMSEA = 0.033. These revised results demonstrate that the adjustments effectively enhanced the model's alignment with theoretical expectations and statistical benchmarks.

4.2.2.3 Household E-waste Recycling Participation

Table 4.16

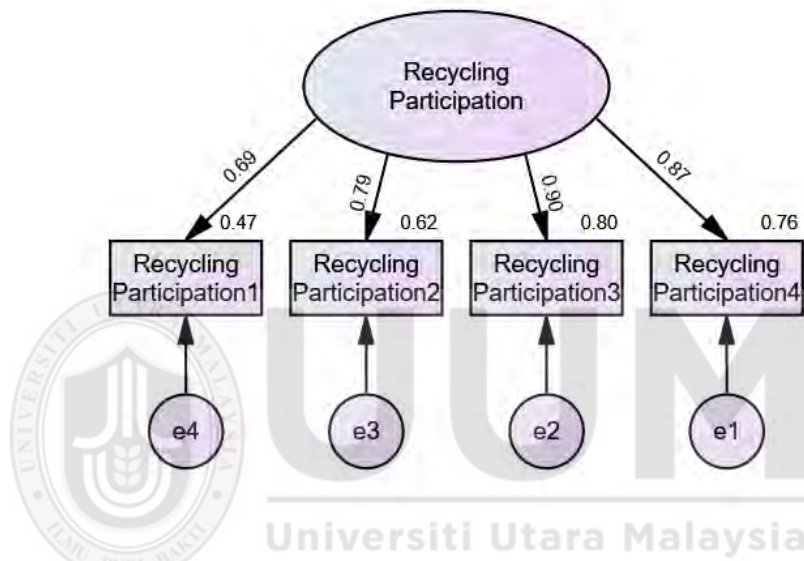
Recycling participation items and their description

Original Items	Item Label	Item Deleted
I would recycle my personal electronic and electrical waste if I received detail information on the important of e-waste recycling in protecting human health and the environment.	RecyclingParticipation1	
I would increase my effort to recycle household electronic and electrical equipment if my residential authority provides more e-waste recycling services.	RecyclingParticipation2	
I would perform household e-waste recycling if there were more media exposure provides by the stakeholders on e-waste recycling.	RecyclingParticipation3	
I would recycle my personal electronic and electrical waste if my local authority provided a simple, informative procedure for recycling household e-waste.	RecyclingParticipation4	

The results of the CFA provided compelling evidence for the validity of the proposed model. As depicted in Table 4.4, the standardized parameter estimates demonstrated that all observed indicators were statistically significant ($P < 0.001$), reflecting strong relationships with their respective latent constructs. The chi-square test yielded a significant result ($\chi^2 = 18.036$, $df = 9.018$, $P = 0.000$, $N = 364$), and the chi-square to degrees of freedom ratio (χ^2/df) was 3, which falls within the range commonly regarded as acceptable for model fit. The evaluation of additional model-fit indices further reinforced the adequacy of the model. The GFI was 0.975, indicating a high degree of fit between the hypothesized model and the observed data. The CFI and TLI were 0.981 and 0.943, respectively, both exceeding the conventional threshold of 0.90, signifying strong comparative and incremental fit. Moreover, the SRMR was 0.014, well below

the recommended maximum of 0.08, and the RMSEA was 0.049, suggesting a close fit of the model with the population data, as values below 0.05 are indicative of excellent fit. Collectively, these model-fit measures highlight the overall goodness of fit, confirming that the model is not only statistically significant but also practically meaningful, providing a robust foundation for subsequent analyses.

Figure 4.12
A CFA measurement model of recycling participation



4.2.2.4 Data Reliability and Validity

Reliability refers to the extent to which measurements are devoid of random error and hence provide results that are consistent (Zikmund, 2003). The goal of reliability is to minimise any errors or biases that may occur during research (R. Yin, 2003). Reliability and error exhibit a reciprocal relationship, whereby an increase in reliability corresponds to a decrease in error magnitude (Punch, 1998). An assessment of reliability and validity is necessary to determine the internal consistency of the data. The concepts of reliability and validity are distinct but interconnected in research methodology (Bollen, 1989). In the context of measurement, it is important to distinguish between two key properties: reliability and validity. Reliability refers to the

consistency of a measure, indicating the extent to which it produces consistent results when repeated under similar conditions (Malhotra and Birks, 2007). On the other hand, validity refers to the accuracy of a measure, indicating the extent to which it measures what it is intended to measure (Zikmund, 2003). According to Holmes-Smith et al. (2006) it is possible for a measure to be reliable but not valid. This means that the measure consistently produces similar results, but those results may not accurately reflect the intended construct or concept. Conversely, a measure can be valid but not reliable (Holmes-Smith et al., 2006). In this case, the measure accurately captures the intended construct, but the results may vary significantly upon repeated measurements. Therefore, it is crucial to consider both reliability and validity when evaluating the quality of a measure. Researchers must strive to develop measures that are both reliable and valid in order to ensure accurate and consistent measurement of the constructs under investigation

In this study, the evaluation of the reliability and validity of the constructs is carried out through the utilization of three distinct methods. These methods include: 1) Cronbach's alpha, which measures the internal consistency of the items within each construct, 2) Construct Reliability (CR), which assesses the reliability of the construct as a whole, and 3) Average Variance Extracted (AVE), which examines the extent to which the construct captures the variance in its own items. Cronbach's alpha, a widely used method for evaluating reliability, is commonly employed in research (Nunnally, 1978; Sekaran, 2003). Additionally, the assessment of reliability of a measurement scale has long been recognised as a crucial step in research methodology.

It is widely regarded as the initial approach that researchers should employ in order to evaluate the reliability and consistency of their measurements. Various levels of acceptance have been proposed in the existing body of literature. As per Nunnally (1978) suggestion, it is recommended that the alpha coefficient should surpass the threshold of 0.70 in order to demonstrate satisfactory levels of internal consistency. Alternatively, Carmines and Zeller (1979) propose a recommended threshold of 0.80 for internal consistency, indicating a level of acceptance. Regarding new scales, a level of 0.60 is deemed appropriate according to Nunnally and Bernstein's research in (1994). Although there are differing opinions on the degree of acceptance, it is widely acknowledged that a value of 0.70 or above for alpha is considered acceptable in indicating internal consistency. Thus, this study employs a minimal threshold of 0.70 to assess the internal consistency of the principles.

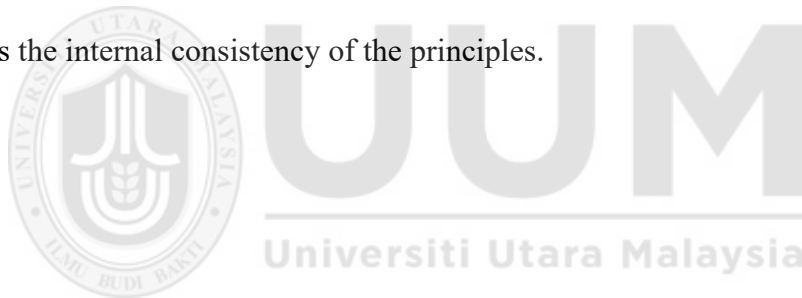


Table 4.17

Measurement model evaluation (Cronbach's alpha, CR and AVE value of variables)

Variables	N of Items	Cronbach's Alpha	CR	AVE
IV 1: Situational Factors				
Accessibility and Availability	5	0.714	0.873	0.633
Convenience	5	0.728	0.736	0.413
Engagement	4	0.734	0.883	0.719
Advertising	5	0.800	0.828	0.551
Education	5	0.817	0.825	0.489
Policy and Regulations	5	0.736	0.837	0.642
IV 2: Personal Factors				
Attitude	5	0.892	0.895	0.632
Social Norms	5	0.850	0.890	0.671
Knowledge and Experience	5	0.711	0.873	0.699
Awareness	5	0.887	0.902	0.658
Psychological Ownership	4	0.745	0.783	0.552
DV				
Household E-waste Recycling Participation	4	0.886	0.888	0.667

All variables have been checked for its Cronbach's Alpha value. Referring to the table above, the Cronbach's value for all variables in the study area are more than 0.70. In relation to the engagement variable that falls under the category of situational factors, the initial value of Cronbach's Alpha was 0.653, which is lower than what Nunnally (1978) anticipated. In order to get a Cronbach's Alpha value of 0.734, item number four in the questionnaire that was associated with this variable was eliminated as suggested in SPSS. Therefore, the items in the variables are consistent. The Cronbach's Alpha coefficient for the scale comprising all the items was found to be greater than 0.70, indicating a strong degree of internal consistency. This confirms its reliability.

The reliability of the measures in this thesis was initially evaluated by employing Cronbach's coefficient alpha, followed by the utilisation of CFA. The establishment of reliable measures is of utmost importance to ensure the reliability and consistency of the data collected in this study. As stated by Hair et al. (1998), the utilisation of dependable measures allows the researcher to enhance their confidence in the reliability of the individual items and their capacity to accurately assess the intended constructs. The two methods employed in this study are CR and AVE, as recommended by Fornell and Larcker (1981). Regarding Cronbach's coefficient alpha, Table 4.17 provides evidence that all the constructs in question surpass the recommended threshold of 0.70, as suggested by Nunnally (1978). When analysing the data, this analysis employed the CR and AVE measures.

The CR values were computed using the CR formula, while the AVE values were calculated using the AVE formula as proposed by Fornell and Larcker (1981). According to the research conducted by Bagozzi and Yi (1988), it is recommended that the CR should have a value equal to or greater than 0.60, while the AVE should have a value equal to or greater than 0.50. However, an AVE value of 0.4 is considered acceptable, given that the CR exceeds 0.6. According to Fornell and Larcker (1981), when the AVE is below the recommended threshold of 0.5 but the CR is above 0.6, the construct's convergent validity can still be deemed satisfactory. According to the calculated data in Table 4.17, both CR and AVE values are within acceptable range. According to Fornell and Larcker criterion, discriminant validity is established when the square root of AVE for a construct is greater than its correlation with the other constructs in the study. Hence, the discriminant validity was established.

4.2.3 Analysis and Results of Structural Models

4.2.3.1 Model A: Validation of Symbiosis Effect between Situational and Personal Factors to Household E-waste Recycling Participation

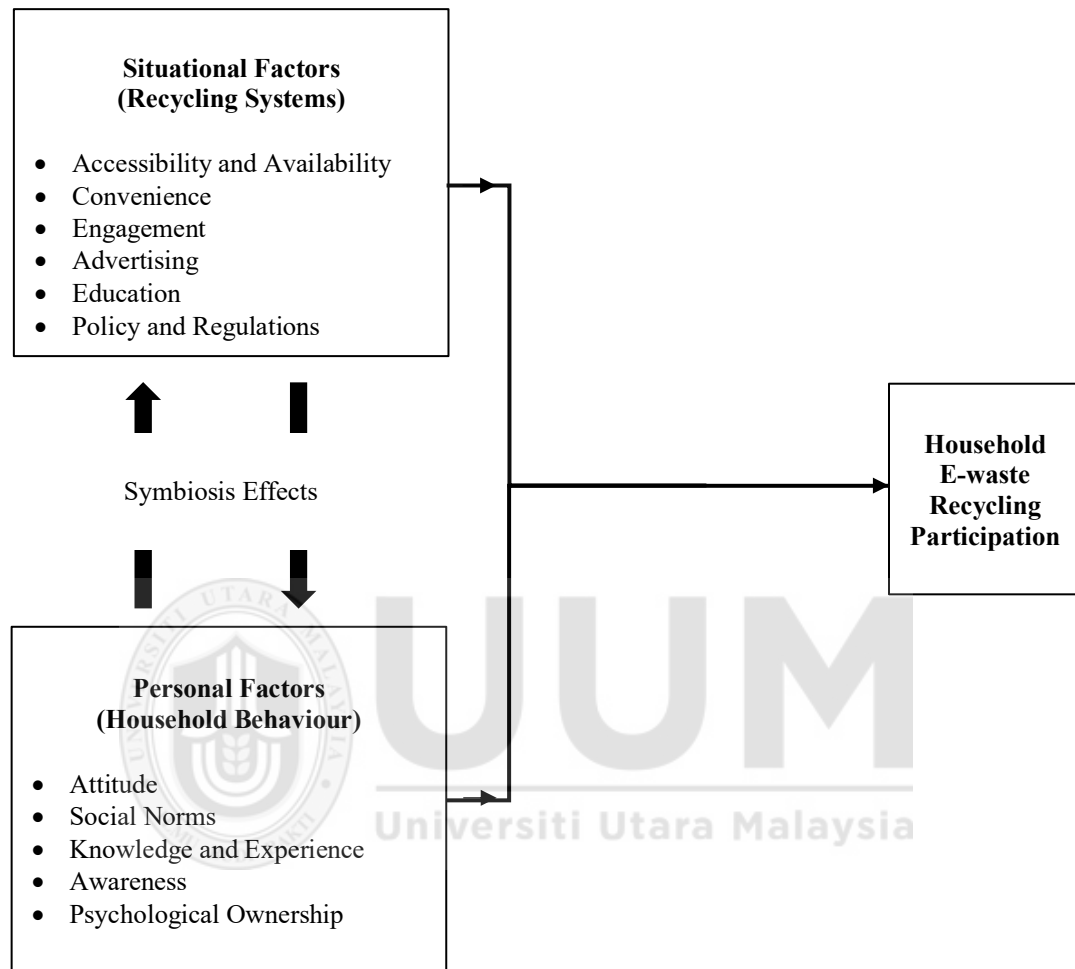


Figure 4.13
Framework tested in Model A

This study conducted a detailed analysis of the constructed conceptual framework, as depicted in the preceding Figure 3.1. Within this chapter, the researcher has made the decision to divide the conceptual framework into two distinct models, namely Model A and Model B. This division has been undertaken in order to provide a clear and comprehensive explanation of the data analysis process in accordance with the specific research questions that have been addressed as the focus of this study in Chapter 1. The

analysis conducted in Model A was utilised to address research questions one, two, and three. Conversely, the final research question was addressed by employing the framework depicted in Model B. Figure 4.13 illustrated a complete framework tested in Model A.

The research questions that were addressed within the framework of Model A are as follows:

- RQ1. How does the situational factors influence households to participate in e-waste recycling in Malaysia?
- RQ2. How does the personal factors influence households to participate in e-waste recycling in Malaysia?
- RQ3. How does the reverse logistics symbiosis between situational and personal factors can influence and support the dynamic interactions between HERS and HERB?

The study that was carried out using Model A provided a comprehensive analysis of the factors that influence household recycling participation. Specifically, the research focused on examining the impact of both situational and personal factors on individuals' decision to engage in recycling activities within their households. In addition, Model A provided a comprehensive explanation of the variables that confirmed the presence of symbiotic effects between HERS and HERB. This concepts were elaborated upon in the subsequent subsections. If the critical ratio for a regression weight is higher than +1.96 or lower than -1.96, or have a p value less than 0.05, that means that particular indicator has a statistically significant influence on the latent construct (Byrne, 2010).

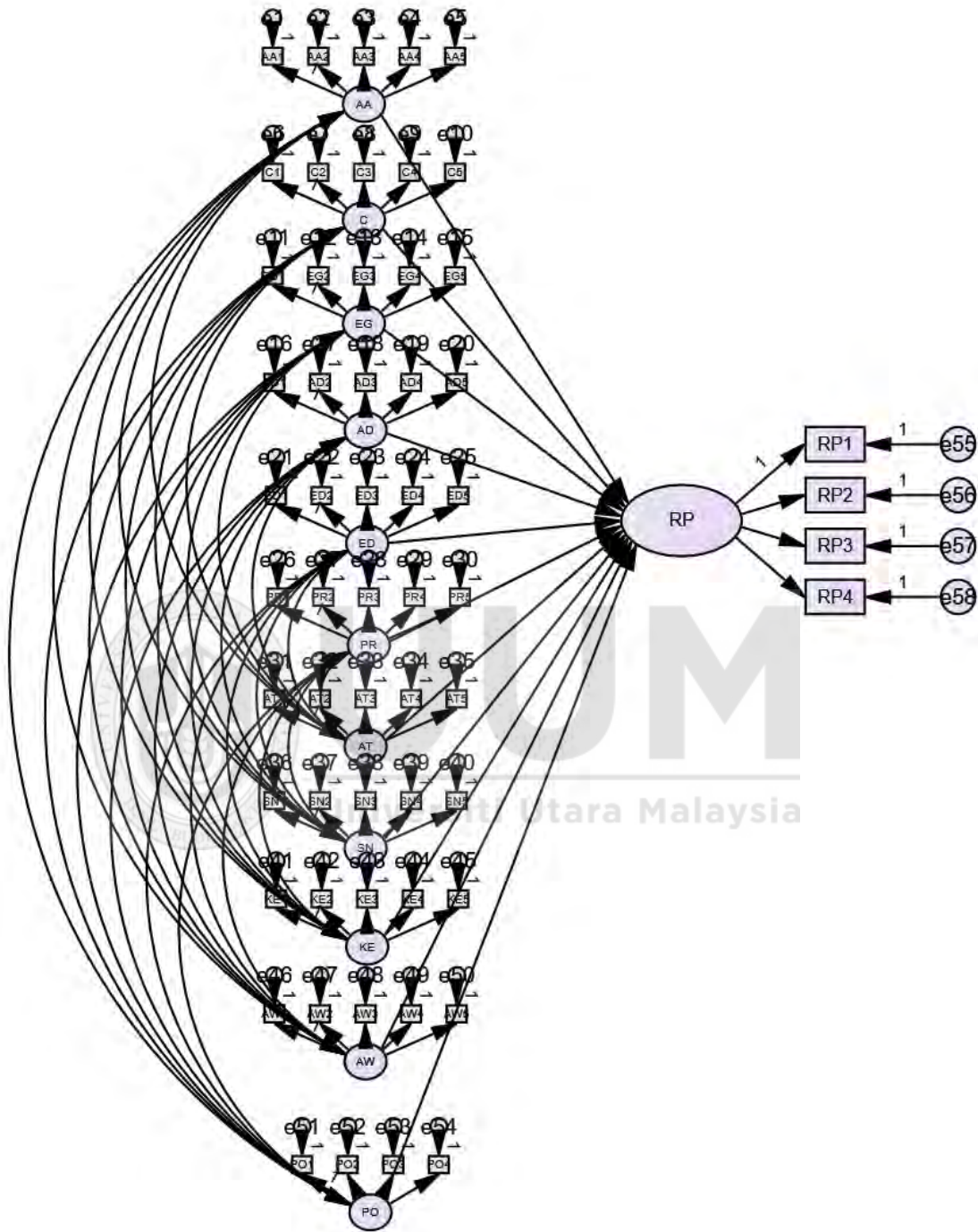


Figure 4.14
 Structural model tested for Model A

4.2.3.1.1 Results for Research Question 1: The Influence of Situational Factors to Household E-waste Recycling Participation

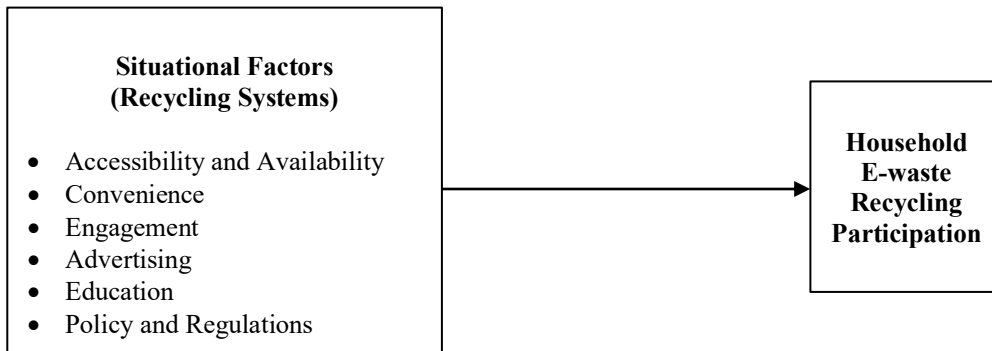


Figure 4.15

Framework of situational factors to household e-waste recycling participation

The first structural model is designed to systematically analyse and provide a comprehensive explanation of the relationships depicted in Figure 4.15. It focuses on examining the pathways between situational factors, such as accessibility and availability, convenience, engagement, advertising, education, and, policy and regulations, and their impact on household e-waste recycling participation. This model were used to assess how these factors interact to influence household e-waste recycling participation, identifying the strength and significance of each connection. Through this analysis, the structural model aims to uncover critical insights into the dynamics driving e-waste recycling participation, highlighting key areas for improvement in recycling systems. The findings served as a foundation for understanding the effectiveness of the proposed framework and guiding targeted interventions to promote sustainable e-waste management practices.

i. Structural Model 1 - Situational Factors to Household E-waste Recycling Participation

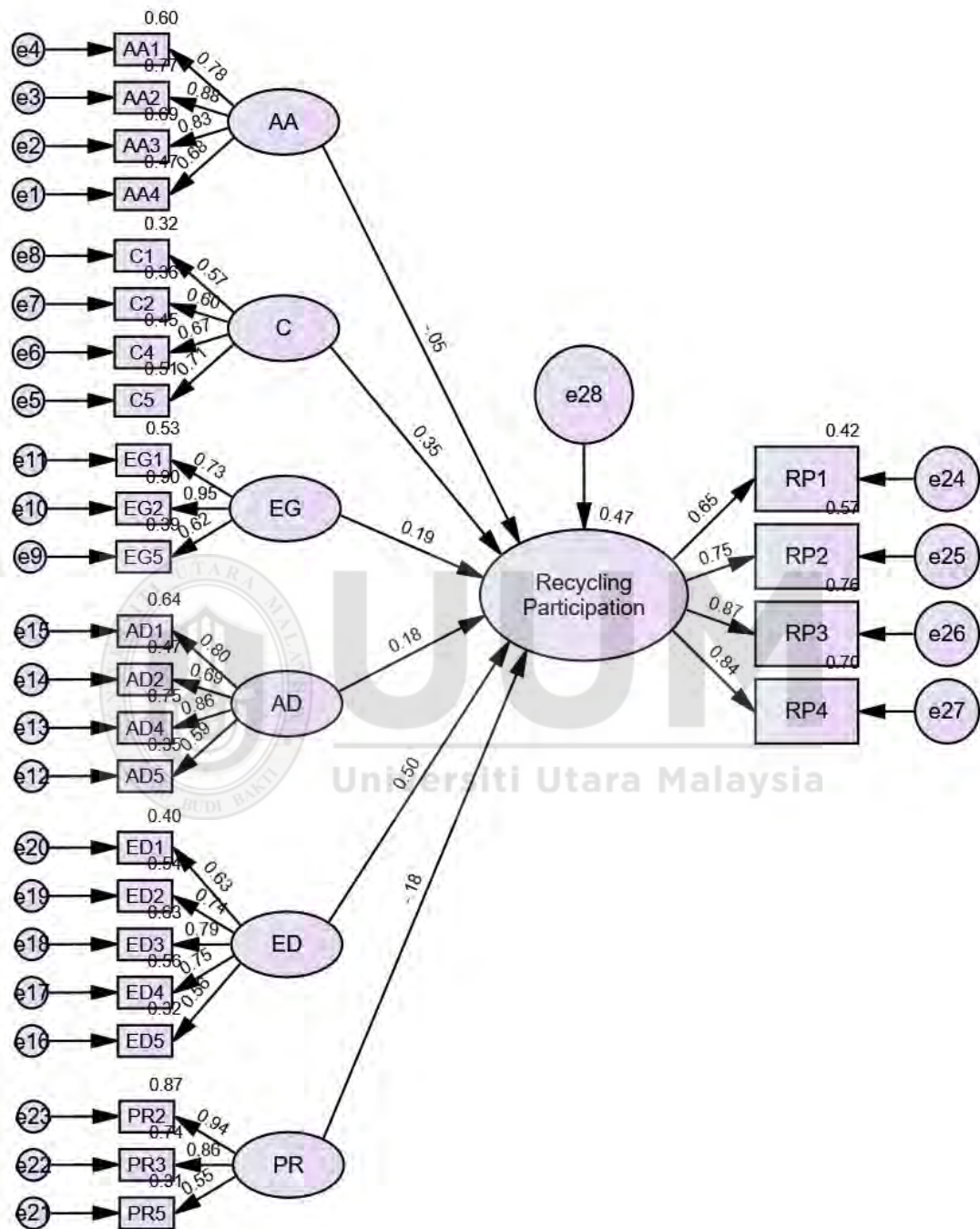


Figure 4.16
The structural model 1

Table 4.18
Underlying influences for RQ1

Influences Path	Influences
Accessibility and Availability → Recycling Participation	Accessibility and Availability have an influence on households to participate in e-waste recycling.
Convenience → Recycling Participation	Convenience has an influence on households to participate in e-waste recycling.
Engagement → Recycling Participation	Engagement has an influence on households to participate in e-waste recycling.
Advertising → Recycling Participation	Advertising has an influence on households to participate in e-waste recycling.
Education → Recycling Participation	Education has an influence on households to participate in e-waste recycling.
Policy and Regulations → Recycling Participation	Policy and Regulations have an influence on households to participate in e-waste recycling.

An examination of goodness-of-fit indices indicate that the structural model 1 (Figure 4.16) fit the data adequately with all fit indices showing reasonable values ($\chi^2 = 285.615$, $df = 127$, $p = .000$). Although the chi-square statistic is statistically significant, this is not deemed unusual given the large sample size (Bagozzi and Yi, 1988). In addition, the GFI = .953, CFI=.984, TLI=.981 and RMSEA= .043. The coefficient parameters estimates are then examined to test the influences path listed in Table 4.18. Results are displayed in Table 4.19.

Table 4.19
Testing the influential factors for RQ1 (structural model 1)

Influences Path	Standardised Estimate (β)	Critical Ratio (z-value)	Results
Accessibility and Availability → Recycling Participation	0.038	-1.006	Do not have an influence
Convenience → Recycling Participation	0.045	5.712	Has an influence
Engagement → Recycling Participation	0.042	3.753	Has an influence
Advertising → Recycling Participation	0.030	3.416	Has an influence
Education → Recycling Participation	0.065	6.943	Has an influence
Policy and Regulations → Recycling Participation	0.048	-3.581	Has an influence

Table 4.19 illustrates that convenience, engagement, advertising, education, policy and regulations are statistically significant and have a direct influence on recycling participation. The critical ratio or z-value shows that all value is either higher than +1.96 or lower than -1.96, which indicates that all five independent variables have an influence to e-waste recycling participation. The standardized estimates for these influences path is all significant ($\beta= 0.045$, $p < 0.001$; $\beta= 0.042$, $p < 0.001$; $\beta= 0.030$, $p < 0.001$ and $\beta= 0.065$, $p < 0.001$), respectively. However, there is one non-significant path (accessibility and availability towards recycling participation) in the above structural model. The relationship between the accessibility and availability with recycling participation were found to be not significant with $\beta= 0.038$, $p= 0.174$. Thus, this situational factor was found to not have direct influence on e-waste recycling participation in Malaysia.

In order to arrive at the most parsimonious model, Byrne (2001) suggests that all non-significant pathways should be deleted from the model. Applying this suggestion, the deleting procedure was performed by removing one non-significant path at a time as suggested by Holmes-Smith et al. (2006). They argued that deleting one path at a time could possibly change the modification indices, structural coefficients and significant levels. It is important to assess the fit of a modified model by deleting the non-significant paths, therefore, allowing the most parsimonious underlying model to be eventually defined.



ii. **Structural Model 2 – Situational Factors to Household E-waste Recycling Participation (Removing One Path)**

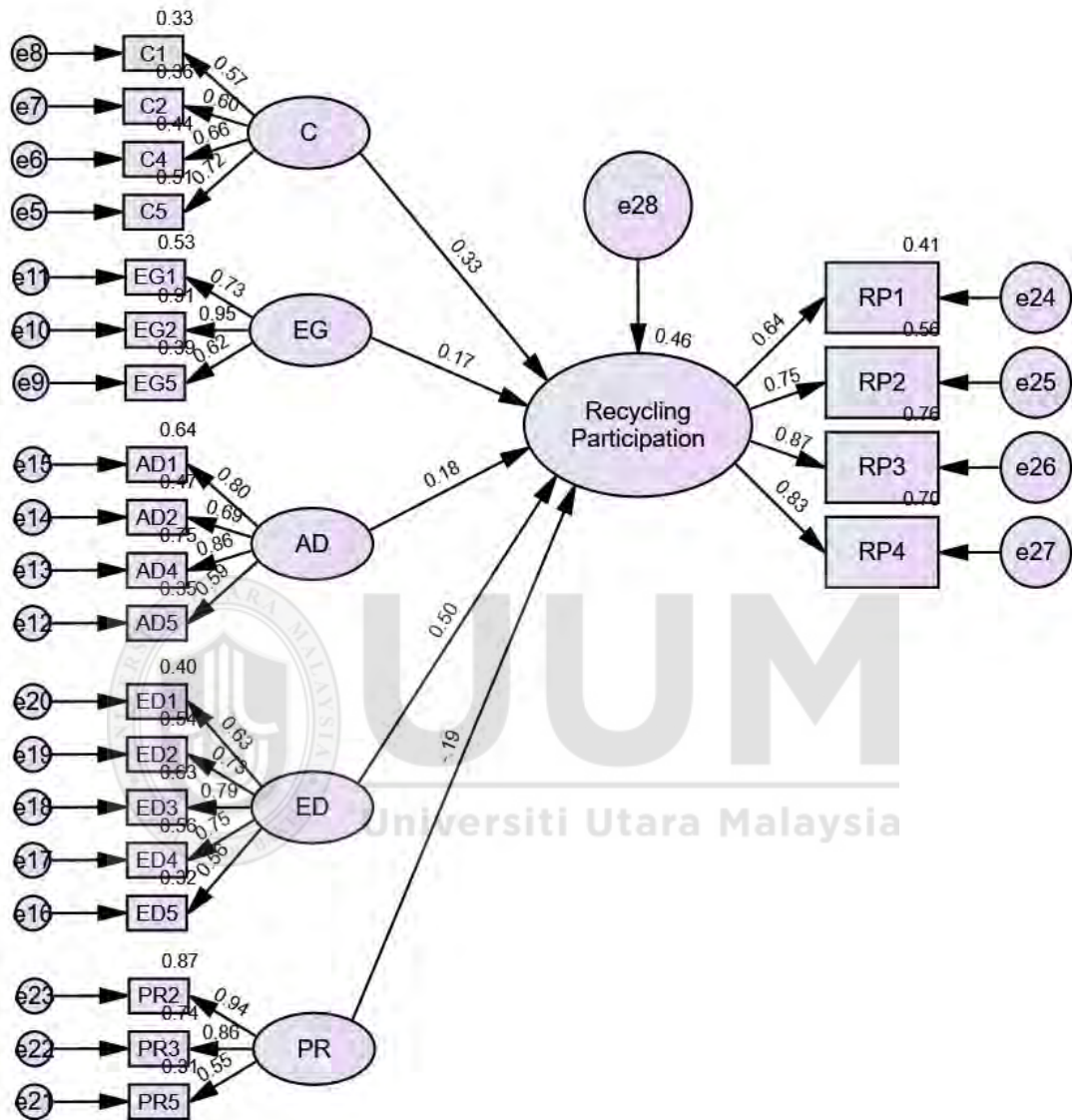


Figure 4.17
The structural model 2

Earlier results indicated that one path needed to be deleted. The non-significant path between accessibility and availability to recycling participation was deleted because this path displayed the lowest β coefficient ($\beta = 0.038$, $p = 0.174$) and the z-value is way more than -1.96. Figure 4.17 illustrates structural model 2. The goodness-of-fit indices indicated that this modified model fitted the data adequately ($\chi^2 = 285.743$, $df = 128$, $p = .000$). In addition, the GFI = 0.953, CFI = 0.984, TLI = 0.981 and RMSEA = 0.043. Consequently, the model was reanalysed (Table 4.21). However, an examination of coefficient parameter estimates after deleting this path indicated no major changes in the results. Based on an examination of goodness-of-fit indices, Structural Model 2 appears to have a better fit compared to previous models. Table 4.20 shows that all the remaining relationships (convenience, engagement, advertising, education, policy and regulations to recycling participation) were statistically significant and in the predicted direction.

Table 4.20
Testing the influential factors for RQ1 (structural model 2)

Influences Path	Standardised Estimate (β)	Critical Ratio (z-value)	Results
Convenience → Recycling Participation	0.044	6.104	Has an influence
Engagement → Recycling Participation	0.042	3.753	Has an influence
Advertising → Recycling Participation	0.030	3.475	Has an influence
Education → Recycling Participation	0.065	6.943	Has an influence
Policy and Regulations → Recycling Participation	0.048	-3.620	Has an influence

4.2.3.1.2 Results for Research Question 2: The Influence of Personal Factors to Household E-waste Recycling Participation

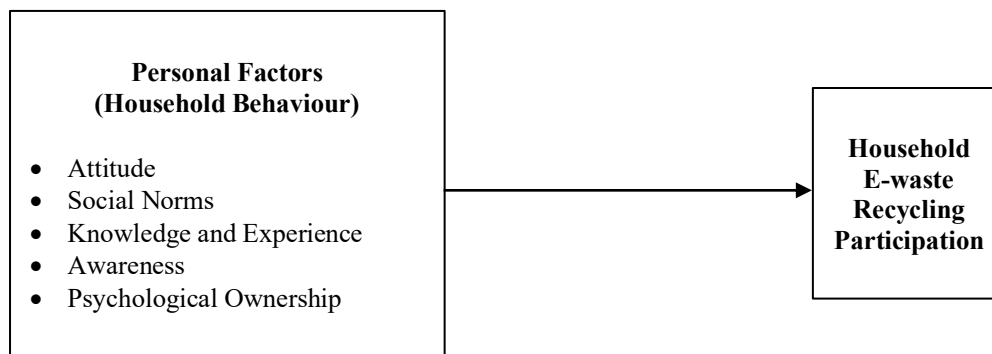


Figure 4.18

Framework of personal factors to household e-waste recycling participation

The next structural model critically analyse and elucidate the relationships illustrated in Figure 4.18, focusing on the influence of personal factors on household e-waste recycling participation. This model explored the interplay between key behavioural dimensions, including attitude, social norms, knowledge and experience, awareness, and psychological ownership, in shaping household e-waste recycling behaviours. By quantifying the strength and statistical significance of these relationships, the model uncovered the underlying mechanisms driving individual participation in e-waste recycling initiatives. Through this analysis, the structural model offered an in-depth understanding of how personal factors collectively and individually contribute to recycling behaviour. This insight is essential for designing strategies that enhance behavioural engagement by addressing cognitive and emotional drivers.

iii. **Structural Model 3 - Personal Factors to Household E-waste Recycling Participation**

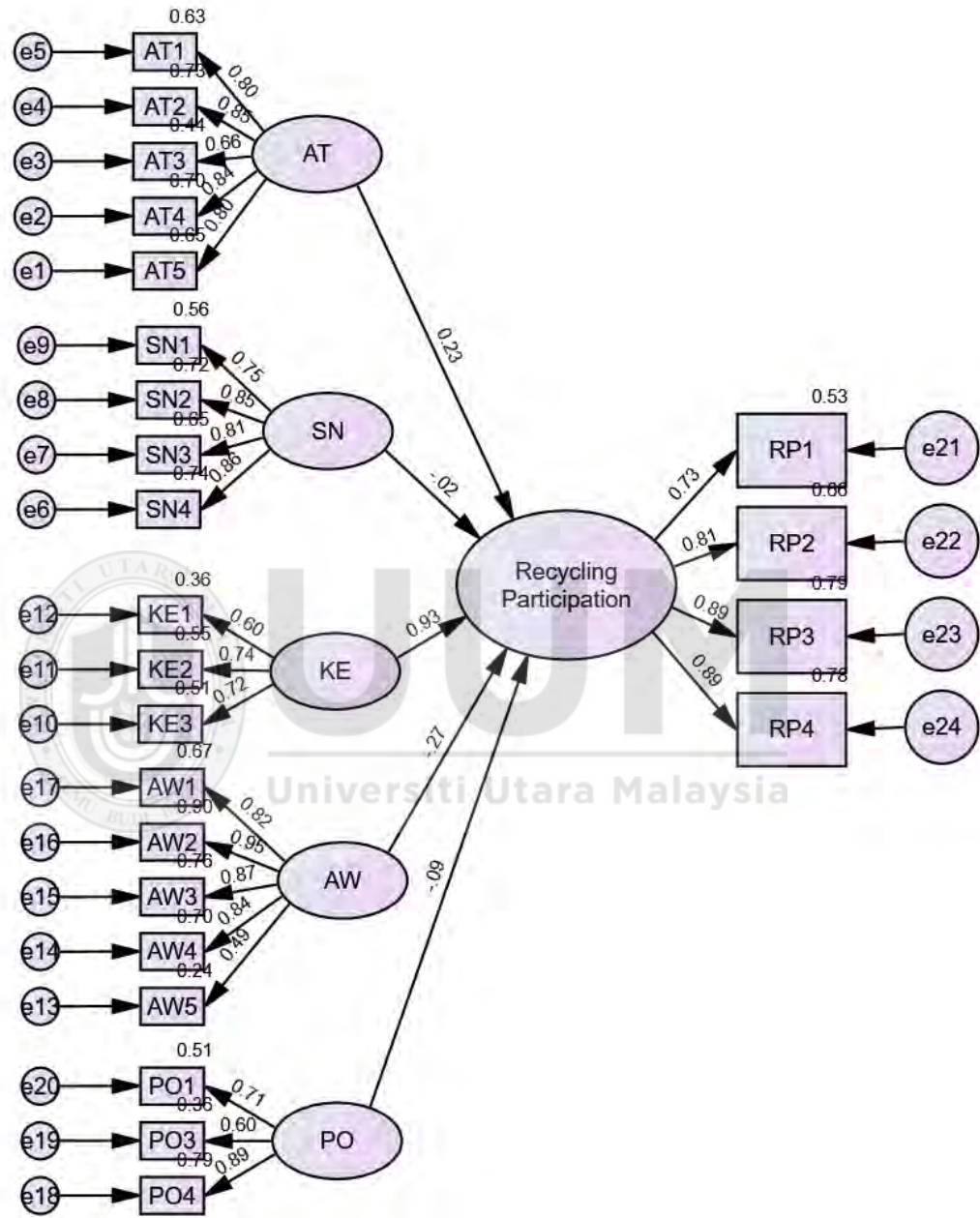


Figure 4.19
The structural model 3

Table 4.21
Underlying influences for RQ 2

Influences Path	Influences
Attitude → Recycling Participation	Attitude has an influence on households to participate in e-waste recycling.
Social Norms → Recycling Participation	Social Norms has an influence on households to participate in e-waste recycling.
Knowledge and Experience → Recycling Participation	Knowledge and Experience have an influence on households to participate in e-waste recycling.
Awareness → Recycling Participation	Awareness has an influence on households to participate in e-waste recycling.
Psychological Ownership → Recycling Participation	Psychological Ownership has an influence on households to participate in e-waste recycling.

An evaluation of the goodness-of-fit indices indicates that Structural Model 3 (Figure 4.19) demonstrates an adequate fit to the data, with all indices reflecting acceptable values ($\chi^2 = 206.238$, $df = 248$, $p = 0.000$). While the chi-square statistic is statistically significant, this result is expected given the large sample size, as noted by Bagozzi and Yi (1988). Supporting the overall model fit, additional indices exhibit strong performance: the GFI is 0.985, the CFI is 0.919, the TLI is 0.988, and the RMSEA is 0.042. Subsequently, the coefficient parameter estimates were examined to assess the influence of the specified paths. The results of this analysis are presented in Table 4.21, providing a detailed overview of the statistical relationships and their influence for the recycling participation structural pathways.

Table 4.22
Testing the influential factors for RQ2

Influences Path	Standardised Estimate (β)	Critical Ratio (z-value)	Results
Attitude → Recycling Participation	0.029	6.651	Has an influence
Social Norms → Recycling Participation	0.020	-0.648	Do not have an influence
Knowledge and Experience → Recycling Participation	0.076	13.288	Has an influence
Awareness → Recycling Participation	0.055	-6.350	Has an influence
Psychological Ownership → Recycling Participation	0.022	-2.555	Has an influence

Table 4.22 illustrates that attitude, knowledge and experience, awareness and psychological ownership are statistically significant and have a direct influence on household e-waste recycling participation. The critical ratio or z-value shows that all value is either higher than +1.96 or lower than -1.96, which indicates that all four independent variables have an influence on e-waste recycling participation. The standardized estimates for these influences path are all significant ($\beta= 0.029$, $p < 0.001$; $\beta= 0.076$, $p < 0.001$; $\beta= 0.055$, $p < 0.001$ and $\beta=0.022$, $p < 0.001$), respectively. However, there is one non-significant path (social norms towards recycling participation) in the structural model 3 (Figure 4.19). The relationship between the social norms with recycling participation were found to be not significant with $\beta= 0.020$, $p= 0.517$. Thus, this personal factor was found to not have direct influence on e-waste recycling participation in Malaysia.

To arrive at the most parsimonious model, Byrne (2001) recommends removing all non-significant pathways. In accordance with this guidance, the model modification process was carried out by sequentially deleting one non-significant path at a time, as proposed by Holmes-Smith et al. (2006). They contended that the deletion of individual paths could potentially alter the modification indices, structural coefficients, and significance levels. Consequently, it is crucial to evaluate the fit of the modified model after each deletion to ensure that the final model accurately reflects the most parsimonious representation of the data.



iv. Structural Model 4 - Personal Factors to Household E-waste Recycling Participation (Removing One Path)

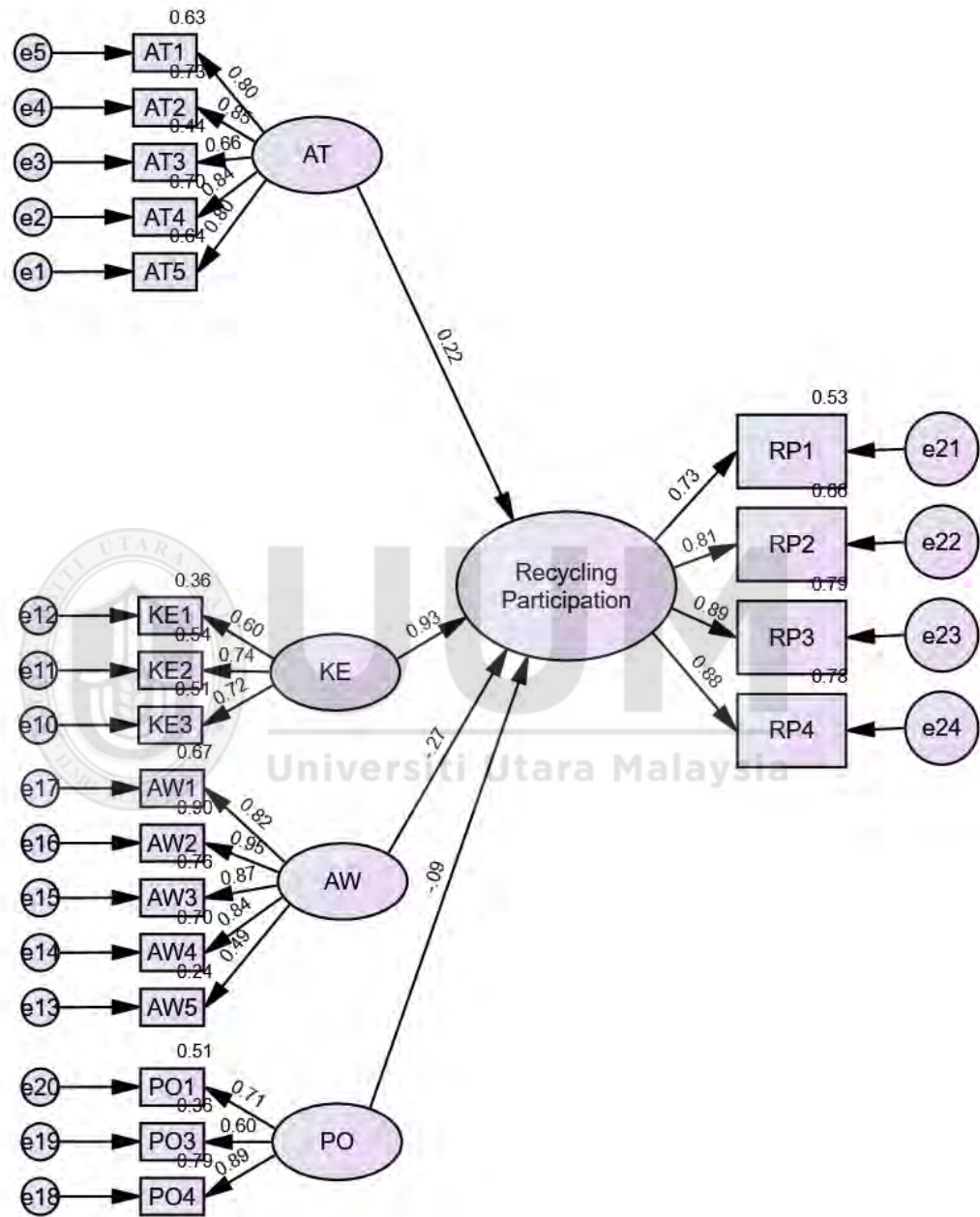


Figure 4.20
The structural model 4

Earlier results indicated that one path needed to be deleted. The non-significant path between social norms and recycling participation was deleted because this path displayed the lowest β coefficient ($\beta= 0.020$, $p= 0.517$) and the z-value is way more than -1.96. Figure 4.20 illustrates structural model 4. The goodness-of-fit indices indicated that this modified model fitted the data adequately ($\chi^2 = 199.52$, $df= 123$, $p= 0.000$). In addition, the GFI= 0.924, CFI= 0.977, TLI= 0.971 and RMSEA= 0.042. Consequently, the model was reanalysed (Table 4.24). However, an examination of coefficient parameter estimates after deleting this path indicated no major changes in the results. Based on an examination of goodness-of-fit indices, structural model 4 appears to have a better fit compared to structural model 3. Table 4.23 shows that all the remaining relationships (attitude, knowledge and experience, awareness and psychological ownership to e-waste recycling participation) were statistically significant and in the predicted direction.

Table 4.23
Testing the influential factors for RQ2 (structural model 4)

Influences Path	Standardised Estimate (β)	Critical Ratio (z-value)	Results
Attitude → Recycling Participation	0.029	6.364	Has an influence
Knowledge and Experience → Recycling Participation	0.077	13.290	Has an influence
Awareness → Recycling Participation	0.055	-6.317	Has an influence
Psychological Ownership → Recycling Participation	0.022	-2.570	Has an influence

4.2.3.1.3 Results for Research Question 3: Existence of Symbiosis Effect between Situational and Personal Factors

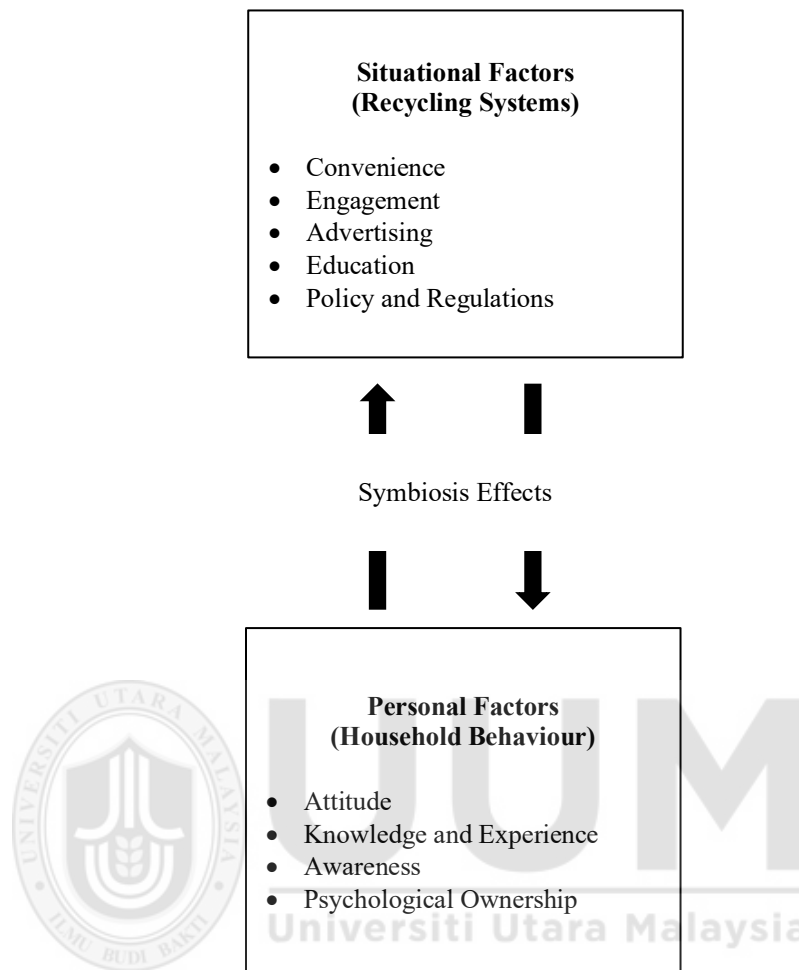


Figure 4.21
Framework of symbiosis effect between situational and personal factors

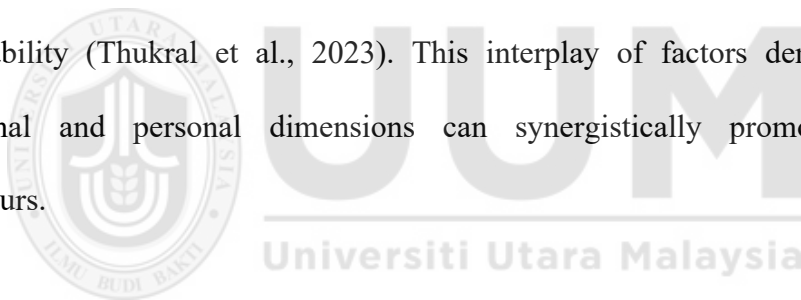
Figure 4.21 illustrates the complex interplay between situational factors, represented by recycling systems provided by the local stakeholders, and personal factors, associated with household behaviour, to examine the symbiosis effect that influences household e-waste recycling participation. This framework serves as a central element of RQ3, investigating whether these factors mutually enhance or reinforce each other, thereby creating a dynamic reciprocal relationship referred to as the symbiosis effect. In the

preceding section, it was established that neither accessibility and availability nor social norms exerted a significant influence on household e-waste participation. Consequently, these factors were excluded from subsequent analyses to focus more precisely on examining the symbiosis effect between the remaining situational and personal factors. This refinement allows for a more targeted exploration of the dynamic interactions and reciprocal relationships that underpin the conceptual framework, providing a clearer understanding of how key situational factors interact with personal factors. By narrowing the scope, the analysis ensures greater precision and relevance in interpreting the results, thereby enhancing the study's overall contributions to the field.

The two key components of this framework are situational factors and personal factors. Situational factors encompass external conditions and systemic characteristics that influence individuals' recycling behaviours. These include the convenience of recycling facilities and services, the level of engagement promoted through community or institutional initiatives, advertising strategies, educational programs, and policy and regulatory measures. On the other hand, personal factors reflect intrinsic characteristics and perceptions that shape household recycling behaviour. These include attitude toward recycling, the depth of knowledge and experience related to recycling practices, environmental awareness, and psychological ownership—a sense of responsibility or personal investment in sustainable practices.

This section delves into a more detailed quantitative and analytical analysis of Figure 4.21, which analysed a bidirectional symbiotic relationship between situational and personal factors. For instance, proving a convenient of recycling facilities and services can foster a more positive attitude toward recycling. In turn, individuals with a positive

attitude are more likely to engage actively with accessible and convenient recycling systems. Such reciprocal influences underscore the interconnectedness of these factors, highlighting the need for integrated approaches to design and implement effective recycling interventions. Empirical research supports this conceptualization. Studies have shown that convenience facilities within an accessible distance significantly enhance pro-environmental behaviours by reducing perceived barriers to participation (Barr et al., 2013; Miafodzyeva and Brandt, 2013). Similarly, engagement strategies provided by local stakeholders and municipal authorities that involve community participation are known to strengthen environmental stewardship (Pahl et al., 2014). Furthermore, education and awareness campaigns have been repeatedly identified as critical in increasing recycling knowledge and fostering positive attitudes toward sustainability (Thukral et al., 2023). This interplay of factors demonstrates how situational and personal dimensions can synergistically promote sustainable behaviours.



A detailed representation of the examination of reciprocal loops between personal and situational elements is illustrated in Figure 4.22. This analysis constitutes a pivotal component of the study's investigation into the symbiosis effect, which seeks to understand the bidirectional influences between these two domains. The analysis was executed utilizing the SEM functionalities available in SPSS AMOS software. Employing SEM in this context facilitated a nuanced exploration of the analysed reciprocal relationships, enabling precise estimation of the interaction effects and rigorous validation of the theoretical framework underpinning the study (Byrne, 2016; Kline, 2015). The use of SPSS AMOS was instrumental in modeling the dynamic and interconnected pathways between situational and personal factors. The advanced

features of AMOS allowed for the identification and quantification of latent variables and their structural relationships, offering empirical clarity to the proposed symbiotic interactions (Arbuckle, 2017). This robust methodological approach ensured that the analysis not only visualized but also statistically substantiated the intricate interplay between these factors.

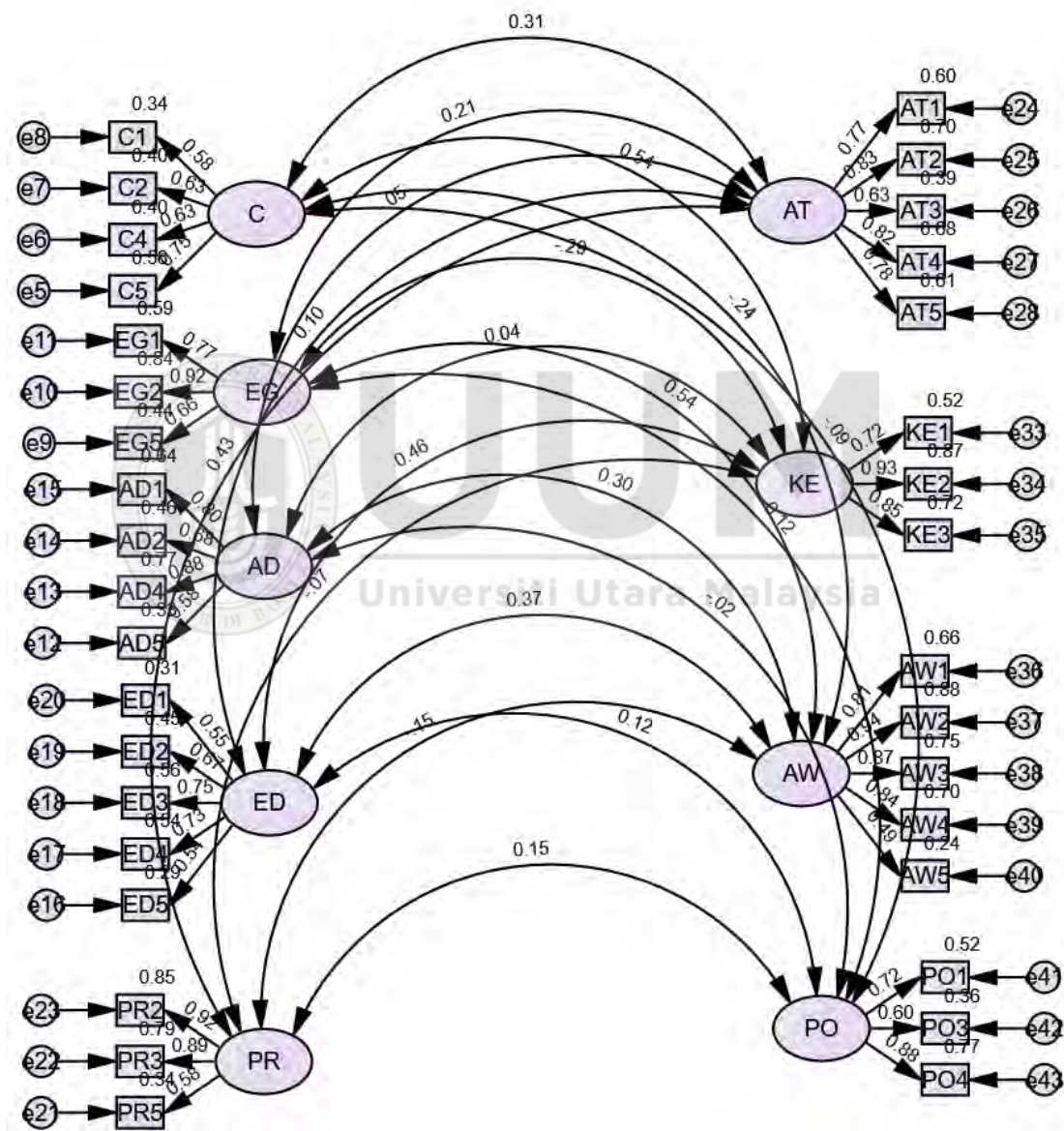


Figure 4.22
The reciprocal loops between situational and personal factors

The findings represented in Figure 4.22 are further substantiated by the results presented in Table 4.24, which detail the existence and magnitude of reciprocal effects, referred to as symbiosis effects, between situational and personal factors. These results affirm the symbiotic influence, with significant pathways demonstrating how situational variables, such as convenience, and engagement, drive changes in personal dimensions like attitude, awareness, and psychological ownership. Conversely, enhanced personal factors exert a positive influence on situational engagement, thereby reinforcing the cyclical and mutually reinforcing nature of these interactions. Collectively, these findings offer robust empirical support for the conceptual model, highlighting its practical implications for promoting sustainable behaviour through strategic interventions targeting both situational and personal domains. The analytical review of Table 4.24 is further elaborated upon in the subsequent subsection.

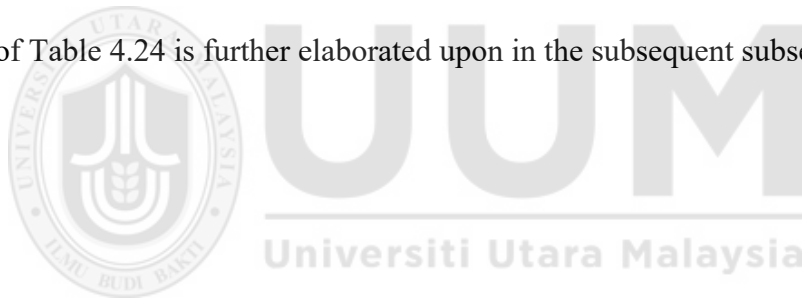


Table 4.24
Testing the reciprocal effects for RQ3

Influences Path	Standardised Estimate (β)	Critical Ratio (z-value)	Existence of Symbiosis Effect
Convenience ↔ Attitude	0.019	5.568	Yes
Convenience ↔ Knowledge and Experience	0.022	7.710	Yes
Convenience ↔ Awareness	0.016	-5.191	Yes
Convenience ↔ Psychological Ownership	0.018	-1.689	No
Engagement ↔ Attitude	0.014	4.365	Yes
Engagement ↔ Knowledge and Experience	0.014	-5.920	Yes
Engagement ↔ Awareness	0.021	7.972	Yes
Engagement ↔ Psychological Ownership	0.015	2.425	Yes
Advertising ↔ Attitude	0.020	-0.972	No
Advertising ↔ Knowledge and Experience	0.016	0.838	No
Advertising ↔ Awareness	0.022	5.580	Yes
Advertising ↔ Psychological Ownership	0.022	-0.381	No
Education ↔ Attitude	0.012	2.090	Yes
Education ↔ Knowledge and Experience	0.016	6.530	Yes
Education ↔ Awareness	0.014	6.313	Yes
Education ↔ Psychological Ownership	0.013	2.187	Yes
Policy and Regulations ↔ Attitude	0.019	6.228	Yes
Policy and Regulations ↔ Knowledge and Experience	0.010	-1.676	No
Policy and Regulations ↔ Awareness	0.011	-3.533	Yes
Policy and Regulations ↔ Psychological Ownership	0.015	2.719	Yes

Table 4.24 offers a detailed examination of the reciprocal effects, referred to as symbiotic relationships, between situational and personal factors within the context of household e-waste recycling behaviour. This analysis aims to illuminate the intricate interconnections between recycling systems in terms of facilities and services provided by local stakeholders (situational factors) and household behaviour (personal factors) that influence household e-waste recycling participation. Situational factors, including

convenience, engagement, advertising, education, and policy regulations, are analysed to shape and influence personal factors such as attitude, knowledge and experience, awareness, and psychological ownership. By conducting a thorough evaluation of the standardized estimates (β) and critical ratios (z-values), this study identifies and quantifies the presence of symbiosis effects between these constructs.

The symbiotic relationship between situational and personal factors in e-waste recycling reflects a dynamic interplay where each factor influences and is influenced by the other. As established by Byrne (2010), the statistical significance of these relationships can be determined by examining the z-value. Specifically, when the critical ratio exceeds +1.96 or falls below -1.96, or when the p-value is less than 0.05, the indicator demonstrates a statistically significant effect on the corresponding latent construct. Upon further scrutiny of the z-values, the analysis uncovers which factors exhibit the strongest and weakest symbiotic relationships between the situational context and household recycling behaviour. These insights are crucial for understanding the mechanisms through which external factors (e.g., convenience or policy) can shape households' attitudes, knowledge, and ownership behaviours in the realm of recycling.

4.2.3.1.3.1 Review of the Existence of Symbiosis Effect between Situational and Personal Factors

In total, the study identifies 15 influential paths in which situational factors exhibit a symbiotic relationship with personal factors, each contributing to the broader understanding of e-waste recycling behaviours. These symbiotic effects reflect mutual influence, where situational factors affect households' perceptions, attitudes, and behaviours, while personal factors can shape responses to situational conditions. The following pathways represent the significant symbiotic effects discovered in the analysis:

1. **Convenience and Attitude:** ($\beta = 0.019$, $z = 5.568$, Yes)

The findings reveal a significant and reciprocal relationship between convenience and attitude, underscoring the critical interplay between situational and personal factors. The β value showing the strength and direction of the relationship between convenience and household attitude in influencing e-waste recycling participation. A positive $\beta = 0.019$ suggests that as convenience improves, household attitude towards e-waste recycling also becomes more positive (or vice versa). A positive z-value (5.568) indicates that the relationship is strongly significant in the positive direction since the value is greater than ± 1.96 . This dynamic highlights the existence of a symbiotic effect, wherein the ease and accessibility of recycling services not only influence households' attitudes but also reflect the broader benefits for stakeholders. Studies by Barr et al. (2013) and Miafodzyeva and Brandt (2013) affirm that ease of access and reduced effort are critical in shaping positive recycling behaviours. When recycling is more convenient, households tend to develop a more positive attitude toward participating in

e-waste recycling. Similarly, a favourable attitude towards recycling might encourage households to seek convenient recycling options. By improving both factors simultaneously, participation in e-waste recycling is likely to increase significantly.

2. **Convenience and Knowledge and Experience:** ($\beta = 0.022$, $z = 7.710$, Yes)

The results obtained prove that convenience and households' knowledge and experience have a symbiotic relationship in enhancing e-waste recycling participation. The β value represents the effect size in a regression model, indicating how strongly convenience and knowledge and experience influence each other in the context of e-waste recycling participation. A positive $\beta = 0.022$ indicates that as convenience increases, household knowledge and experience with e-waste recycling also tend to rise in enhancing the household participation in e-waste recycling and vice versa. When systems are straightforward and accessible, they facilitate learning by reducing the complexity and encouraging active participation among households. This finding emphasizes the critical role that well-designed and convenient recycling infrastructure plays not only in facilitating participation but also in shaping individuals' long-term commitment to sustainable waste management practices (DiGiacomo et al., 2018).

3. **Convenience and Awareness:** ($\beta = 0.016$, $z = -5.191$, Yes)

The statistical results obtained indicate a symbiotic relationship between convenience and awareness in enhancing e-waste recycling participation. The β value represents the regression coefficient, which measures the strength and direction of the relationship between convenience and awareness in predicting e-waste recycling participation. A

positive $\beta = 0.016$ suggests that as convenience increases, awareness also tends to increase (or vice versa), reinforcing their joint influence on recycling participation. A negative z-value (-5.191) suggests that there is a significant inverse standard deviation shift in the model, which could mean that without one of the factors (either convenience or awareness), the relationship weakens. The large magnitude of 5.191 indicates a strong statistical significance existed between the two factors, thus signify the existence of a symbiotic relationship between them. This results shows that convenience plays a pivotal role in fostering awareness, as accessible and user-friendly systems effectively highlight recycling opportunities, thereby enhancing public consciousness. A well-designed and convenient recycling system not only enhances the physical accessibility of recycling opportunities but also plays a critical role in raising individuals' awareness of the environmental consequences associated with improper e-waste disposal (Miao et al., 2020). Finally, convenience and awareness are found to mutually reinforce each other—when people find recycling convenient, they are more likely to be aware of its importance, and when they are aware, they seek convenient recycling options.

4. **Engagement and Attitude:** ($\beta = 0.014$, $z = 4.365$, Yes)

Active engagement in recycling initiatives plays a critical role in positively shaping households' attitudes toward recycling. The findings illustrate a symbiotic relationship between stakeholders' efforts to promote e-waste recycling participation and households' attitudes toward adopting such practices. The β value signifies the impact size, reflecting the intensity of the correlation between stakeholder involvement and household attitudes towards e-waste recycling. A positive $\beta = 0.014$ indicates that more stakeholder participation correlates with a more favourable household attitude towards

e-waste recycling, and conversely. A z-value of 4.365 signifies that the relationship is highly significant in promoting household e-waste recycling participation. This findings were in line with research statement by Pahl et al. (2014), that local stakeholders involvement and participatory approaches have been shown to significantly influence individual attitudes toward sustainability such as recycling.

5. **Engagement and Knowledge and Experience:** ($\beta = 0.014$, $z = -5.920$, Yes)

The results indicate that stakeholders' engagement with households' knowledge and experience share a symbiotic relationship in enhancing e-waste recycling participation. The β value represents the strength and direction of the relationship between stakeholders' engagement and household knowledge and experience in the context of e-waste recycling. A positive $\beta = 0.014$ suggests that greater stakeholder engagement is associated with increased household knowledge and experience regarding e-waste recycling (or vice versa). A negative z-value (-5.920) suggests a significant but inverse standardization effect, meaning that while engagement with knowledge and experience are related, the relationship's nature might be more complex. This could be due to differences in how engagement impacts various household segments. Therefore, the results require deeper thought through qualitative approach, However, the large absolute value of $z = 5.920$ signifies that the relationship is highly statistically significant. This symbiotic connection indicates that stakeholder engagement, including participation from government agencies, private stakeholders in waste management, NGOs, and environmental organizations, enhances household knowledge and experience with e-waste recycling. In contrast, households with more knowledge and experience may be more inclined to participate with stakeholders in recycling activities.

6. **Engagement and Awareness:** ($\beta = 0.021$, $z = 7.972$, Yes)

The engagement demonstrated by local stakeholders, coupled with heightened individual awareness of waste recycling, exhibits the strongest symbiotic relationship among all observed pathways. A positive $\beta = 0.021$ indicates that greater stakeholder engagement correlates with heightened awareness of e-waste recycling, and the relationship is reciprocal. A high z -value (7.972) indicates that the relationship between the two variables, stakeholders' engagement and awareness, is highly statistically significant. This indicates that the relationship is genuine and not a result of random variability. The interdependent connection indicates that enhanced involvement from various stakeholders (such as governments, businesses, NGOs, and local communities) boosts awareness of e-waste recycling, and this increased awareness subsequently fosters greater participation among households. The connection between engagement and awareness stands out as the most significant among all pathways examined in the study, underscoring its vital importance in promoting households participation in e-waste recycling.

7. **Engagement and Psychological Ownership:** ($\beta = 0.015$, $z = 2.425$, Yes)

The findings suggest a mutually beneficial connection between stakeholder engagement and psychological ownership, which contributes to increased participation in e-waste recycling efforts. The β value quantifies the strength and direction of the relationship between stakeholder engagement and psychological ownership within the framework of e-waste recycling. A positive $\beta = 0.015$ indicates that greater stakeholder engagement correlates with enhanced psychological ownership regarding e-waste recycling. A z -

value of 2.425 exceeds the typical significance threshold, indicating that the connection between engagement and psychological ownership is statistically significant. The symbiotic link indicates that increased stakeholder engagement, such as outreach, communication, and collaboration with local organisations, cultivates a feeling of psychological ownership about e-waste recycling. Consequently, psychological ownership; the perception that recycling actions have personal significance and are an individual obligation, may increase involvement in recycling programs. Ofori (2020) said that highlighting the potential of recycled components to be reused for new EEE diminishes the need for raw resources, hence increasing consumers' willingness to dispose of these items.

8. **Advertising and Awareness:** ($\beta = 0.022$, $z = 5.580$, Yes)

The β value indicates the degree of association between advertising initiatives and the awareness surrounding e-waste recycling. An observed β value of 0.022 indicates a correlation between heightened advertising efforts and an increase in awareness regarding e-waste recycling among individuals. The elevated z-value (5.580) strengthens the credibility of this observation. The findings indicate that there is a mutually beneficial connection between advertising and awareness in boosting participation in e-waste recycling. The interdependent nature of advertising and awareness suggests a mutual relationship between the two. Enhanced advertising initiatives, including media campaigns, social media engagement, and local outreach, result in elevated awareness about e-waste recycling. Research has consistently demonstrated that awareness campaigns are instrumental in improving public understanding of environmental challenges, including waste management and e-waste

recycling (Baldé et al., 2017). Furthermore, as awareness grows, individual might become more inclined to engage in recycling initiatives, potentially strengthening their psychological connection to the recycling process.

9. **Education and Attitude:** ($\beta = 0.012$, $z = 2.090$, Yes)

The weak effect size ($\beta = 0.012$) and the relatively low z-value (2.090) demonstrate that education exhibits the weakest reciprocal influence on attitudes towards increasing household e-waste recycling participation. In comparison to other relationships examined in the study, this one seems to be the least robust. This suggests that education by itself may not be enough to substantially change attitudes. While education contributes to fostering positive attitudes, it does not emerge as the most influential factor in driving recycling participation. Nonetheless, the findings continue to demonstrate a mutually beneficial connection between education and attitude in promoting participation in e-waste recycling. It may be necessary to strengthen educational initiatives or integrate them with additional approaches to more effectively influence perspectives on e-waste recycling.

10. **Education and Knowledge and Experience:** ($\beta = 0.016$, $z = 6.530$, Yes)

A positive $\beta = 0.016$ signifies that enhanced education correlates with elevated individual knowledge and experience with e-waste recycling, and conversely. The affirmative z-value substantiates the assertion that education has a consistent and beneficial influence on knowledge and experience regarding e-waste recycling. The interplay of education, knowledge, and households' experience in e-waste recycling is

shown to be symbiotic, with one element mutually influencing the others, hence augmenting involvement in recycling programs. The symbiotic connection indicates that education and individuals with prior knowledge and experience in recycling operations mutually reinforce one other. As people acquire more information about e-waste recycling—through official programs, awareness campaigns, or workshops—they not only enhance their knowledge but also obtain practical experience in recycling processes. This augmented understanding and expertise may elevate their propensity to engage in e-waste recycling initiatives. Researchers concur that education acts as a vital catalyst in this process, since it not only establishes core information about recycling but also enhances awareness of its environmental, economic, and social advantages (Singh et al., 2022; Wu and Wu, 2019).

11. **Education and Awareness:** ($\beta = 0.014$, $z = 6.313$, Yes)

The interplay between education and awareness in promoting e-waste recycling participation is marked by mutual interdependencies, with one aspect always affecting and strengthening the other. A positive $\beta = 0.014$ indicates that increased educational attainment correlates with heightened awareness concerning e-waste recycling. As educational initiatives or campaigns proliferate, individuals' comprehension of the significance of e-waste recycling also increases. A z-value of 6.313 significantly exceeds the essential threshold, indicating a highly statistically significant link. As people gain understanding of the environmental ramifications of incorrect e-waste disposal via educational campaigns, they are more inclined to convert this information into concrete recycling actions (Bamberg, 2003; Schultz, 2014). In contrast, when people participate in recycling activities and acquire direct experience with the

recycling process, their awareness and comprehension improve, establishing a positive feedback loop that strengthens both knowledge and involvement (Kahriman Öztürk and Olgan, 2016).

12. Education and Psychological Ownership: ($\beta = 0.013$, $z = 2.187$, Yes)

The relationship between education and psychological ownership significantly impacts household involvement in e-waste recycling. Education acts as a crucial situational element, while psychological ownership serves as an essential personal motivator. The concept of psychological ownership encompasses the emotional and cognitive ties that a person develops with their outdated electronic devices, as well as the impact of education on this feeling of ownership, which may lead to increased participation in recycling initiatives. The β value measures both the direction and intensity of the connection between education and the psychological ownership of outdated electrical items. A positive $\beta = 0.013$ indicates that there is a correlation between higher levels of education and a marginally stronger psychological attachment to personally owned outdated electrical devices. This indicates that as people gain a deeper understanding of the environmental consequences of e-waste and the advantages of recycling, their feelings of ownership and accountability regarding these items could grow, encouraging them to participate in recycling initiatives. A z-value of 2.187 exceeds the critical value, suggesting that education significantly influences psychological ownership and vice versa.

13. **Policy and Regulations and Attitude:** ($\beta = 0.019$, $z = 6.228$, Yes)

The results indicate a mutually beneficial connection between policies and regulations and perceptions regarding e-waste recycling, leading to increased engagement in recycling initiatives. The β value signifies the intensity and orientation of the connection between policy and regulations and the attitude towards e-waste recycling. The interconnectedness indicates that policies, regulations, and attitudes regarding recycling mutually strengthen each other. When people recognise that the regulatory framework supports recycling (such as through clear guidelines, enforcement, and incentives), they are more inclined to cultivate favourable attitudes towards recycling behaviours. Simultaneously, positive individuals' perceptions of recycling can facilitate the successful implementation and adherence to policies. This could subsequently lead to a rise in engagement with e-waste recycling initiatives. Oke et al. (2021), indicate that comprehensive recycling regulations establish a structured framework for promoting desired behaviours and contribute to a cultural shift, making recycling a recognised civic responsibility.

14. **Policy and Regulations and Awareness:** ($\beta = 0.011$, $z = -3.533$, Yes)

Policies and regulations confirm the presence of a mutually beneficial relationship with household awareness, serving as a vital catalyst for household involvement in e-waste recycling. The interplay between these two elements; policies and awareness, creates a symbiotic relationship, enhancing the effectiveness of e-waste recycling management systems. An interdependent relationship suggests that well-crafted policies boost awareness, which subsequently strengthens the success and efficacy of those policies.

Given that awareness by itself may not lead to lasting behavioural change, this indicates the importance of combining policies and regulations with collaborative and educational strategies to attain more thorough and sustainable results (Askari et al., 2014; Biswas, 2018; Hartley et al., 2022). In summary, the results indicate a statistically significant mutual relationship between policy and regulations and awareness of e-waste recycling, as evidenced by $\beta = 0.011$ and $z = -3.533$. This relationship underscores that well-designed regulatory frameworks can enhance awareness regarding the significance of e-waste recycling, subsequently leading to increased participation rates in recycling initiatives.

15. **Policy and Regulations and Psychological Ownership:** ($\beta = 0.015$, $z = 2.719$, Yes)

The findings shown in Table 4.25 demonstrate a symbiotic relationship between policy and regulations and psychological ownership that enhances household participation in e-waste recycling. The z-value of 2.719 indicates that the relationship is statistically significant and offers compelling evidence for the interdependence between these two factors. The findings suggest that policies aimed at managing e-waste and implementing regulations positively affect individuals' perceptions of ownership regarding their e-waste items, as well as their sense of personal responsibility for recycling these items. Consequently, enhanced psychological ownership may motivate individuals to adhere to these regulations, resulting in increased engagement in recycling efforts.

4.2.3.2 Finalized Model A

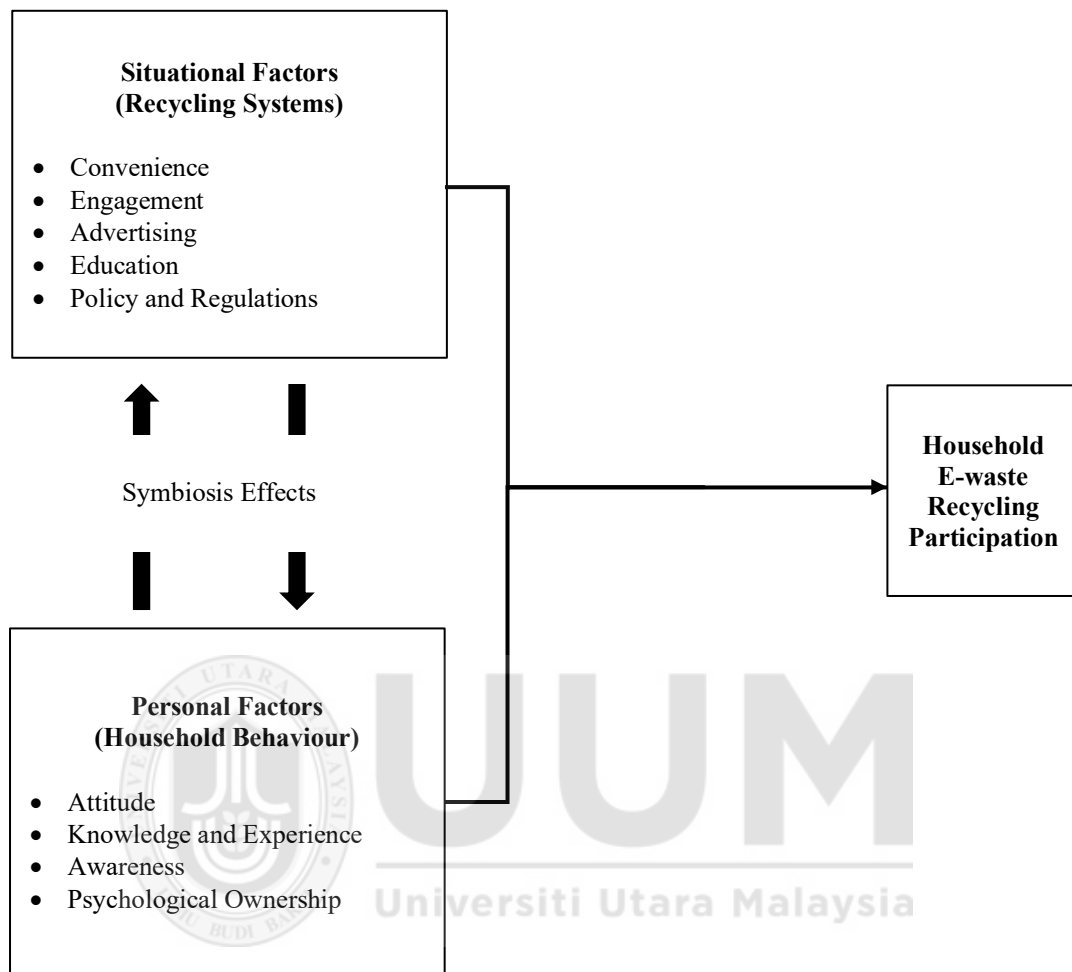


Figure 4.23
Model A – The final conceptual model

Upon completing the first phase of analysis and engaging in a thorough discussion of the results, the finalized conceptual framework, Model A, was developed and is presented in Figure 4.23. This model integrates the critical factors that influence household participation in e-waste recycling, structured around two primary domains: situational factors and personal factors. These domains collectively shape and drive recycling behaviour, providing a comprehensive lens through which to understand the motivations and barriers to participation. The situational factors domain includes five

pivotal elements: convenience, engagement, advertising, education, and policy and regulations. Each of these factors has been shown to significantly influence household recycling behaviour, with aspects such as convenience and engagement serving as essential facilitators for participation. However, during the analytical process, the attributes of accessibility and availability were removed from the model. These factors were found to have insignificant pathways in Structural Model 2, suggesting that they do not significantly contribute to the promotion of household e-waste recycling within the context of this specific framework. This exclusion highlights the importance of refining the model to focus on the most impactful elements, ensuring a more accurate representation of the factors that truly drive recycling behaviour.

The personal factors domain now comprises four core elements: attitude, knowledge and experience, awareness, and psychological ownership. These factors are central to shaping individual attitudes and behaviours toward recycling. Attitude reflects individuals' predispositions toward recycling, while knowledge and experience contribute to their understanding of the environmental impact of e-waste. Awareness and psychological ownership further influence individuals' sense of responsibility and personal connection to the recycling process, thereby enhancing their participation. The attribute of social norms, which was initially included in Structural Model 3, was ultimately excluded from the framework due to its insignificant contribution to household e-waste recycling participation. This decision underscores the complexity of human behaviour and the need for a nuanced approach to understanding the factors that promote sustainable actions like recycling. Despite the exclusion of social norms, the remaining elements within the model offer a robust and well-supported structure for analysing the multifaceted influences on e-waste recycling behaviour.

The finalized framework not only highlights the importance of situational and personal factors but also underscores their substantial influence in promoting household participation in e-waste recycling. These factors, when considered collectively, provide a deeper understanding of the underlying drivers that motivate individuals to engage in sustainable recycling behaviours. Moreover, the model demonstrates that these factors interact in a way that significantly enhances recycling participation, creating a synergistic effect that supports the broader goal of improving environmental sustainability.

In addition to these findings, the symbiotic relationship between the various factors was quantitatively validated through rigorous analysis. As elaborated in the preceding subchapter and presented in Table 4.24, the data analysis confirms that the interactions among situational and personal factors, as well as other variables within the research framework, are interdependent and mutually reinforcing. This symbiosis is a critical aspect of the model, providing a comprehensive understanding of how different elements within the system contribute to the overall behaviour of household e-waste recycling. Model A has undergone a thorough process of refinement, ensuring that all elements are both theoretically sound and empirically validated. This comprehensive validation process strengthens the reliability of the model, confirming its robustness and relevance in addressing the research questions. With these refinements, Model A establishes a solid and well-supported foundation, positioning it as a critical tool for the next stages of analysis and contributing to the advancement of knowledge in the field of e-waste management and recycling behaviour.

v. Structural Model 5 – The Finalized Model for Model A

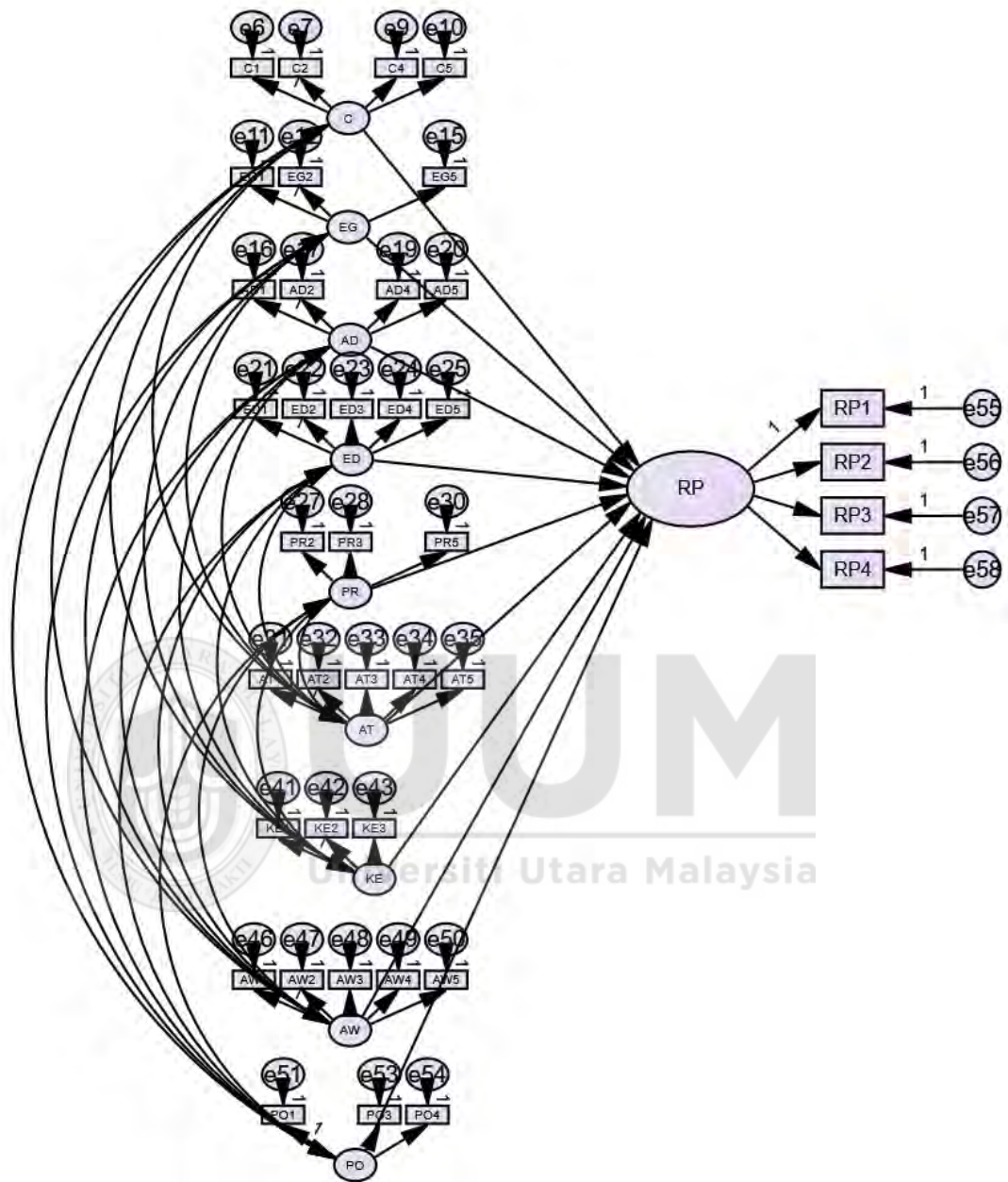


Figure 4.24
The structural model 5

4.2.3.3 Model B: Moderating Effect of Demographic Profiles to Model A

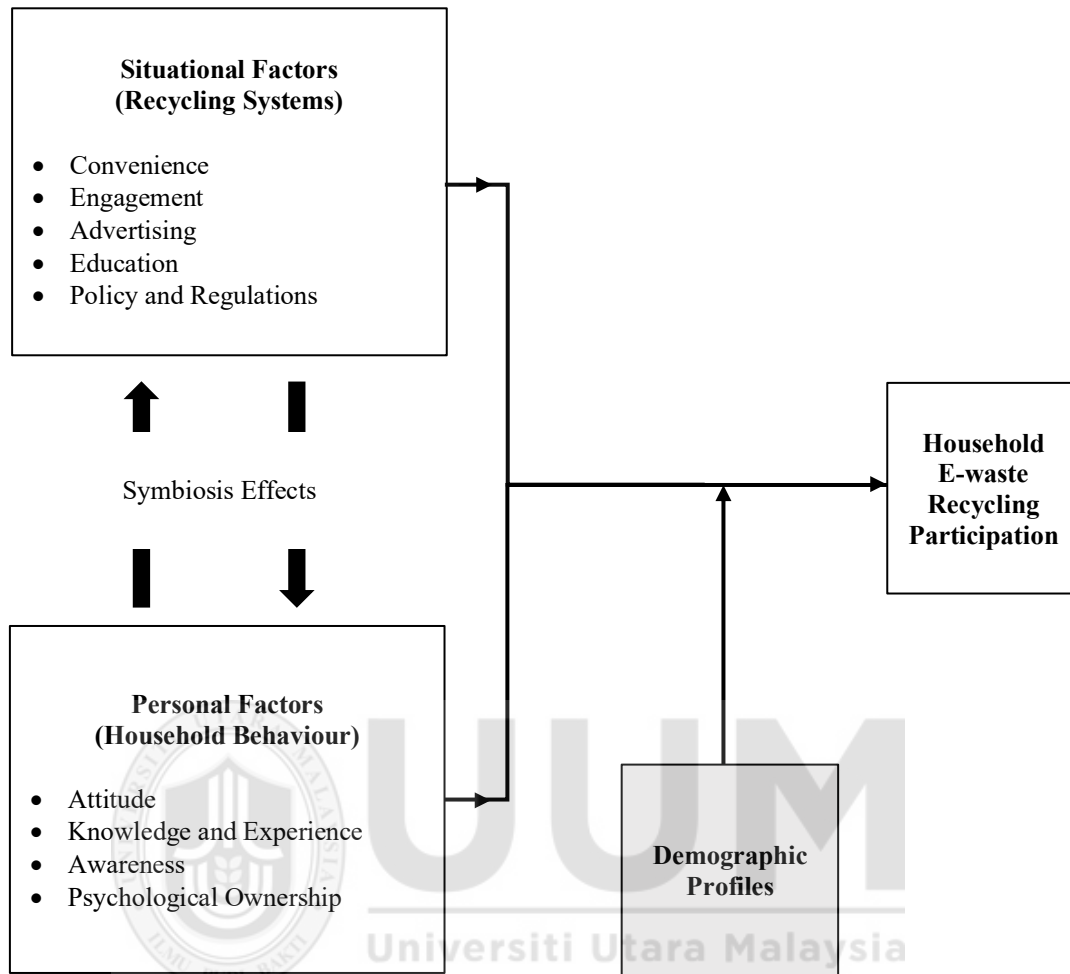


Figure 4.25
Framework tested in Model B

Figure 4.25 illustrates the complete framework tested in Model B, where the interaction between situational and personal factors with household e-waste recycling participation is moderated by demographic profiles. To address this question, a structural moderating model was tested using AMOS, following the methodology proposed by Marsh et al. (2004). The analysis for Model B extends prior research by incorporating demographic profiles as a moderating variable to examine their influence on the relationships between key constructs, Model A.

The research question that was addressed within the framework of Model B stated as follows:

RQ4. Does the interactions between both factors (situational and personal) and household e-waste recycling participation vary depending on demographic profiles?

4.2.3.3.1 Results for Research Question 4: Moderating Influence of Demographic Profiles

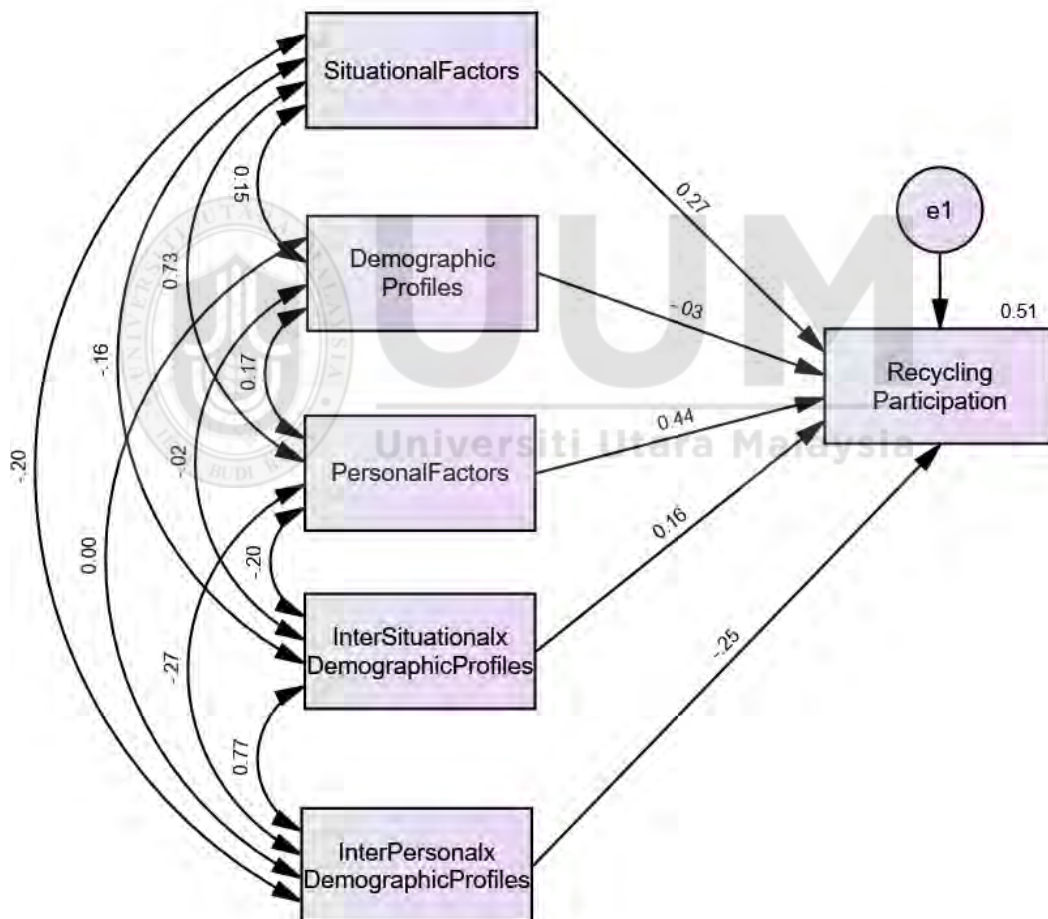


Figure 4.26
Structural moderating model tested in Model B

Table 4.25

Testing the moderating effects of demographic profiles for RQ4

Relationship	Regression Coefficient	Standardised Estimate (β)	Critical Ratio (z-value)	P-value	Existence of Moderator Influence
Situational Factors to Recycling Participation Moderated by Demographic Profiles	0.914	0.065	5.009	0.005	Yes
Personal Factors to Recycling Participation Moderated by Demographic Profiles	-1.424	0.335	-4.247	0.000	Yes

This study assessed the moderating role of demographic profiles on the relationship between both situational and personal factors on household e-waste recycling participation. The results revealed significant moderating impact of demographic profiles for both situational and personal factors to household e-waste recycling participation. The relationship from situational factors to household e-waste recycling participation is being strengthened by demographic profiles because the estimate influence is positive (0.914). The critical ratio (z -value = 5.009, p = 0.005) indicates a statistically significant positive moderating effect of demographic profiles on the relationship between situational factors and household e-waste recycling participation. This implies that demographic characteristics, such as age, gender, or subclusters, play a critical role in shaping the strength and direction of the relationship between situational factors and recycling behaviours. The significance of this moderation highlights the heterogeneous nature of recycling participation across different demographic groups.

Demographic profiles are weakening the relationship from personal factors to household e-waste recycling participation because the estimate influence is negative (-1.424). The critical value (z-value = -4.247, $p = 0.000$) reveals a statistically significant negative moderating effect of demographic profiles on the relationship between personal factors and household e-waste recycling participation. This finding underscores that the influence of personal factors, such as attitude, knowledge, experience, awareness, and psychological ownership, is not consistent across all demographic groups. Instead, certain demographic characteristics; such as age, income, education, and geographic location, can either reduce (attenuate) or completely alter (reverse) the expected influence of these personal factors on recycling behaviours. However, the moderating results for this study indicates that demographic profiles have a significant relationship to household e-waste recycling participation with p-value of less than 0.05. Thus, this result indicates a positive influence for research question 4. Moderation analysis summary is presented in Table 4.25. The in-depth discussion and interpretation of demographic profiles as moderator findings provided in the final phase, Phase 3.

4.3. PHASE 2: Qualitative Results

The data collected during Phase 2 was analysed using thematic analysis, which organized the findings into distinct themes. These themes were cross-checked against existing literature and enriched with supporting data for clarity and depth. To ensure the reliability of the data collection tools, the themes were aligned with the questionnaire design. The initial phase of this qualitative analysis focused on identifying and refining key themes emerging from the discussions and discoveries from the in-depth interviews and FGD, as outlined by Roulston (2018). These refined themes were subsequently integrated to answer and clarify the research questions. Phenomenological interviewing was employed to explore these themes further, ensuring they were grounded in insights derived from the prior literature review.

4.3.1 Thematic Analysis

Thematic approaches are extensively utilized in qualitative data analysis to uncover patterns within seemingly unstructured information, enabling the organization of data into meaningful and coherent themes. In this study, in-depth semi-structured interviews, guided by a phenomenological framework, were conducted to explore the lived experiences of both stakeholders and householders involved in waste recycling management. This methodological approach facilitated a comprehensive and nuanced understanding of participants' perspectives, highlighting the complexities of their engagement with recycling practices within the broader framework of municipal initiatives. The interviews were designed using probes informed by a priori themes to ensure the discussions remained focused while allowing participants to elaborate on their experiences freely. Emerging themes identified from the interviews were

systematically analysed, reorganized, and classified into central categories. Within this context, a theme is understood as a representation of significant elements of stakeholders' perspectives, encompassing their interests, concerns, and perceptions relevant to the core aspects of the study. The thematic analysis thus provided a detailed account of the meanings and interpretations ascribed by both stakeholders and householders to e-waste recycling management. To support this analytical process, ATLAS.ti software was employed, offering a structured platform for organizing, coding, and interpreting the data. This software facilitated the thematic categorization, ensuring a rigorous and systematic approach to data analysis.

As outlined in the preceding chapters, two principal elements were identified as pivotal to understanding the symbiosis effect: situational factors, which focus on respondents' perspectives regarding reverse logistics within their HERS, and personal factors, which delve into respondents' intrinsic attitudes and opinions about environmental issues, recycling behaviours, and societal and governmental roles in waste recycling management. Data for these analyses were derived from participant discussions, extracted from transcriptions and field notes, and subsequently synthesized into a summary of findings. The qualitative approach employed facilitated the identification and integration of key insights into overarching themes, encompassing both situational and personal factors, while also contributing to the conceptualization of the symbiosis effect. The analysis of the interview data was structured around the key concepts explored in the literature review in Chapter 2, ensuring a theoretical alignment with existing frameworks. The evaluation process was guided by the researcher's interpretive insights, derived from detailed memos and transcriptions, with the goal of developing

a tabulated framework in the subsequent phase of analysis to systematically present the findings.

The data analysis process commenced with coding, a fundamental interpretive procedure in qualitative research. Coding involves assigning concise, meaningful labels to distinct segments of the data, enabling the systematic identification of variations and similarities across different data points. This process serves as the foundation for the development of themes, which represent a higher level of data abstraction. Themes are formed by consolidating interconnected categories of codes, thereby uncovering deeper patterns and insights within the data. In this study, the qualitative data were systematically examined, with coherent segments coded to encapsulate their underlying meanings. These codes were then synthesized into themes, which were aligned with the study's research questions. The findings are organized around three primary themes: the situational factor, represented by HERS, and the personal factor, encapsulated as HERB, and the demographic profiles moderating factor. Each theme is further delineated into relevant subthemes, which are comprehensively detailed in Table 4.26. This thematic organization provides a structured and nuanced understanding of the qualitative data.

Table 4.26
Linkages between codes, subthemes and themes

Themes	Subthemes	Codes
HERS Situational Factors	Convenience	<ul style="list-style-type: none"> • Nearby drop-off centres. • Door-to-door collection services. • Distance of recycling facilities less than 5 kilometres. • Frequent scheduled collection services. • Numerous recycling bins throughout residential communities.
	Engagement	<ul style="list-style-type: none"> • Delivering a series of recycling programs. • Interact with communities for waste recycling feedback. • Provision of recycling incentives and rewards.
	Advertising	<ul style="list-style-type: none"> • Provide information on ways to recycle. • Media exposure on e-waste recycling.
	Education	<ul style="list-style-type: none"> • Strengthened curriculum frameworks on environmental protection. • Introduce e-waste recycling culture.
	Policy and Regulations	<ul style="list-style-type: none"> • Implement a penalty policy. • Implement and enforce the developed policies and regulations • Joint partnership in developing the waste recycling policy
HERB Personal Factors	Attitude	<ul style="list-style-type: none"> • Take initiative to recycle. • Recycle for rewards and benefits provided.
	Knowledge and Experience	<ul style="list-style-type: none"> • Have prior knowledge of the importance of waste recycling. • Recycle on a scheduled basis.
	Awareness	<ul style="list-style-type: none"> • Aware about recycling campaigns delivered by municipalities. • Aware on methods to recycle.
	Psychological Ownership	<ul style="list-style-type: none"> • Willing to recycle sentimental valued items. • Preference to keep or recycle obsolete EEE.
Demographic Profiles	Residential areas	<ul style="list-style-type: none"> • Preference to recycle for urban, suburban and rural households. • Disparity in access to recycling facilities and services.
	Age	<ul style="list-style-type: none"> • Youngsters dominate the recycling participation
	Gender	<ul style="list-style-type: none"> • Women exhibit stronger pro-environmental behaviour.

4.3.1.1 Theme 1: Situational Factors to Household E-waste Recycling Participation

i. Convenience

A total of 14 interviewees underscored the significance of convenient recycling facilities and services in attracting households to engage in e-waste recycling. Stakeholders consistently highlighted that reducing barriers and increasing accessibility are key to encouraging household involvement. Among the participants, four stakeholders, representing private waste collection operators and licensed NGOs, specifically emphasized the provision of door-to-door collection services conducted by their organization. According to stakeholders, household recyclers simply need to contact the service providers to arrange for e-waste pickup. This process not only streamlines participation but also ensures that large household appliances such as refrigerators, televisions, and washing machines are efficiently collected, addressing logistical challenges faced by households.

Furthermore, innovative solutions were identified to extend the reach and flexibility of these services. For instance, one private waste collector explained the integration of e-hailing services such as Lalamove Malaysia into their operations:

I04: "My company is using Lalamove. So, basically, Lalamove operates from our client's location to our area. This reduces transportation costs significantly because instead of deploying our own transportation, we outsource the transportation for pickup and delivery services. It also reduces the operational costs and allows us to serve more households, even in remote areas."

This approach demonstrates an adaptive response to logistical challenges, enabling the collection of e-waste from households located outside the standard service zones. By leveraging existing e-hailing systems, stakeholders not only lower operational costs but also provide households with a flexible and accessible recycling solution.

Next, the presence of nearby drop-off centres and recycling facilities emerged as a recurring theme in the interviews. Stakeholders indicated that the availability of drop-off locations within a reasonable distance, ideally less than 5 kilometres, fosters greater participation by minimizing the effort required for households to recycle. For example, one participant from a local municipality stated:

I15: "When recycling facilities are within a short distance from households, it becomes easier for people to take part. I personally have participate in recycling my old laptop and handphones when drop-off centres are placed strategically near my house".

Apart from nearby drop-off centres, The provision of frequent and reliable scheduled collection services was another convenience factor highlighted by the participants. This approach ensures that households can easily dispose of their e-waste without the need for transportation. A private waste operator noted:

I08:"Scheduled collection services are especially effective in urban areas, where people are often too busy to take e-waste to drop-off centres. Knowing that collection happens regularly increases participation and reduces illegal dumping."

The stakeholders emphasized that regular collection schedules also help build trust between service providers and households, ensuring a consistent flow of e-waste into the recycling stream. The availability of multiple recycling bins in residential

neighbourhoods was then seen as another crucial enabler. Stakeholders and local municipal representatives agreed that placing recycling bins in high-density community areas, such as parks, shopping centres, and residential complexes, significantly lowers the threshold for participation. One municipal officer explained:

I03: "Communities are more likely to recycle when they see bins within walking distance from their homes. It signals that recycling is a priority and makes it convenient for people to dispose of smaller e-waste items like phones or batteries."

The insights from the stakeholders highlight the importance of collaboration between private waste operators and local municipalities to improve recycling infrastructure and services. Proximity to drop-off centres, the availability of numerous recycling bins, frequent scheduled collections, and door-to-door services all contribute to reducing barriers and increasing household e-waste recycling participation.

ii. Engagement

Engagement strategies, including direct interaction with communities, educational initiatives, and the provision of tailored programs, have been identified as effective measures to foster recycling behaviour. Local authorities emphasized the importance of engaging directly with communities to understand the factors that motivate households to recycle their e-waste. This interaction allows authorities to design programs that address community needs and expectations. One local authority representative shared:

I03: "Once we started interacting with households, we found out that they expect us, the authorities, to provide collection programs within their communities. We hear the voice of our community. Since then, they started bringing their e-waste to be recycled at our recycling centres."

Through these engagements, local authorities implemented initiatives such as recycling programs, waste collection services, and awareness campaigns, which align with community expectations. These efforts not only encouraged households to participate but also fostered trust between the government and the public. Moreover, the local municipalities highlighted the importance of disseminating information about the location and availability of recycling centres. Previous municipal officer added:

I03: "By making our recycling services visible and easily accessible, we empower households to take part in e-waste recycling. The community needs to see that we are responsive to their feedback."

Private waste operators and NGOs also demonstrated a strong commitment to engaging with local households. These stakeholders focused on educational efforts, particularly on the segregation of recyclable materials, to encourage proper recycling practices. For example, stakeholders reported dedicating time to educate households on the separation of e-waste items before bringing them to collection centres. One private waste operator described an innovative approach to incentivize participation:

I04: "We offered free transportation costs for individuals who segregated their waste according to the groups before recycling them with us."

The qualitative data underscores that stakeholder engagement is a pivotal factor in promoting household e-waste recycling. By fostering open communication, addressing community expectations, and offering tailored programs, stakeholders can significantly enhance participation rates. The collaborative efforts between local authorities, private waste operators, and NGOs demonstrate a multi-stakeholder approach that effectively reduces barriers to recycling.

Another key strategy identified under stakeholder engagement is the provision of recycling incentives and rewards, which serve as motivators for households to adopt consistent recycling behaviours. Incentives not only increase participation but also cultivate a positive perception of recycling practices, making them more appealing and accessible. Local municipalities express concerns in this issue as stated:

I02: "We understand that many households need an extra push to start recycling. That's why we introduced incentives like discount vouchers, cash-back offers, and free collection services to encourage them to bring their e-waste to our recycling centres."

The statement were then followed by additional insights from federal stakeholder:

I01: "To further incentivize recycling, we run programs where households can accumulate points for each item they recycle, which can later be redeemed for rewards. This gamified approach has significantly increased participation rates, especially among younger families."

These initiatives highlight the importance of stakeholder engagement in shaping household recycling behaviours. By offering tangible benefits, stakeholders create a reciprocal relationship where both environmental sustainability and household needs are addressed.

iii. Advertising

Local municipalities, in collaboration with the federal government and media entities, have employed innovative and creative strategies to reach diverse audiences and promote HERB effectively. Local municipalities have actively utilized various media platforms to disseminate information and raise public awareness about e-waste recycling. These efforts aim to make recycling knowledge more accessible while fostering a sense of responsibility among citizens. One municipal officer explained:

I12: "We published waste recycling information on our social media platforms and even collaborated with artists and influencers to attract the public to recycle their e-waste."

The use of social media has proven particularly effective in engaging younger audiences, who are frequent users of platforms like Instagram, Facebook, and TikTok. By partnering with influencers and content creators, municipalities have leveraged the popularity and reach of these individuals to convey recycling messages in relatable and engaging formats. At the federal level, the government has broadened its approach by collaborating with media authorities to amplify awareness campaigns through television, radio, and internet channels. These initiatives aim to ensure that messages about waste recycling reach households across urban, suburban, and rural areas. A standout example of this approach was described by a federal government representative:

I11: "We collaborated with Malaysia's famous animation 'Upin and Ipin' to educate citizens about the importance of recycling and how to recycle their waste at home. They even produced three episodes addressing different issues in waste recycling: e-waste, plastics, and paper. Now, even a five-year-old has knowledge of e-waste recycling."

By tailoring content to different audiences, such as using animations for children, influencers for younger adults, and television campaigns for broader household audiences, stakeholders have maximized the outreach and impact. These efforts align with research by Sujata et al. (2019), which emphasizes the significance of targeted media campaigns in fostering environmental awareness and encouraging sustainable recycling behaviours.

iv. Education

Both local and private stakeholders agreed that instilling recycling habits from a young age can create long-lasting attitudes toward sustainability. Introducing e-waste recycling as part of early education, they argue, helps to establish a culture of recycling that persists into adulthood, thereby ensuring continued participation in household e-waste recycling and ultimately protecting the environment for future generations. Stakeholders from both local and private sectors expressed a shared belief in the value of introducing recycling education at an early age. One local authority representative stated:

I02: "Educate the public from primary schools, or even way before that. The sooner we can start instilling recycling habits, the better. We need to build this culture from a young age."

The idea of early education is supported by educational psychology research, which suggests that habits and attitudes formed early in life are more likely to persist throughout adulthood (Verplanken and Orbell, 2021). By incorporating recycling education into school curricula, stakeholders believe that children will grow up with an

intrinsic understanding of environmental responsibility. Stakeholders further referenced global best practices in waste management, particularly Japan's approach to waste disposal and recycling. A local authority officer mentioned:

I03: "I agree. Japan is a great example of fostering environmental responsibility. In their schools, students clean their own classrooms, demonstrating the nation's commitment to instilling accountability and sustainable habits from a young age."

Stakeholders highlighted that replicating such practices could help embed a similar culture in Malaysia, ensuring that future generations will maintain and advance e-waste recycling initiatives. The introduction of e-waste recycling as part of early education also serves as a foundation for building a broader societal culture of recycling. As one private waste operator noted:

I01: "If we teach children early about the importance of e-waste recycling, they will pass this knowledge on to their parents and peers. This creates a ripple effect that can encourage entire households to participate in recycling programs."

Local municipalities are uniquely positioned to implement early education programs, given their established relationships with schools and local communities. Through school-based outreach, municipal programs can educate students on waste management and encourage them to bring recycling practices home. The first local authority officer further elaborated on the potential impact of these educational efforts:

I01: "We have already started collaborating with local schools to incorporate environmental education into their curriculum. If we can educate children early about waste management, they will carry these values with them into adulthood, influencing how their families approach recycling."

v. Policy and Regulations

Stakeholders collectively acknowledged the presence of policies and regulations governing waste recycling in Malaysia but expressed diverse perspectives on their implementation, effectiveness, and enforcement. The discussions revealed a consensus on the need for more robust, specific, and consistent policy frameworks to address the unique challenges associated with e-waste management.

I05: "The waste policy framework exists, but it undergoes frequent changes over time. At times, we struggle to keep up with the constant amendments."

This sentiment underscores the difficulties stakeholders face in adapting to evolving regulations, suggesting a need for greater clarity and stability in policy development. Frequent amendments can lead to confusion among waste operators, potentially resulting in non-compliance and inefficiencies in waste management systems. Furthermore, stakeholders emphasized the importance of communication between federal and state authorities and e-waste operators to ensure that all parties are informed of policy changes. Effective dissemination of information is critical to avoid unintentional violations that may harm the environment.

I07: "Currently, Malaysia lacks a dedicated policy specifically addressing e-waste. It continues to be classified under general solid waste management, which is inadequate for effective e-waste recycling. The hazardous electronic components within e-waste require specialized handling and cannot be treated like regular solid waste."

This observation highlights a significant gap in Malaysia's current waste management framework. The lack of a dedicated e-waste policy creates challenges in handling

hazardous materials effectively, emphasizing the need for tailored regulations that prioritize environmental safety and proper disposal methods for e-waste. Several stakeholders proposed the introduction of penalty policies to address unlicensed operators and ensure compliance among licensed collectors and processors. Unlicensed waste operators undermine the market by offering unregulated and often unsafe recycling services, which outcompete licensed operators.

I06: "It may be beneficial for KPKT, through its enforcement agency SWCORP, to establish a penalty policy aimed at unlicensed waste collectors. These operators often exploit illegal channels, creating an unfair advantage and undermining the legitimate e-waste recycling market."

Stakeholders also pointed out issues with licensed operators who fail to adhere to proper waste segregation practices.

I09: "Penalties should also be imposed on waste collectors who fail to properly segregate e-waste, mixing it with other household waste. This not only complicates the processing at disposal centres but also creates issues that could have been prevented if proper segregation had been ensured at the collection stage."

Stakeholders emphasized the need for joint partnerships between government agencies, private operators, and NGOs to create comprehensive, clear, and enforceable regulations. Such collaborations would promote knowledge sharing, enhance enforcement mechanisms, and address existing gaps in the regulatory framework. The findings underscore that strengthening stakeholder engagement, improving communication, and developing specific, stable, and enforceable policies are crucial for advancing e-waste recycling efforts in Malaysia.

4.3.1.2 Theme 2: Personal Factors to Household E-waste Recycling Participation

i. Attitude

The positive environmental attitude of households significantly influences their participation in e-waste recycling. Respondent from rural households demonstrate a high level of commitment by proactively taking the initiative to transport the collected e-waste to designated collection centres, often overlooking the distance and inconvenience recycling facilities.

I17: "I drive more than 6 kilometres every two weeks to recycle the e-waste I've collected at home. It makes me feel like I'm contributing something to the environment."

This behaviour reflects a strong intrinsic motivation rooted in environmental values, highlighting that a positive environmental attitude can drive individuals to engage in sustainable waste management practices. Furthermore, positive attitudes toward e-waste recycling are often influenced by societal norms and community engagement. Local municipalities and waste management organizations have noted that public education and community outreach programs that highlight the environmental impact of e-waste and provide practical guidance on recycling can strengthen these attitudes and encourage broader recycling participation.

I09: "When we engage directly with the community and share the importance of recycling, we see a shift in attitudes. People start to feel a greater sense of responsibility, not just for their own waste, but for their entire community's environmental impact. It's about building a culture of sustainability from the ground up."

This dialogue underscores the role of local authorities in shaping attitudes toward recycling through engagement and education. By making recycling part of the community's social fabric, municipalities can foster a culture where positive environmental attitudes become ingrained, leading to sustained participation in e-waste recycling over time.

ii. Knowledge and Experience

A significant number of respondents indicated that their exposure to recycling practices began at a young age, often facilitated through family, community, or educational influences. These early experiences, rooted in deeply ingrained family values and communal norms, such as the principle of “nothing goes to waste”, played a crucial role in fostering a long-term commitment to sustainability and waste reduction. Such foundational beliefs not only provided the essential knowledge for effective recycling practices but also instilled habitual behaviours within the household, which have continued to shape their recycling routines over time. This early socialization into recycling, therefore, contributed significantly to the respondents' sustained engagement with environmentally responsible behaviours. Householders from urban subclusters shared experience in personal recycling activities:

I15: "Growing up, my parents always emphasized the importance of recycling. They taught me that nothing should be wasted, not even the smallest things. It's a habit we carried into our own home. I've been recycling for as long as I can remember."

The habitual nature of these behaviours is rooted in the knowledge that recycling is not just an activity but a responsibility ingrained in the household's daily routines. In line

with this, respondents highlighted the importance of continuous exposure to information on the importance of waste recycling. For many, recycling was not only a moral responsibility but a deeply ingrained practice informed by years of family influence and local community values. Households with prior knowledge of waste recycling were often more proactive in seeking out opportunities to engage in the practice and were more likely to recycle on a scheduled basis.

I10: "Our programs aim to target young people, educating them from an early age. Once they understand the importance of recycling, it becomes second nature to them. The more exposure they have, the more consistent they are in recycling on a scheduled basis."

This statement reinforces the importance of exposure to recycling education. Local authorities mentioned that the prior knowledge of recycling could significantly influence how households engage with recycling systems. Those with prior experience in segregating and recycling waste often demonstrated a higher level of commitment and consistency in their e-waste recycling practices.

I13: "It is clear that households who have learned about recycling from an early age, either from their families or through our education programs, tend to recycle more consistently. Their awareness of the impact of e-waste on the environment is stronger, and they make a point to recycle regularly."

The knowledge and experience accumulated from early exposure to recycling initiatives, whether through family values, educational programs, or community-based initiatives, significantly shapes household attitudes toward recycling. Those with prior knowledge tend to engage in scheduled recycling more consistently, and their

participation is grounded in a deep understanding of the importance of sustainable waste management practices.

iii. Awareness

All three householders universally acknowledged their awareness of e-waste recycling. Another theme emerging from the interviews was the strong relationship between public awareness and household behaviour toward recycling. Householders from this study respondent indicated that they were introduced to recycling practices through multiple channels, with social media being the most prominent source of information. One respondents among the households mentioned her involvement in local recycling programs organized by municipal authorities:

I16: “This one weekend, I attended a recycling program organized by the state government in Penang, Georgetown, at the city centre. It was there that I discovered that my area had a monthly e-waste collection service. I never knew about it until I attended this program, and it made it so much easier for me to recycle.”

This reflects how localized, accessible initiatives, such as community-based recycling programs, can bridge the knowledge gap and improve participation. Stakeholders noted that public education campaigns conducted in high-traffic areas, such as city centres, are highly effective in engaging the public. Local municipalities have strategically placed these programs in areas where they can capture a wide audience, which enhances awareness and fosters positive behavioural change that contribute to household e-waste recycling participation.

iv. Psychological Ownership

There was one householders in this study exhibit strong psychological ownership over personal old electronic items, particularly those that carry sentimental value. The respondent expressed an attachment to an old, non-functional laptop simply because it was a gift from her mother. Such attachment is not merely a product of utility or convenience but is grounded in personal memories and emotional ties. This phenomenon is consistent with literature on consumer psychology, where objects serve as symbols of identity, relationships, and personal history (Pierce et al., 2001).

In contrast to the above perspective, one households living in suburban residential area, exhibit a more pragmatic approach toward his obsolete EEE. The respondent stated a willingness to recycle his old electronics, even if they hold sentimental value. This reflects an understanding that the object's sentimental value does not justify its continued existence in the household, particularly if recycling can benefit others. Research by Ofori (2020) on personal values and the attachment to possessions suggests that while many individuals experience sentimental attachment, this does not always translate into an unwillingness to part with the object if it serves a higher purpose.

4.3.1.3 Theme 3: Influence of Demographic Profiles in Household E-waste Recycling Participation

i. Residential areas

The disparities in access to recycling facilities and services across urban, suburban, and rural households significantly influence households recycling participation. Urban areas often benefit from vast recycling infrastructure, including easily accessible facilities and organized scheduled waste collection services, which accommodate a wide range of recyclers within their communities. However, the presence of infrastructure alone does not guarantee active participation. Urban households emphasize that personal attitudes greatly influence their recycling habits. As one urban respondent stated:

I15: “Even if pickup services are available, people who are indifferent to environmental issues won’t bother recycling. It’s all about mindset.”

This highlights how situational factors, such as availability of services, may be undermined by personal attitudes and behaviours. In contrast, rural areas often face challenges such as limited facilities or complete lack of recycling services. These logistical barriers significantly deter e-waste recycling participation. Rural households expressed a willingness to participate if access was made easier, as one rural respondent noted:

I17: “If there were drop-off points or someone came to collect, we’d recycle. It’s not about unwillingness—it’s about accessibility.”

This underscores the critical role of situational factors in rural settings, where the absence of convenient options creates a significant gap in participation. In addition, suburban and rural households often demonstrate a preference for incentives as a key motivator to engage in e-waste recycling. Unlike urban households, which may have greater access to recycling facilities and awareness programs, suburban and rural communities frequently face logistical challenges, such as longer distances to drop-off centres or limited recycling services. In these contexts, incentives provide an effective means of addressing participation barriers while encouraging sustainable waste management practices.

I14: "In our experience, suburban and rural households often more responsive when incentives are part of the program. Whether it's free collection or vouchers for goods, these measures help bridge the gap and make recycling participation more feasible."

Stakeholders in the waste management sector also recognize the importance of incentivizing recycling behaviours. Both local authorities and private sector actors noted that the provision of rewards and benefits could further encourage households to participate in e-waste recycling. Incentive schemes, such as offering tangible rewards for recycling efforts, can motivate individuals to recycle more consistently and can serve as a reinforcement of their environmental values. This highlights the complementary role of both intrinsic motivation and extrinsic rewards in fostering sustained e-waste recycling behaviour. By providing incentives that align with households' environmental attitudes, stakeholders can further promote active participation, leading to more widespread engagement in e-waste recycling initiatives across diverse subclusters.

ii. Age

Age is a significant demographic factor influencing recycling behaviour, with younger individuals demonstrating higher participation rates compared to other age groups. Most of the respondents acknowledged that younger household members often play a pivotal role in initiating and sustaining recycling practices. One of them even shared his experience acknowledging this statement:

I11: “My children are the ones who convinced us to start sorting our waste. They learned about recycling at school and insisted we do our part at home.”

This dynamic underscores the importance of equipping young people with the tools and knowledge they need to lead by example. Conversely, municipalities and waste operators face challenges in engaging older demographics. Many older adults may not have grown up with recycling as a norm, leading to gaps in knowledge or reluctance to change habits. A municipal official remarked:

I05: “We get feedback from matured residents who say they’re unsure about how to recycle e-waste or find it inconvenient. This shows we need to focus more on simplifying the process for them.”

Waste operators also note logistical hurdles in serving older populations. A representative commented:

I13: “Some older people struggle to bring large e-waste items to drop-off points. We’re exploring mobile collection units or home pickup services to address this.”

The interplay of age-specific factors in household e-waste recycling participation underscores the need for tailored approaches by municipalities and waste operators.

iii. Gender

Gender has emerged as a significant factor influencing household recycling behaviours, with women consistently exhibiting stronger pro-environmental attitudes and actions. This aligns with findings from previous research, such as (Obulesu and Sujatha, 2024), which demonstrated that women are more likely to engage in activities addressing environmental concerns, including recycling. Women's participation is often driven by a sense of responsibility for future generations, practical household management roles, and heightened awareness of environmental issues. As one female respondent noted:

I12: "I recycle because I think about the world my children will inherit. Every little action counts."

The role of women in e-waste recycling reflects a broader trend of pro-environmental behaviour, yet achieving sustainable outcomes requires addressing the gendered division of responsibility. Municipalities, federal governments, and NGOs must collaborate to ensure gender inclusivity in recycling initiatives by recognizing women's contributions while empowering men to engage equally. As one dialogue from the federal government aptly summarized:

I07: "Women may lead recycling efforts, but achieving real change requires everyone; women, men, and communities, working together. By building on women's strengths and addressing barriers for men, we can create a culture of shared responsibility for the environment."

Table 4.29 presents a detailed summary of the thematic analysis conducted during the qualitative phase of the study. This table offers a numerical representation of the discussions and insights provided by the stakeholders and household participants who

were interviewed. The coding system used in the analysis serves to distinguish the level of engagement and consensus on the various themes identified as influencing household e-waste recycling participation.

A coding value of "1" indicates that the respondents, whether stakeholders or householders, actively engaged in discussions regarding a specific theme or its related subthemes. This coding also signifies that a consensus was reached regarding the importance or impact of the identified theme on enhancing household e-waste recycling participation. These themes represent key factors that were widely recognized by the participants as being instrumental in driving behaviour change and promoting more sustainable recycling practices at the household level. In contrast, a coding value of "2" suggests that either the stakeholders and householders did not engage in meaningful discussion about the relevant theme or they failed to reach a consensus regarding the influence of that theme on household e-waste recycling participation. This outcome may indicate a lack of awareness or varying perspectives on the theme's relevance, or it could suggest that the theme was not perceived as a significant factor influencing recycling behaviour within the context of the study.

By summarizing the findings in this way, Table 4.29 provides a clear and concise overview of the qualitative data, allowing for an easy comparison of themes based on their level of engagement and consensus. This numerical summary complements the qualitative insights, providing a more structured and systematic view of the factors influencing household e-waste recycling participation. It also highlights areas where further exploration may be needed, particularly for themes that did not elicit strong consensus or discussion among the respondents.

Table 4.27
Summary of thematic analysis (n=17)

Thematic Analysis																	
Themes/sub Interviewees	I01	I02	I03	I04	I05	I06	I07	I08	I09	I10	I11	I12	I13	I14	I15	I16	I17
<u>Situational Factors (HERS)</u>																	
Convenience	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	1
Engagement	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
Advertising	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	2	2
Education	1	1	1	2	2	1	1	1	1	1	2	1	1	1	2	2	2
Policy and Regulations	1	2	2	2	1	1	1	2	1	1	1	1	1	2	2	1	1
<u>Personal Factors (HERB)</u>																	
Attitude	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Knowledge and Experience	2	2	1	2	1	1	1	2	1	1	2	2	1	2	1	1	1
Awareness	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Psychological Ownership	1	1	1	1	1	2	2	2	2	1	2	2	2	1	1	1	1
<u>Moderating factor (Demographic Profiles)</u>																	
Residential areas	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Age	2	1	1	2	1	1	1	1	1	2	1	2	1	1	1	1	2
Gender	1	1	1	1	1	2	1	1	1	1	1	1	2	2	2	1	1
Income Level	2	2	2	2	2	2	1	1	1	1	2	1	1	1	1	2	1

Note: 1=yes, 2=no

4.3.2 Existence of Symbiotic Relation between Situational and Personal Factors via Thematic Network Approach

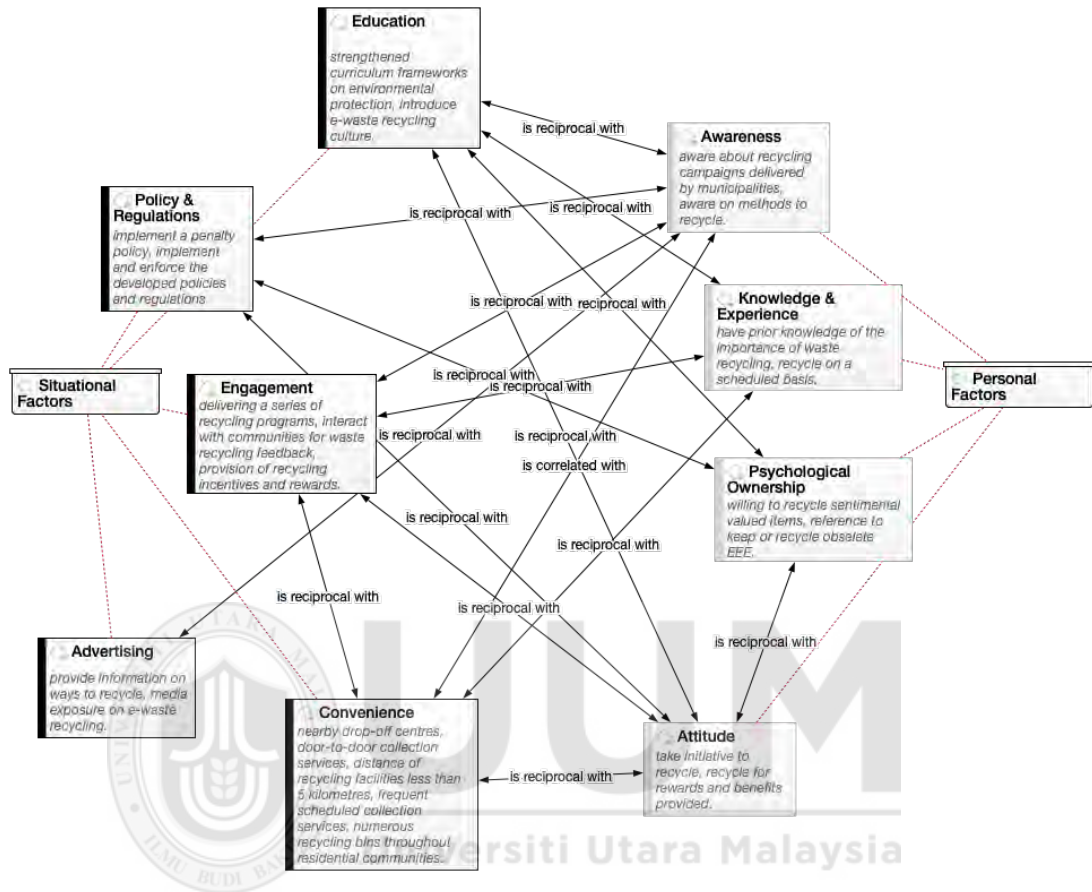


Figure 4.27
Thematic network on HERS and HERB in household e-waste recycling participation

Figure 4.27 illustrates a thematic network approach that clearly outlines the relationships between codes and themes, emphasising the interconnections among all variables. This depiction not only showcases the interconnectedness of themes and codes but also highlights the complex web of connections that enhance the comprehension of reciprocal relationship that exist between HERS and HERB. The visual representation facilitates a comprehensive investigation, allowing for the analysis of the connections among themes, codes, quotations, and help validating and

answering research question 3. The network illustrates the interconnected factors that indicate a symbiotic interaction between situational and personal factors in promoting households e-waste recycling participation. This approach improves the understanding of intricate interactions and offers a thorough structure for examining qualitative data.

i. Situational (Convenience) and Personal (Attitude, Psychological Ownership)

A significant number of households expressed a tendency to either sell their e-waste to a second-hand reseller or dispose of it alongside their regular waste. This can be linked to the strong emotional connections individuals form with their belongings. Research has shown that people who form significant emotional bonds with their digital devices are more likely to accumulate obsolete items at home instead of recycling them appropriately (Ofori, 2020). This concern will lead to the uncontrolled reprocessing of materials and their final disposal in landfills without suitable processing (Ahmad Kalana, 2010). A resident from a rural region articulated their dissatisfaction regarding the lack of e-waste recycling facilities in their locality. They are left with no choice but to discard their obsolete electronic devices in standard household waste bins.

Prior investigations have demonstrated that inadequate recycling infrastructure and services can greatly reduce the participation rates in recycling efforts. The findings of Parameswaran et al. (2015) indicate a distinct relationship between the accessibility of recycling infrastructure and the level of participation in recycling activities among individuals. This analysis clearly indicates that depending exclusively on positive household behaviour in e-waste recycling does not adequately enhance the overall

recycling participation rate in the country. For householders to engage in pro-environmental actions, it is essential that the government and stakeholders actively support and supply the required facilities and infrastructure. This investigation uncovers a mutual connection between the two entities that enhances the nation's sustainability via the process of recycling.

ii. **Situational (Convenience, Engagement, Advertising) and Personal (Awareness, Attitude)**

In the FGD with licensed e-waste collectors, it was noted that authorised e-waste collectors offer convenient and accessible recycling facilities and services, including drive-through options in collaboration with Lalamove Malaysia and designated pickup centres. In every state of Malaysia, those involved in the collection of e-waste collaborate with various service units to guarantee that the collection facilities are readily accessible to local residents. They carry out initiatives to promote awareness about e-waste while concurrently gathering e-waste from households. The studies conducted by Cahill et al. (2011) and Favot (2015) demonstrate that involving stakeholders across multiple policy levels increases the likelihood of successful outcomes in e-waste management. This underscores the importance of active engagement and collaboration among stakeholders to ensure the effectiveness and success of e-waste management systems, thereby increasing participation in e-waste recycling among households. Additionally, local and private stakeholders, such as NGOs, are engaged in media campaigns that advocate for e-waste collection and recycling centres. The stakeholders share information regarding the available services and enhance awareness within households about the importance of e-waste recycling.

The findings indicated that employing diverse media formats to share information regarding recycling could enhance recycling practices. The influence of social media emerged as a significant factor in shaping recycling attitudes, particularly when those attitudes are negative (Sujata et al., 2019). This illustrates the interconnectedness of households and stakeholders living within the same nation as they strive to positively impact the environment they share.

Next, studies have shown that using positive reinforcement is an effective method for promoting desirable behaviour. A study by Grilli and Curtis (2019) indicates that providing rewards, both monetary and non-monetary, can significantly increase participation and promote a pro-environmentalist attitude in individuals regarding e-waste recycling. Interviews carried out by authorised e-waste recycling facilities reveal that individuals residing in more isolated or rural regions, in particular, prefer to receive monetary or alternative compensation for their recyclables. The declaration made by the local authorities has received consensus from all three sub-clusters of the households under examination. This indicates that enhancing the number of incentives provided alongside e-waste recycling could boost public engagement and participation in the initiative. The cultural attitude that an household follows can influence their viewpoints, alongside societal expectations regarding the rewards associated with engaging in environmentally responsible actions. Research conducted by various scholars (Khalil et al., 2017; Kianpour et al., 2017; Nguyen et al., 2019; Shaharudin et al., 2020) demonstrated that individuals who are near someone who adheres to positive recycling practices are more inclined to participate in similar behaviours due to the appeal they experience towards that individual.

A rural resident articulated their dissatisfaction regarding the absence of accessible e-waste recycling facilities in their locality. Recycling facilities were located in metropolitan regions, necessitating a journey of more than 30 minutes, which was viewed as a considerable hassle. This finding is consistent with earlier research, including the work of Parameswaran et al. (2015), which showed a significant relationship between the convenience to access recycling infrastructure and the level of public engagement in recycling efforts. Insufficient and impractical infrastructure significantly hinders individuals, especially in rural regions, from participating in e-waste recycling efforts.

The findings indicate that depending exclusively on favourable household practices is inadequate to significantly boost the national e-waste recycling rate. For households to engage in consistent pro-environmental actions, it is essential for governments and stakeholders to invest actively in and offer convenient facilities and infrastructure. By tackling infrastructure deficiencies and minimising access obstacles, authorities and involved parties can enhance participation levels in waste recycling among households.

iii. Situational (Education, Policy and Regulations) and Personal (Awareness, Knowledge and Experience)

The findings from the FGD with the e-waste operational organisation indicate that the existing provision of disposal facilities and infrastructure for households is viewed as insufficient. All facility initiatives must adhere rigorously to the required standards and regulations, and it is essential to implement a thorough enforcement mechanism. This initiative aims to ensure the mandatory implementation of recycling standards. In

Malaysia, stakeholders concluded that a robust enforcement system would likely encourage citizens to adhere to the law. The study by Liu et al. (2019) indicates that the announcement of rules and restrictions contributed to heightened environmental awareness among households, which in turn fostered a greater willingness to recycle e-waste. This initiative seeks to guarantee adherence to recycling regulations among households through the establishment of compulsory enforcement mechanisms. Subsequently, stakeholders have indicated that Malaysians tend to comply with regulations more effectively when a robust enforcement system is established. However, a discussion during an individual interview with a householder uncovers a differing conclusion. They maintained that it is unjust for local municipalities to enforce penalties without ensuring that the householder is fully informed about the applicable regulations. Liu et al. (2019) suggest that an increase in waste generation within societies could stem from insufficient education and awareness regarding environmental sustainability. Consequently, it is essential for all tiers of government to enhance their efforts in educating the public prior to the enactment of any new laws and regulations.

Table 4.28 encapsulates the summary of interrelations between various factors discussed in this study. The table serves as a comprehensive overview, synthesizing the relationships among key variables of HERS and HERB to enhance household e-waste recycling participation. These interrelations provide a foundation for understanding the underlying challenges and opportunities in addressing e-waste recycling participation.

Table 4.28
The interrelation of various factors to the issue discussed

Discussed issues	Situational Factors					Personal Factors			
	Convenience	Engagement	Advertising	Education	Policy and Regulations	Attitude	Knowledge and Awareness	Psychological Ownership	
Public attitude to recycle in Malaysia for solid waste is increasing.		√	√			√		√	
Introducing WEEE recycling culture in education centres (schools, universities etc.).		√		√			√	√	
Having a joint partnership in developing the WEEE recycling policy and enforcement.		√			√				
Government and private stakeholders engaged in making e-waste recycling awareness programs.		√	√			√		√	
Providing convenience recycling facilities for the public (drive thru recycling centres, door-to door services, nearby facilities). Linking services with e-hailing.	√	√				√		√	
Easy access and nearer recycling centres influence recyclers to participate in e-waste recycling	√					√			
Awareness in e-waste recycling through medias.		√	√					√	
Awareness and knowledge in e-waste recycling through physical campaign and activities held near residential areas.	√	√				√		√	
Incentives for selling of recyclables WEEE items (cash vouchers, cash, cash-back etc.).		√				√			
Stockpile WEEE at home / dispose it with daily waste. Sentimental values towards EEE owned.				√		√		√	
Recycling behaviour encouraged through surrounding norms.				√		√	√	√	

4.4. Chapter Summary

This chapter concentrated on two main analyses: the quantitative analysis in Phase 1 and the qualitative analysis in Phase 2, consistent with the mixed-methods approach of explanatory sequential design. The initial phase of analysis employed a quantitative method, incorporating a structured survey. This phase explored two models developed from the research framework. The initial model, Model A, was created to tackle RQ 1, 2, and 3. Subsequently, Model B was developed to delve deeper into the moderating effects observed in Model A, incorporating demographic profiles to address RQ 4.

The analysis of reliability and validity showed that the measurement tools employed were adequately robust and reliable for subsequent studies. The findings from the structural models resulted in the elimination of two independent factors; accessibility and availability from the situational factors of HERS, and social norms from the personal factors of HERB. These factors were excluded from the conceptual framework due to their insignificant influence on household e-waste recycling participation.

The validation of a symbiotic effect between situational and personal factors was achieved through the analysis of reciprocal loops. The confirmation of symbiotic relationships was observed across 15 distinct pathways. The findings in Model B indicated that the connection between situational and personal factors varied according to household demographic profiles. This study demonstrates that situational factors interact in both positive and negative ways with demographic aspects of personal factors, such as subclusters; urban, suburban, rural settings, age, and gender. These interactions are essential in influencing and establishing participation in household e-waste recycling.

The second phase of qualitative analysis utilised a thematic, phenomenological approach in conjunction with ethnographic analysis to tackle the research questions. This phase examined themes related to HERS and HERB, while further developing the concept of the symbiosis effect in the realm of household e-waste. The classification of essential elements for the two primary factors; personal and situational was obtained through thematic analyses and pre-existing empirical studies within the framework of HERS and HERB.

The FGD with stakeholders and private interview sessions with households across three different subclusters uncovered the presence of reciprocal integrations (symbiosis effect) between personal and situational factors, consistent with the Symbiosis Effect Theory (A-Jalil, 2015). The interaction between personal factors and situational factors leads to a transformation in household recycling behaviour, influenced by the impact of situational factors like convenience, engagement, advertising, education, and policy and regulations. The qualitative analysis offered profound insights that clarified and justified the reasoning behind the results acquired in the quantitative phase (Phase 1), thereby enhancing the comprehension of the study's findings.

The findings from Phases 1 and 2 of the explanatory sequential design are summarised in Table 4.29.

Table 4.29

Summary of phase 1 and phase 2 addressing the RQs

Research Questions	Results	
	Phase 1: Quantitative	Phase 2: Qualitative
RQ1. How does the situational factors influence households to participate in e-waste recycling in Malaysia?	<ul style="list-style-type: none"> • Supported that situational factors did influence households to participate in e-waste recycling • The situational factors that influence e-waste recycling participation are convenience, engagement, advertising, education, policy and regulations. 	<ul style="list-style-type: none"> • Further supported results in Phase 1. • No differences between local stakeholders and households in relation to the positive influence of situational factors.
RQ2. How does the personal factors influence households to participate in e-waste recycling in Malaysia?	<ul style="list-style-type: none"> • Supported that personal factors did influence households to participate in e-waste recycling • The personal factors that influence e-waste recycling participation are attitude, knowledge and experience, awareness and psychological ownership. 	<ul style="list-style-type: none"> • Further supported results in Phase 1. • No differences between local stakeholders and households in relation to the positive influence of personal factors.
RQ3. How does the interactions between situational and personal factors can support the existence of symbiosis effects between HERS and HERB?	<ul style="list-style-type: none"> • Supported when situational factors interacting with personal factors, the e-waste recycling participation will transform according to how effectively the effects of HERS are established. • Proves the existence of symbiosis effect between HERS and HERB. 	<ul style="list-style-type: none"> • Supported when situational factors interacting with personal factors, the e-waste recycling participation will transform according to how effectively the effects of HERS are established. • Validates the existence of symbiosis effect between HERS and HERB.
RQ4. Does the interactions between both factors (situational and personal) and household e-waste recycling participation vary depending on demographic profiles?	<ul style="list-style-type: none"> • Results indicated that demographic profiles have a significant relationship to household e-waste recycling participation and alter the interactions between HERS and HERB. 	<ul style="list-style-type: none"> • Supported the moderate influence of demographic profiles. • Demographic profiles altered the interaction between HERS and HERB.

CHAPTER FIVE

TRIANGULATION AND DISCUSSIONS

5.1 Introduction

This research examines the dynamics between local stakeholders and households concerning the recycling of e-waste at the household level. The initial phase employed structured questionnaires to ascertain the primary factors affecting household engagement in e-waste recycling. In the subsequent phase, semi-structured interviews were carried out to investigate the interdependent relationship between local waste management stakeholders and households across three distinct subclusters of urban, suburban, and rural within the stakeholders' jurisdiction. The conducted interviews facilitated the identification of prevalent themes associated with household e-waste recycling. The qualitative investigation delved deeper into the relationship between personal and situational factors identified in Phase 1, integrating insights from both stakeholders and households. The triangulation approach proved to be crucial for the cross-validation and synthesis of findings from both phases, facilitating a more comprehensive interpretation of the data and deepening the overall analysis.

The study's fundamental RQs has been adequately answered by the results of Phases 1 and 2. Previous findings suggest that a mutually beneficial relationship has developed as a consequence of the interaction of situational (HERS) and personal (HERB) variables. Phase 3 is devoted to triangulation rather than investigating new results, in keeping with Creswell and Clark (2018) explanatory sequential design.

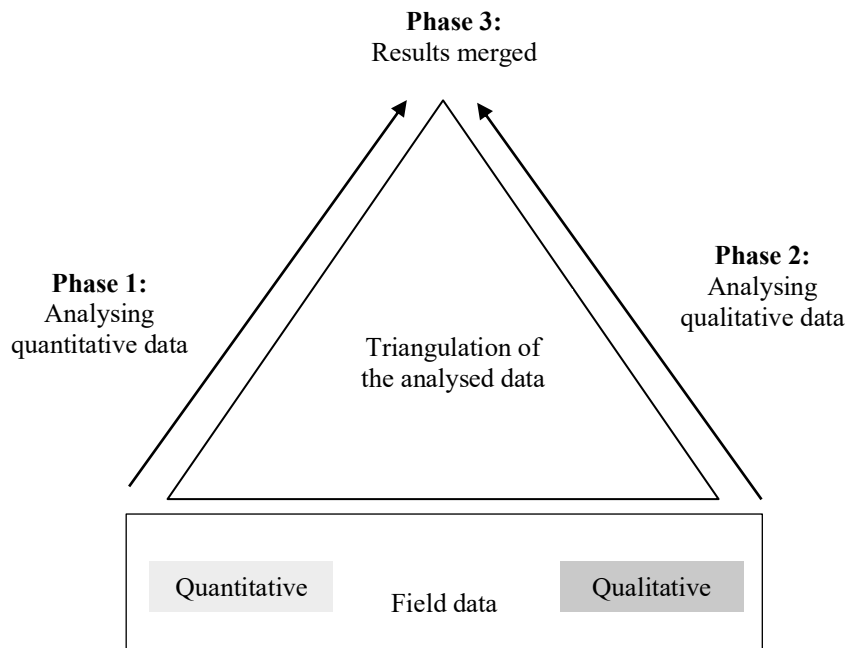


Figure 5.1
Triangulation protocol for explanatory sequential design in mixed methodology approach

Figure 5.1 illustrates the triangulation protocol in explanatory sequential design adapted for this final phase. In mixed methods research, the triangulation process offers a systematic framework for synthesising diverse data sources, methodologies, or viewpoints to get a thorough comprehension of the study issue. This method utilises the advantages of both qualitative and quantitative data while alleviating their individual shortcomings (Ivankova et al., 2006). In this explanatory mixed-methods approach, quantitative (QUAN) data is prioritised and gathered first, followed by qualitative (QUAL) data, which aims to build on or contextualise the quantitative results guided by Creswell and Clark (2018) explanatory sequential QUAN-QUAL research design. The qualitative data subsequently aids in addressing any conceptual deficiencies revealed in the quantitative study. This approach offers a significant advantage through its ability to improve and strengthen quantitative results.

5.2 Phase 3: Triangulation Phase

This final phase emphasised the analysis of the findings derived from Phase 1 and 2. This triangulation phase performed an essential part in the cross-examination of findings derived from the earlier phases of the explanatory sequential design, enabling the synthesis of consensus-based feedback that encapsulates the overall study. This investigation employs a triangulation process that facilitates a thorough integration of statistical correlations derived from quantitative analysis alongside contextual insights obtained from qualitative data. This approach ensures that the conclusions reached are both empirically supported and contextually refined. Phase 3 functioned as an extensive evaluation of the study's results, synthesising information gathered from structured questionnaires, in-depth private interviews with households, and FGD among local stakeholders and households. This integration facilitated a more profound comprehension of the critical elements affecting household e-waste recycling participation, along with the symbiotic relationships existed among these elements. This phase focused on consolidating and enhancing the findings from earlier stages, with the objective of achieving a coherent and well-supported conclusion, rather than pursuing new data or uncovering new phenomena.

In addition, Phase 3 offers a thorough analysis of the key findings, emphasising the most and least significant factors affecting household engagement in e-waste recycling, as well as the strongest and weakest symbiotic relationships identified among 15 distinct symbiotic pathways, as established through quantitative analysis. Given that data collection was conducted in a sequential manner, with qualitative data serving a supplementary function, the main quantitative findings were subsequently analysed through the lens of insights derived from the FGD in Phase 2. The results from both

phases were subsequently synthesised to formulate strong conclusions and enhance comprehension of the issue, thus aiding in addressing the RQ 1, 2 and 3. This phase also merged the discussion from both research approaches in providing comprehensive understanding on the influence of demographic profiles in altering the relationship between situational and personal factors to household e-waste recycling participation, thus aiding in addressing the final RQ. The following sections present verifications of the RQs through the application of the triangulation approach.

5.3 Discussion for Results in Addressing RQ1 *How does the situational factors influence households to participate in e-waste recycling in Malaysia?*

5.3.1 Merge Discussion for Quantitative and Qualitative Phase

5.3.1.1 Rationale for the Exclusion of Accessibility and Availability

In the quantitative phase (Phase 1) of this study, statistical analysis revealed that situational factors, including convenience, engagement, advertising, education, and policy regulations, significantly influence household participation in e-waste recycling in Malaysia. However, one situational factor; accessibility and availability of recycling facilities, infrastructure, and services, was found to be statistically insignificant in predicting household e-waste recycling participation. As a result, this factor was excluded from further quantitative analysis. To validate and contextualize these findings, FGDs and private interview sessions were conducted with householders, waste management operators/collectors, local municipalities, and representatives from the federal government. These qualitative sessions provided in-depth insights into the issue, supporting the exclusion of accessibility and availability as a standalone key

factor while reinforcing the importance of attitude, engagement, and policy support in driving household e-waste recycling participation.

During FGDs with Malaysian stakeholders, many respondents acknowledged that accessibility and availability of e-waste recycling services are no longer major barriers in today's urban and semi-urban settings. Several respondents among the households noted the presence of recycling collection points in residential areas, shopping malls, and government facilities, as well as door-to-door collection services offered by private waste management operators. One urban household expressed:

I15: "I can see e-waste collection bins in several places around my neighbourhood. Even the shopping malls, including Ikea and Lotus have designated areas to drop off old electronics. But honestly, I have never used them. It's not about access; it's just that I don't think about recycling my e-waste as much as I should."

The representative from the federal government in waste management department highlighted:

I07: "Nowadays, waste collectors even come to your house if you book a pickup. What more accessibility do we need? The real issue is people's attitude. Many just don't care enough to sort and recycle their e-waste."

Another stakeholder among private waste collector mentioned:

I08: "Some residents even request us to pick up their e-waste directly from their homes. We do it for free in many cases. But the challenge remains—many people still don't take action. We need stronger incentives to change behaviour."

The findings presented are consistent with existing behavioural research regarding recycling participation. This body of work highlights that although the presence of infrastructure and its availability enhance accessibility, they do not inherently affect recycling behaviour unless there is a corresponding motivation among individuals to engage in such activities (Zhang et al., 2019). This finding aligns with the TPB, indicating that attitudes and perceived behavioural control serve as more significant predictors of recycling behaviour compared to the mere presence of facilities (Ajzen, 1991; Miafodzyeva and Brandt, 2013).

Private waste collectors and recycling operators also echoed the sentiment that accessibility and availability are not the key barriers in modern e-waste management. One authorised waste management stated:

I14: "We provide scheduled e-waste collection services and even organize special collection days. Despite these efforts, participation rates remain low. People often say they are 'too busy' or 'forget' to recycle their e-waste. It's not a lack of access; it's a lack of willingness."

This aligns with research findings indicating that even in areas with well-established recycling programs, participation rates remain suboptimal unless individuals perceive recycling as convenient and personally beneficial (Saphores et al., 2016; B. Wang et al., 2019). Local municipal officials recognised that there has been a notable enhancement in accessibility and availability over the years, attributable to policy initiatives and the engagement of the private sector. Nonetheless, it was acknowledged that the mere presence of infrastructure does not ensure an upturn in recycling participation rates. A municipal officer in waste management department explained:

I12: “We have implemented various e-waste collection points in strategic locations, and we continue to collaborate with recycling operators. But participation rates remain low. This shows that merely providing infrastructure is not enough.”

Another municipal suggested:

I02: “Instead of treating accessibility as a separate factor, we should integrate it under the broader concept of ‘convenience.’ Convenience encompasses not only physical access but also the ease with which households can participate in recycling programs”.

This recommendation aligns with global best practices in waste management, where convenience is defined not just by accessibility but also by factors such as user-friendly recycling schemes, awareness campaigns, and economic incentives (DiGiacomo et al., 2018; Rajapaksa et al., 2019).

The results derived from both statistical and qualitative analyses support the assertion that the accessibility and availability of e-waste recycling facilities are no longer considerable obstacles to modern Malaysia. Conversely, various situational factors identified by stakeholders regarding recycling systems, including convenience and engagement, significantly impact household e-waste recycling participation. The incorporation of accessibility and availability within the broader category of convenience framework is consistent with worldwide best practices, underscoring the necessity for both behavioural and regulatory strategies to improve household participation in e-waste recycling initiatives.

5.3.1.2 The Strongest and Weakest Influencing Factors Among Situational Variables

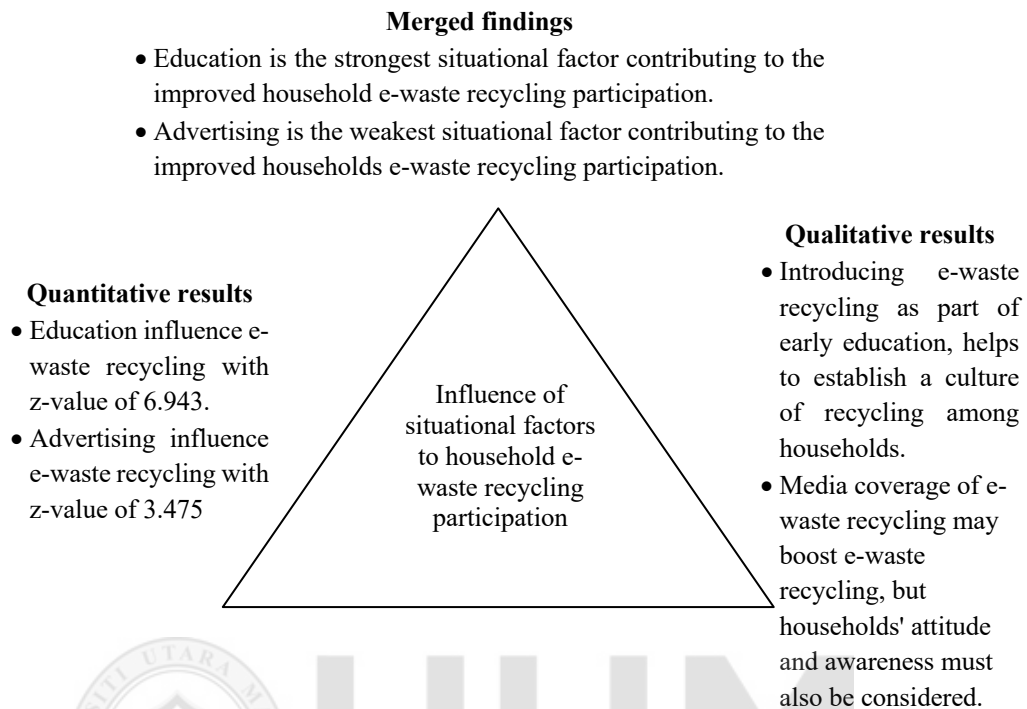


Figure 5.2
Triangulation analysis on the influence of situational factors to household e-waste recycling participation

This subsection discusses how triangulation facilitates the integration of quantitative and qualitative data, thereby offering a comprehensive approach to address RQ1. This triangulation analysis was performed to evaluate the impact of situational factors on household engagement in e-waste recycling within the context of Malaysia. The triangulation framework illustrated in Figure 5.2 integrates statistical results obtained from the quantitative phase with qualitative insights gathered from FGDs and individual interview sessions. This approach guarantees that the findings are both statistically reliable and strengthened by contextual insights from relevant stakeholders, such as local municipalities, waste operators and collectors, federal government agencies, householders, and licensed NGOs engaged in waste recycling efforts.

The analysis is structured into three key components. The first component comprises the quantitative findings, which reveal the statistical significance of various situational factors in influencing household e-waste recycling participation. The second component includes qualitative findings, which provide context and deeper understanding through stakeholder and household discussions. The final component, merged findings, synthesizes both data sets to present a cohesive interpretation of the strongest and weakest situational factors impacting household e-waste recycling participation.

The quantitative phase of the research, conducted through statistical analysis, identified education as the most influential situational factor in determining household participation in e-waste recycling. The statistical findings indicated a high level of significance in the relationship between education and recycling participation, with a z-value of 6.943. Households that demonstrated higher levels of awareness and knowledge regarding e-waste recycling were significantly more likely to participate in recycling programs. This finding is consistent with existing literature, which emphasizes the role of environmental education in fostering sustainable waste management practices (Abdullah et al., 2022; Singh et al., 2022). Education plays a crucial role in shaping household attitudes and behaviours, as it equips individuals with the necessary information on the environmental and health impacts of improper e-waste disposal, thus encouraging responsible recycling practices.

Conversely, advertising was identified as the weakest situational factor influencing household participation in e-waste recycling, with a z-value of 3.475. While advertising campaigns do contribute to raising awareness, their effectiveness in translating awareness into sustained behavioural change was found to be minimal. The study revealed that media coverage alone is insufficient in fostering long-term participation, as the initial engagement it generates tends to diminish over time. Similar findings have been reported in prior studies, where advertising efforts were shown to increase temporary engagement but failed to create lasting behavioural changes unless combined with other factors such as policy enforcement and education (Chen and Lee, 2020).

The qualitative phase of the research provided further depth to the quantitative findings by incorporating perspectives from key stakeholders involved in waste management. Local municipalities play a vital role in managing household waste and ensuring the effectiveness of recycling programs. During the interviews, municipal representatives emphasized the significance of early education in cultivating long-term recycling habits among households. One municipal officer remarked:

I05: "We have observed that communities that incorporate environmental education into their school curriculum and local awareness programs tend to have higher rates of e-waste recycling. It is evident that when children are exposed to recycling concepts from an early age, they grow up understanding its importance and influence their family members to adopt responsible disposal practices."

This observation aligns with previous research indicating that early exposure to environmental education leads to increased participation in recycling programs (Pérez-Belis et al., 2015). The representatives further argued that while advertising campaigns

do raise temporary awareness, they are not as impactful as structured educational initiatives that integrate environmental responsibility into everyday life. Waste operators and collectors, who are directly involved in e-waste collection and management, provided critical insights into household e-waste recycling participation. Their experiences suggested that while media campaigns do generate short-term interest, the long-term sustainability of e-waste recycling programs depends on continuous engagement from the stakeholders in providing HERS. A waste operator shared:

I09: "We often see spikes in e-waste collection after major advertising campaigns or awareness programs. However, this interest usually fades within a few months unless there is an ongoing effort to keep people engaged. Households need a consistent reminder, whether through incentives, or community engagement programs, to maintain regular participation in recycling."

These findings corroborate previous studies indicating that while media coverage can temporarily boost participation rates, sustained engagement requires policy-driven approaches such as tax incentives for proper recycling or penalties for improper disposal (Abila and Kantola, 2019; Rajapaksa et al., 2019). The following dialogue excerpt is derived from comprehensive interviews conducted with rural householder, emphasising their perspectives on e-waste recycling and the impact of advertising on their involvement in this practice. The findings indicate that participants are aware of advertising's presence; however, they demonstrate that their attitudes towards recycling exert a more significant influence on their behaviour.

I17: "...people around here don't really see e-waste recycling as a priority. There's always something else that needs doing, like getting the crops in or fixing the tractor. It's just not at the top of the list, even if we see the ads."

The dialogue extracted from rural household link with the statement obtained from the suburban household. The suburban household stated that:

I16: "I've seen a few ads about recycling electronics, but honestly, it's not something I think about all the time. It's not like I'm sitting on a pile of old electronics every day. It's easy to forget. I think the ads are good, but I'm just not convinced it's that important, to be honest."

The dialogue reveals that rural householders acknowledge the existence of advertising campaigns promoting e-waste recycling, however, their attitudes toward recycling significantly influence their participation in these programs. Both participants recognize the presence of ads but express a sense of detachment, indicating that advertising alone is not enough to inspire action. Both responses suggest that attitudes toward the importance of recycling and perceived inconvenience play a more significant role than advertising in determining their recycling behaviours to participate in e-waste recycling. The lack of urgency and priority associated with e-waste recycling is a recurring theme in their responses. Furthermore, rural householders indicate that while advertising provides information regarding the availability of recycling services, it fails to adequately engage with the fundamental attitudes or emotional connections related to the issue. For instance, a household in rural regions often prioritises immediate concerns such as agricultural activities, which subsequently reduces the perceived significance of e-waste recycling. Research indicates that in rural

communities, the efficacy of advertising campaigns frequently does not meet expectations because of entrenched attitudes regarding recycling. Although residents might possess knowledge of recycling initiatives, their engagement is often impeded by a diminished sense of urgency or personal significance (Lu et al., 2022).

In addition, government representatives interviewed in this study acknowledged that while advertising and awareness campaigns serve as useful tools, their effectiveness remains limited without strong policy enforcement. One official stated:

I01: "Our approach is shifting towards policy-driven strategies rather than relying solely on media campaigns. For example, providing incentives for every recycling activities that the households participate. It doesn't have to be in terms of money, maybe through discount vouchers, free collection charges..."

This statement is supported by global research highlighting the effectiveness of policy-driven strategies in enhancing e-waste recycling rates (Department of Trade and Industry, 2005; Junfeng et al., 2018; Menikpura and Hotta, 2014; L. Yu et al., 2014). The success of e-waste recycling programs in other countries, such as Japan and China, has shown that mandatory regulations, financial incentives, and enforcement mechanisms are more effective than voluntary participation encouraged through advertising alone. The official further emphasized the need for a combination of education, incentives, and regulatory measures to achieve sustainable recycling participation in Malaysia.

Next, licensed NGOs play a crucial role in bridging the gap between policy implementation and household engagement in e-waste recycling initiatives. Many

NGOs actively conduct awareness programs, training sessions, and collection drives to encourage household participation. A representative from an NGO specializing in e-waste recycling highlighted:

I13: "We have found that community-driven programs and grassroots engagement are far more effective in changing household recycling behaviours than mass media campaigns. When we conduct door-to-door collection programs and provide direct incentives, participation rates increase significantly. The key is personalized engagement rather than just broadcasting advertisements."

The findings suggest that localised, community-oriented initiatives produce more substantial outcomes in comparison to broader national advertising campaigns. This is consistent with findings from Soon (2024), which indicate that decentralised, community-led recycling initiatives frequently surpass government-driven campaigns in promoting sustained behavioural change.

The triangulation of quantitative and qualitative findings leads to the conclusion that education is the most influential factor driving household e-waste recycling participation. The statistical analysis demonstrated its significant impact, while qualitative insights from stakeholders reinforced its role in fostering long-term behavioural change. In contrast, advertising was identified as the weakest factor, as its effects were found to be temporary and insufficient in sustaining long-term engagement without complementary measures. Based on these findings, a multi-faceted approach is recommended, integrating education, policy enforcement, and community-driven initiatives through stakeholders' engagement in providing convenience HERS. By leveraging educational institutions, enhancing regulations, and fostering localized

recycling facilities and infrastructure, Malaysia can establish a sustainable e-waste recycling culture. Further collaboration between government bodies, municipalities, waste operators, NGOs, and households are critical in driving long-term participation in responsible e-waste disposal.

5.4 Discussion for results in addressing RQ2 *How does the personal factors influence households to participate in e-waste recycling in Malaysia?*

5.4.1 Merge Discussion for Quantitative and Qualitative Phase

5.4.1.1 Rationale for the Exclusion of Social Norms

The results from Phase 1 of this research, which involved statistical analysis, provide significant insights into the personal factors influencing household participation in e-waste recycling in Malaysia. Among these factors, attitude, knowledge and experience, awareness, and psychological ownership were found to have a significant influence on the household e-waste recycling participation. However, one personal factor; social norms, was excluded from the initial analysis as it showed no statistically significant effect on household e-waste recycling participation. The results were additionally supported by qualitative data collected via FGD and private interviews with a range of stakeholders, such as local municipalities, waste operators, federal government representatives, non-governmental organisations, and the householders themselves. The qualitative findings contributed to a more nuanced understanding of the underlying dynamics and illuminated the reasons why specific personal factors exert greater influence in the promotion of e-waste recycling.

Social norms, as the quantitative analysis suggested, appear not to be a critical factor in influencing household recycling participation, particularly in the case of e-waste. During the FGD sessions, participants emphasized that the presence or absence of social norms related to recycling facilities did not significantly motivate them to recycle e-waste. One respondent from a local municipality articulated:

I12: “We have facilities in place, but it’s not enough to change the behaviour of people. Their decision not to recycle seems to come from personal choice rather than external influences from their environment.”

This sentiment was echoed by waste collectors and operators, who noted that social pressure or the perceived behaviour of others was not a strong driver of household recycling practices. A waste operator mentioned:

I08: “Most people will not recycle because they see others not doing it, but that doesn’t mean they shouldn’t. It’s really about personal conviction.”

Indeed, as several respondents noted during the interviews, individuals often view recycling, especially e-waste, as a personal responsibility rather than something driven by societal expectations or the actions of those around them. A respondent from an NGO involved in environmental advocacy stated:

I10: “The decision to recycle comes down to the person themselves. Even though we run campaigns and raise awareness, we find that those who consistently recycle often have a deeper sense of responsibility to the environment, something ingrained in them over time.”

This aligns with findings from academic literature on environmental behaviour, which argue that individual attitudes and intrinsic motivations are more important than

external social influences when it comes to recycling behaviour (Biel and Thøgersen, 2007; Bortoleto et al., 2022).

On the other hand, other personal factors such as attitude, awareness, past recycling experience, and psychological ownership were highlighted as crucial in motivating households to participate in e-waste recycling. Attitude, in particular, was a dominant theme in the qualitative interviews. A household participant shared:

I15: "I've always believed that we need to take care of our planet, so I make sure to recycle everything I can, especially electronic waste. If we don't take action, who will?"

This reflects the strong relationship between personal attitudes toward the environment and actual recycling behaviours. Furthermore, individuals who had prior experience with recycling, for example one household from suburban area, who made it a habit to recycle every week reported higher engagement with e-waste recycling initiatives. A participant from a municipal waste management agency highlighted:

I02: "Those who already recycle are more likely to recycle e-waste, even if the process is a bit more complicated. They understand the benefits of recycling and the steps they need to take."

The role of awareness in influencing recycling behaviours was also underscored. Several interviewees mentioned that being aware of the environmental impact of e-waste and the proper ways to dispose of it contributed significantly to their decision to participate. A representative from an NGO dedicated to environmental sustainability explained:

I10: “Awareness is key. People who understand the environmental harms of improper e-waste disposal are more likely to engage in proper recycling. It’s about making sure the information reaches them clearly.”

Last situational factor, psychological ownership, as indicated by the quantitative findings, emerged as another important driver. Many respondents indicated a personal connection to the electronic devices they owned, viewing the proper disposal of e-waste as a way of protecting the planet. One respondent from a householder noted:

I16: “I recycle my old favourite computer because it benefits both the environment and me. It feels good knowing that by recycling, I’m reducing e-waste, supporting a more sustainable future, and ensuring valuable materials get reused instead of being dumped in landfills.”

This concept of psychological ownership is consistent with past research in environmental psychology, which shows that individuals who feel personally responsible for the environmental consequences of their actions are more likely to engage in sustainable practices (Pierce et al., 2001). This finding is consistent with the current research conducted by Ofori (2020), which reveals that individuals who exhibit a strong attraction to their obsolete electrical and EEE are likely to demonstrate a positive disposition towards disposing of it through appropriate recycling channels.

In conclusion, the qualitative insights from the FGD and interviews strongly support and expand upon the quantitative findings. While social norms do not emerge as a major driver for household participation in e-waste recycling, personal factors such as attitude, experience, awareness, and psychological ownership play a vital role in increasing

engagement. This suggests that policies aimed at boosting e-waste recycling in Malaysia should focus on strengthening these personal factors, through targeted awareness campaigns and by encouraging individuals to take personal responsibility for environmental sustainability. Moreover, it is essential for local municipalities, waste operators, and NGOs to engage in collaborative efforts aimed at establishing accessible and intuitive recycling facilities. This collaboration can facilitate the ability of motivated households to recycle with simple and effective procedures. The next section delves deeper into the analysis of the most and least influential personal factors in driving household participation in e-waste recycling.

5.4.1.2 The Strongest and Weakest Influencing Factors Among Personal Variables

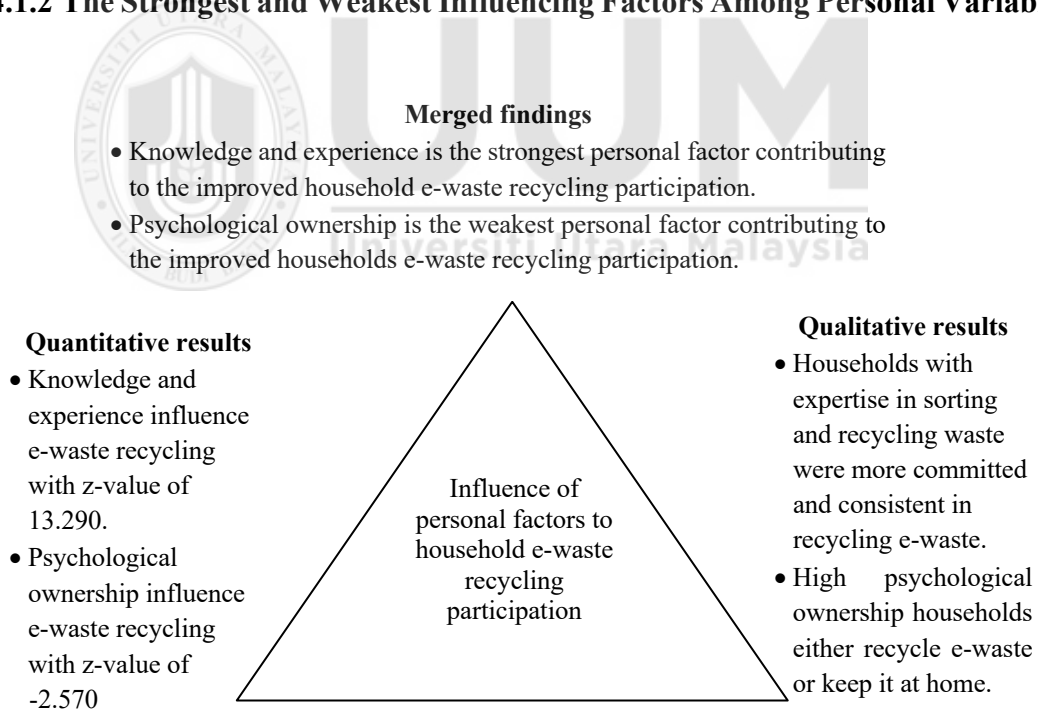


Figure 5.3
Triangulation analysis on the influence of personal factors to household e-waste recycling participation

This subsection examines the significance of triangulation in the integration of quantitative and qualitative data, thus facilitating a more thorough approach to address RQ2. The process of triangulation serves to enhance both the validity and reliability of research findings by facilitating the cross-verification of data collected through various methods and sources, thereby enriching the overall depth and breadth of the analysis. In the earlier quantitative phase (Phase 1), the findings indicated that personal factors such as attitude, knowledge and experience, awareness, and psychological ownership, have a considerable impact on the participation of households in e-waste recycling. Although these quantitative findings offer measurable evidence of the relationships in question, they do not fully encompass the intricate lived experiences, perceptions, and contextual challenges that influence recycling behaviours in practical settings. Consequently, qualitative analysis functions as an essential supplementary method, providing profound insights into the motivations, barriers, and contextual intricacies from the mentioned significant personal factors that affect household participation in e-waste recycling.

The triangulation approach employed in this phase serves to integrate and synthesise qualitative data gathered from dialogues with key stakeholders, which encompass local municipalities, waste operators, federal government agencies, licensed waste NGOs, and householders. The integration of varied perspectives facilitates a comprehensive understanding of the most significant and least influential personal determinants that impact household participation in e-waste recycling. This comprehensive investigation reveals significant factors that promote or hinder recycling behaviour, highlighting deficiencies in policy, systemic inefficiencies, and possible approaches to improve household e-waste recycling participation. Ultimately, this methodological

triangulation ensures a robust and well-rounded examination of the issue, bridging the gap between statistical trends and real-world stakeholder and householders' experiences. This integration not only strengthens the research findings but also provides a solid foundation for developing targeted interventions and upgraded recycling systems aimed at improving household e-waste recycling participation.

Figure 5.3 illustrates a triangulation analysis that explores the influence of personal factors on the participation of households in e-waste recycling activities. The triangulated findings indicate that knowledge and experience emerge as the most influential personal factors, evidenced by a z-value of 13.290, which significantly contributes to household participation in e-waste recycling activities. Conversely, psychological ownership, evidenced by a z-value of -2.570, appears to be the least influential factor affecting participation. This finding aligns with the research conducted by Berge et al. (2023), which suggests that individuals who possess sentimental attachments to their old electronic devices demonstrate a lower probability of disposing of them.

The quantitative findings indicate a direct relationship between knowledge and experience and the propensity to participate in e-waste recycling activities. Prior exposure to waste sorting and recycling practices is associated with an increased commitment to proper disposal methods (Tanskanen, 2013). The findings were further reinforced through qualitative interviews with various respondents involved in waste recycling to enhance and deepen the understanding established in the quantitative phase, confirming that recycling participation among households are shaped by both

personal and situational factors. Interviews with waste operators emphasized the role of experience in reinforcing recycling habits. A waste collector shared:

I09: “When people have experience with recycling, they tend to be more proactive. We have seen that those who have interacted with collection centres or have been educated about the environmental impact of e-waste disposal are more likely to participate in our programs.”

Current studies acknowledge on the significance of practical experience in fostering sustainable behaviours. Research conducted by Kihila et al. (2021) indicates that individuals participating in recycling initiatives demonstrate a higher likelihood of cultivating enduring pro-environmental habits. This finding implies that both familiarity and personal experience are crucial factors influencing attitudes and behaviours related to recycling. This is consistent with the broader theory of habitual behaviour, which suggests that consistent participation in environmentally sustainable practices can result in the establishment of ingrained behaviours over time (Verplanken and Wood, 2006). The interviews with householders further reinforced this notion. A householder who had consistently engaged in recycling practices shared how her family’s experience with recycling was passed down through generations, underscoring the importance of early socialization in developing recycling habits. The householder echoed the sentiment:

I15: “My family has always been conscious about recycling. I learned from my parents about the importance of separating waste, and now I ensure my own children follow the same practice.”

This narrative not only reflects the transmission of pro-environmental values across generations but also highlights how early exposure to recycling behaviours can shape an individual's recycling habits throughout their life. This observation supports findings by Koger (2014), who assert that family-based socialization plays a crucial role in fostering environmental stewardship, particularly in the context of waste management. The continuity of recycling practices within families can contribute to long-term behaviour change, demonstrating the role of social influence in shaping environmental behaviours.

Moreover, the role of NGOs in facilitating knowledge transfer and bridging the knowledge gap about e-waste recycling was emphasized in the interviews with licensed waste NGOs. A representative from one such NGO explained the impact of community education efforts on increasing participation in e-waste recycling programs:

I10: "One of our major focuses is community education. We find that once people understand the long-term environmental consequences of improper e-waste disposal, they are more willing to participate. Many of our educational campaigns have resulted in a noticeable increase in e-waste drop-offs at our collection points."

This statement highlights the critical role of education in influencing recycling behaviours, an aspect that has been increasingly recognized in the literature. Recent studies have demonstrated that individuals who are informed about the environmental and health risks associated with improper e-waste disposal are more likely to participate in recycling programs (Mor et al., 2021). According to a study by Cheng et al. (2022), targeted educational initiatives can significantly increase recycling rates by enhancing awareness and motivating individuals to act on their environmental concerns. NGOs,

therefore, serve as important intermediaries in raising awareness and facilitating access to recycling services, ensuring that individuals understand both the environmental importance and the logistical aspects of proper e-waste disposal.

Furthermore, the federal government's perspective strongly supports the integration of public education within e-waste management policies. One government official remarked:

I01: "...we also recognize the importance of public education. Households that have knowledge about proper disposal methods are far more likely to participate in recycling programs."

This statement reflects the growing recognition of the need for consumer awareness and education in the successful implementation of waste management strategies. Pérez-Belis et al. (2015) argue that the integration of public education into national policies is crucial, as it helps empower consumers with the knowledge to make informed decisions about the disposal of e-waste. The growing body of research suggests that educational campaigns, which highlight both the environmental consequences of improper disposal and the benefits of recycling, are instrumental in increasing participation rates (Attia et al., 2021; Cheng et al., 2022; Islam et al., 2016). It is well-documented that individuals with a higher level of knowledge about the environmental impacts of e-waste are more likely to engage in recycling participation. Thus, the federal government's emphasis on education aligns with these findings and serves as a cornerstone for encouraging widespread participation in recycling programs.

On the other hand, the psychological ownership of electronic devices presents a unique challenge that complicates efforts to increase recycling rates. The quantitative analysis indicated that this factor exerts the least significant influence on the participation of households in e-waste recycling. Psychological ownership refers to the feeling of attachment or possession individuals experience toward objects, which in the context of e-waste, often leads to retention rather than recycling (Cole and Gnanapragasam, 2017). However, research conducted by Ofori (2020) indicates that households exhibiting high psychological ownership, which involves a considerable sentimental attachment to their old electronic and electrical items, demonstrate two distinct behaviours: they either engage in recycling the e-waste to ensure proper disposal or choose to retain the items within their homes. The qualitative data from the interviews reveal that households with high psychological ownership of their electronic devices are less likely to dispose of them, even when they are no longer functional. One householder shared:

I17: "I still have my first computer and my old mobile phones because they hold sentimental value. I know I should recycle them, but I feel attached to these items, so I store them instead."

This sentiment underscores the emotional attachment that many people have toward their electronic devices, which may stem from the memories or experiences associated with them. Puzzo and Prati (2024) highlighted similar findings, suggesting that such attachment significantly hampers the recycling of e-waste. These emotional ties often prevent individuals from viewing their old electronics as waste, leading them to hoard devices rather than dispose of them in an environmentally responsible manner.

This emotional attachment was further emphasized by NGO representatives, who pointed out the challenge of addressing psychological ownership in their outreach efforts. One representative explained,

I10: “We frequently encounter people who hoard old electronics because they associate them with personal memories. Unless we address this attachment through targeted behavioural campaigns, participation rates will remain limited.”

Cole and Gnanapragasam (2017) argue that emotional attachment, if left unaddressed, can significantly undermine recycling efforts. Therefore, the need for interventions that specifically target and address the psychological barriers associated with e-waste recycling becomes essential. Behavioural campaigns designed to promote detachment from outdated electronics by presenting these devices as contributors to environmental degradation rather than objects of sentimental value, may effectively reduce the hesitance to engage in recycling practices. The results of this study contribute to the expanding body of research regarding the influence of psychological factors on waste management practices. They underscore the importance of incorporating behavioural insights into the design and implementation of recycling initiatives (Baxter and Gram-Hanssen, 2016). Waste operators also echoed these concerns, observing inefficiencies in the collection process due to the reluctance of households to dispose of electronics.

A waste collector explained:

I06: “We find that some households only decide to recycle their e-waste when they run out of space. Until then, they hold on to items that could have been processed and recycled much earlier.”

Ofori (2020) observed similar patterns in household e-waste retention, noting that many people hold on to devices long past their functional lifespan due to psychological ownership, only disposing of them when space constraints force a decision. This inefficiency not only affects waste operators but also limits the potential environmental benefits that could be gained from earlier recycling.

The triangulation analysis illustrated in Figure 5.3 offers an in-depth examination of the influence of personal factors on participation in household e-waste recycling. The findings indicate that knowledge and experience serve as the primary factors influencing participation, highlighting the necessity for comprehensive educational campaigns, municipal outreach efforts, and initiatives supported by government entities. Psychological ownership presents a notable obstacle, necessitating behavioural interventions, more engaging recycling programs, and targeted awareness initiatives to address emotional attachment to outdated electronics. The synthesis of data from various stakeholders, such as municipalities, waste operators, NGOs, federal agencies, and householders, highlights the importance of a symbiotic approach that addresses both situational and personal factors in promoting sustainable participation in e-waste recycling. These aspects were further clarified and discussed in the subsequent subsection.

5.5 Verification in addressing RQ3 *How does the interactions between situational and personal factors can support the existence of symbiosis effects between HERS and HERB?*

5.5.1 Merge Discussion for Quantitative and Qualitative Phase

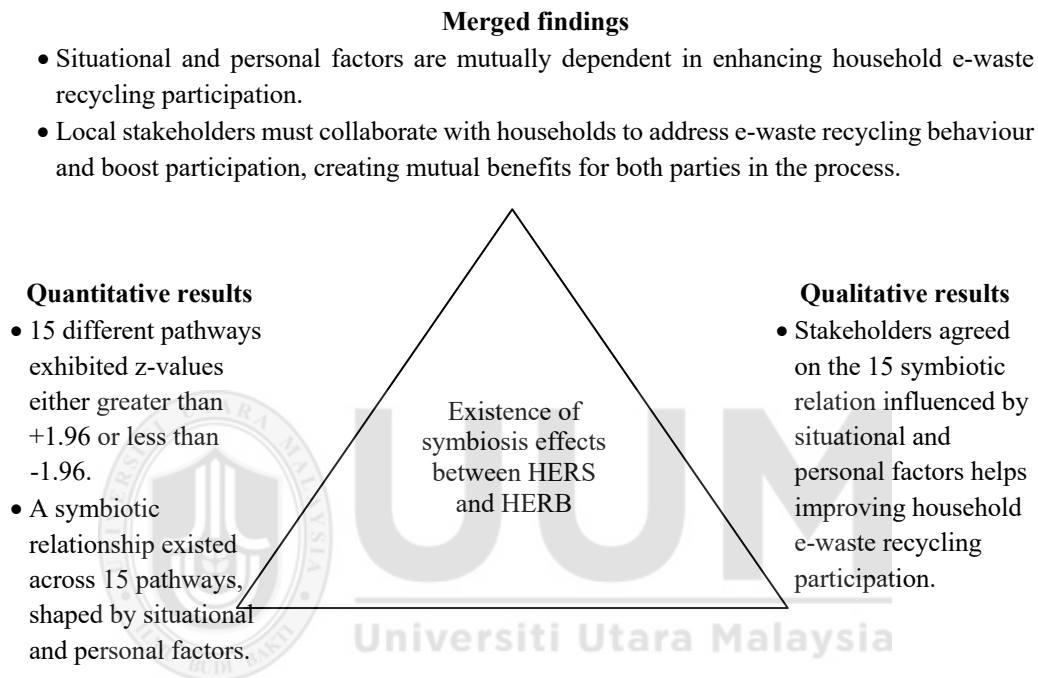


Figure 5.4

Triangulation analysis on the existence of symbiosis effects between HERS and HERB

This subsection explores how triangulation facilitates the integration of both quantitative and qualitative data, offering a comprehensive approach to address RQ3.

The reciprocal effects analysis conducted in quantitative phase (Phase 1) revealed 15 distinct pathways, confirming the existence of a symbiotic relationship between situational and personal factors in promoting household e-waste recycling participation.

Each of these pathways exhibited z-values either greater than +1.96 or less than -1.96, thereby validating the significant symbiotic influence between these factors. This

statistical finding underscores the influence of both situational and personal factors in driving household e-waste recycling participation.

The quantitative results were further validated through qualitative data gathered in Phase 2, during which interviews and FGDs with local stakeholders and householders yielded comprehensive insights. The qualitative findings verified the quantitative results, indicating that both local stakeholders and householders acknowledged the essential role of collaboration in addressing e-waste recycling practices. Both groups complied that the establishment of effective engagement between local stakeholders and households is essential for improving participation in e-waste recycling, thereby promoting mutual benefits for both parties.

Additionally, an in-depth examination of the 15 unique pathways uncovered a multifaceted interrelationship between situational and individual factors. The interaction of these factors was meticulously analysed to provide a more detailed comprehension of their combined influence on enhancing household e-waste recycling participation. This integration of quantitative and qualitative findings presents a comprehensive view of the underlying dynamics and yields significant insights for waste management practices aimed at improving household participation in e-waste recycling. A deeper understanding of the various factors identified as mutually dependent between situational and personal elements across the 15 distinct pathways is provided below, where these interdependencies are thoroughly discussed and analysed to highlight their integrated influence on household e-waste recycling participation.

1. Convenience and Attitude: ($\beta = 0.019$, $z = 5.568$)

The convenience of e-waste recycling infrastructure and services appears to be symbiotically related with household attitudes, playing a significant role in influencing participation in e-waste recycling efforts. The quantitative analysis reveals a significant positive correlation ($\beta = 0.019$, $z = 5.568$), indicating that the presence of user-friendly facilities for recycling plays a crucial role in enhancing favourable household attitudes towards recycling. This mutual advantage is evident as households actively utilize the services provided, thereby fulfilling their environmental responsibilities while supporting the effectiveness and reach of waste management systems.

When authorities develop accessible and easy recycling systems, households are more likely to cultivate favourable views and practices towards e-waste recycling. This reciprocal link underscores the need of well-constructed recycling infrastructure in fostering sustainable waste disposal practices (Miafodzyeva and Brandt, 2013; Soon, 2024). During an FGD session, a local government official from the municipal waste management department highlighted:

I05: "Households often complain about the lack of nearby recycling drop-off points. We have observed that when we establish collection centres in strategic locations, participation rates increase significantly. The key issue is convenience distance of recycling facilities—people will not travel far just to recycle their e-waste."

This statement highlights the crucial role of convenient recycling facilities, such as strategically located drop-off points and easily accessible recycling bins, in encouraging household participation in recycling efforts. Previous studies confirm that perceived

inconvenience is a significant barrier to waste recycling, emphasizing that proximity and ease of access are key factors in determining household engagement in recycling programs (DiGiacomo et al., 2018; Schultz, 2014). One private e-waste collection organization highlighted their collaboration with Malaysia's e-hailing services to enhance the convenience of recycling for households. This initiative eliminates the need for householders to physically visit recycling centres, as they can simply arrange for e-hailing service providers to collect and transport their e-waste directly to designated recycling facilities. This approach aligns with the growing emphasis on digital solutions and service integration in waste management, further reducing logistical barriers and increasing household participation in e-waste recycling initiatives. A representative from a private recycling operator added:

I08: "From our experience, the more we simplify the recycling process for example, by offering door-to-door collection, placing recycling bins in convenient locations, and using digital platforms for scheduling pick-ups, the more people are willing to recycle. People need convenience, or they simply won't do it."

This perspective aligns with research indicating that minimizing effort required for waste disposal significantly enhances participation rates (Nguyen et al., 2019). By integrating digital solutions such as mobile applications for scheduling e-waste collection, waste management operators can leverage technology to further enhance convenience and, consequently, household attitudes toward recycling. Householders also expressed varying perspectives regarding the convenience of recycling facilities. A middle-aged respondent from the interviews emphasized:

I17: "I want to recycle my old gadgets, but the nearest collection centre is too far. If there were a drop-off point in my neighbourhood or at the supermarket, I'd do it regularly."

These responses illustrate that while awareness and willingness exist, practical constraints such as distance and time significantly hinder active participation. This aligns with research by Soon (2024), which emphasizes that the convenience of recycling programs plays a crucial role in determining participation levels. Interestingly, household attitudes also symbiotically influence the development and accessibility of recycling facilities. As municipal authorities respond to increasing public demand and advocacy for more convenient recycling options, infrastructure investments are often guided by household engagement trends. A municipal officer during the FGD noted:

I05: "We expand recycling facilities based on community response. If we see consistent participation in existing drop-off points, it justifies the need for more collection centres in those areas."

A member of an NGO working on waste management campaigns further elaborated:

I10: "Community engagement and attitude plays a huge role. The more people advocate for accessible recycling facilities, the more pressure it puts on us and waste management authorities to allocate resources toward improved infrastructure."

This feedback illustrates that heightened recycling participation encourages local authorities to improve and expand their services. A proactive and environmentally conscious attitude among householders signals demand for better recycling

infrastructure, leading to enhanced municipal efforts in service provision (Tang et al., 2022). Thus, the reciprocal influence between household attitudes and recycling convenience reinforces the need for a participatory approach in waste management planning. When householders demonstrate consistent recycling participation, it validates municipal investments in infrastructure, ensuring sustained service improvements and a more effective recycling ecosystem.

2. Convenience and Awareness: ($\beta = 0.016$, $z = -5.191$)

The findings from the qualitative analysis further substantiate the symbiotic relationship between convenience and awareness in promoting household e-waste recycling participation. The quantitative results ($\beta = 0.016$, $z = -5.191$) indicate that these two factors mutually reinforce each other, greater convenience in recycling facilities enhances public awareness, while increased awareness fosters demand for more accessible and convenience recycling options. This interdependent dynamic suggests that efforts to improve recycling infrastructure must be accompanied by robust public awareness campaigns to maximize participation. Semi-structured interviews with householders further enriched the analysis by capturing their perspectives on how these factors influence their recycling behaviours.

During an FGD session, a stakeholder in waste management official highlighted:

I14: "Many people are simply unaware of where and how to recycle their e-waste. We receive frequent inquiries from residents asking where to dispose of their old electronics. This tells us that awareness is still a major gap. If recycling stations were more visible and information more accessible, participation would naturally increase."

This statement aligns with research by Mahat et al. (2019), which emphasizes that a lack of awareness is one of the primary barriers to e-waste recycling. Awareness efforts must not only inform the public about the existence of recycling programs but also provide clear, practical guidance on how and where to recycle. A well-informed public is more likely to utilize available recycling facilities, reinforcing the importance of convenience. A representative from a private recycling operator echoed similar sentiments:

I03: "We have set up several drop-off points, but many people still don't use them because they don't know they exist. When we conduct awareness campaigns, through social media, local events, or school programs, we see an immediate increase in recycling volumes."

This perspective underscores the reciprocal nature of convenience and awareness. Increased awareness leads to higher demand for convenient recycling options, prompting authorities and service providers to enhance infrastructure. Conversely, the presence of convenient facilities helps sustain awareness efforts by making recycling a visible and routine practice within communities (DiGiacomo et al., 2018; Schultz, 2014; Soon, 2024). Householder also provided valuable insights into how convenience and awareness influence recycling behaviours. An urban householder respondent expressed:

I15: "I always thought recycling e-waste was complicated. But when my local supermarket started providing a drop-off bin and advertised it, I realized it was actually quite simple. If more people knew how easy it is, I'm sure they'd do it too."

These responses indicate that even individuals who may not actively seek out recycling opportunities are likely to engage when the process is made convenient and well-publicized. This finding aligns with the work of Wang et al. (2016), who argue that visibility and accessibility play crucial roles in translating awareness into action.

The merged findings provide compelling evidence that convenience and awareness are mutually reinforcing factors in e-waste recycling participation. The presence of easily accessible recycling facilities fosters greater awareness, while increased awareness generates demand for enhanced convenience in waste disposal services. Both stakeholders and householders acknowledge the critical role of these interconnected elements in shaping sustainable recycling behaviours. By addressing infrastructure accessibility and implementing targeted awareness campaigns, local authorities and private operators can strengthen this relationship, ultimately driving more effective and inclusive e-waste recycling practices.

3. Convenience and Knowledge and Experience: ($\beta = 0.022$, $z = 7.710$)

The qualitative findings reinforce the symbiotic relationship between the availability of convenient recycling facilities and services and the level of household knowledge and experience in e-waste recycling. The quantitative results ($\beta = 0.022$, $z = 7.710$) indicate that these two factors mutually enhance each other—households with greater knowledge and experience in e-waste recycling are more likely to seek out and utilize convenient recycling options, while the presence of accessible facilities and services fosters experiential learning and knowledge retention. This bidirectional influence suggests that improving infrastructure alone is insufficient; rather, it must be

complemented by educational initiatives to enhance household awareness and skill in recycling practices. The discussions among local stakeholders in Phase 2 highlighted how household knowledge and experience shape engagement with recycling infrastructure and vice versa. A federal waste management official stated:

I07: “We noticed that neighbourhoods with a history of active waste segregation and participation in recycling programs make better use of our facilities. However, in areas where there has been little prior engagement, even the best facilities remain underutilized.”

This statement aligns with research by Xu et al. (2017), which emphasizes that familiarity and past experiences with waste management programs and recycling activities strongly influence future participation. Households with prior exposure to recycling are more likely to engage consistently. Householders provided first-hand accounts of how their knowledge and experience impact their recycling habits. An urban youngster household expressed:

I17: “I’ve always been conscious of waste management, so when the city introduced an e-waste collection program, I immediately started using it. My experience in previous recycling efforts made it easy for me to transition to e-waste recycling.”

In contrast, a rural middle aged household expressed frustration:

I17: “I want to recycle, but I don’t know where to start. I’ve never done it before.. If there were simple instructions, I think more people like me would participate.”

These responses suggest that while prior experience facilitates engagement, a lack of knowledge can serve as a significant barrier. This aligns with research by Tang et al. (2022), which found that people with prior exposure to recycling programs exhibit

higher participation rates and greater willingness to seek out recycling options. The reciprocal influence of convenience and household knowledge on e-waste recycling underscores the importance of integrated strategies. Governments, private sector operators, and NGOs must collaborate to develop initiatives that not only expand recycling infrastructure but also actively educate communities on its use. Local stakeholders must adopt a dual strategy prior to establishing e-waste recycling facilities; investing in recycling infrastructure without accompanying education results in poor participation, while education devoid of infrastructure leads to dissatisfaction. This dual strategy is supported by studies indicating that the most successful waste management programs integrate user-friendly infrastructure with continuous public engagement campaigns (Miafodzyeva and Brandt, 2013). For example, some private waste management operators have combined digital platforms with recycling initiatives, allowing users to locate drop-off points via mobile apps while also providing educational resources in promoting household e-waste recycling participation.

This merged findings substantiate the symbiotic relationship between convenient recycling facilities and household knowledge and experience in performing the act of waste recycling. While accessible infrastructure encourages participation by reducing logistical barriers, household awareness and familiarity with recycling practices are essential for sustained engagement. The data reveal that knowledge and experience shape recycling behaviours, while convenient facilities provide an avenue for experiential learning, reinforcing long-term habits. These findings highlight the necessity for holistic approaches that integrate infrastructure improvements with educational initiatives, ensuring that e-waste recycling becomes an accessible, routine, and sustainable practice for all communities.

4. Engagement and Attitude: ($\beta = 0.014$, $z = 4.365$)

The findings in Phase 1 indicate a strong symbiotic relationship between engagement and household attitudes toward e-waste recycling ($\beta = 0.014$, $z = 4.365$). Stakeholders' engagement in providing recycling campaigns and initiatives has been consistently shown to significantly enhance individuals' attitudes toward recycling, reinforcing the critical role of active participation in fostering pro-environmental behaviours. Research indicates that when stakeholders are actively engaged in providing and creating creative recycling programs, households are more likely to develop positive attitudes toward recycling, as these initiatives serve as a mechanism for both raising awareness and building environmental responsibility (Cialdini and Jacobson, 2021; Tanner and Feltz, 2022). This reciprocal dynamic highlights the importance of collaborative efforts in creating a shared commitment to sustainable waste management practices and advancing the broader goals of environmental stewardship. Active participation in recycling efforts leads to a more profound understanding of the environmental consequences of improper waste management, which further strengthens individuals' commitment to pro-environmental actions (Thukral et al., 2023).

Moreover, engagement in recycling programs can serve as a catalyst for the internalization of environmental values, which in turn drive long-term behavioural change. A representative from an NGO working in environmental advocacy noted:

I13: "Our community engagement efforts, such as door-to-door awareness programs, recycling incentives, have significantly improved people's perceptions of recycling. Attitudes changed because they saw tangible benefits, such as reduced waste collection fees, vouchers for sustainable products..."

The NGO representative highlights a shift from indifference to proactive participation among community members, attributing this change to initiatives like door-to-door awareness programs and recycling incentives. This underscores the effectiveness of direct engagement strategies in altering public attitudes toward environmental practices. Such findings align with research emphasizing the importance of participatory approaches in fostering environmental stewardship (Miafodzyeva, 2012). The discussion on providing tangible benefits, such as reduced waste collection fees and vouchers for sustainable products, illustrates how incentives can motivate households to engage in e-waste recycling. This approach is supported by studies indicating that economic incentives can significantly influence pro-environmental behaviour (Abila and Kantola, 2019; Rajapaksa et al., 2019; Shevchenko et al., 2019).

This research underscores the significance of a collaborative, multi-stakeholder strategy in promoting sustainable waste management methods. The interdependent relationship between stakeholder engagement and household attitude highlights the need for a collective commitment to sustainable environment. Engagement in recycling initiatives enhances households' comprehension of the environmental consequences of inadequate waste management, hence reinforcing their dedication to environmentally responsible behaviours.

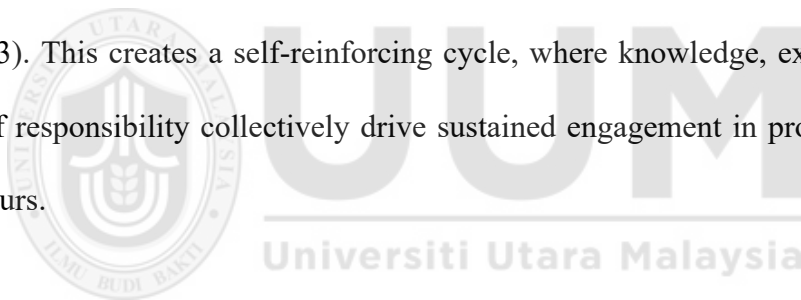
5. Engagement and Knowledge and Experience: ($\beta = 0.014$, $z = -5.920$)

The quantitative results of this study indicate a significant symbiotic relationship between stakeholders' engagement in recycling initiatives and household prior knowledge and experience in e-waste recycling. Specifically, the data suggest that households with previous experience in recycling, particularly those who have participated in e-waste recycling programs in the past, are more likely to engage again in similar practices. This suggests that prior knowledge and experience create a feedback loop, where households with more experience are more likely to recycle in the future. Stakeholder engagement serves as a critical reinforcing mechanism for households with prior recycling experience. By offering continuous support, such as providing information on how to properly sort e-waste or introducing new incentives for recycling, stakeholders can ensure that households maintain their commitment to recycling. A waste management operator representative shared:

I04: "When we see a household that has previously participated in an e-waste recycling program, we try to provide them with new incentives and make sure they know about upcoming collection events. It's important to recognize that recycling isn't a one-time effort, it's about building long-term habits and providing ongoing opportunities for participation."

This statement reflects the idea that stakeholder engagement should not be episodic but continuous, ensuring that households are consistently supported and incentivized to recycle. Research has shown that continued engagement and reinforcement are essential for maintaining long-term pro-environmental behaviours (Abila and Kantola, 2019). Stakeholders play a vital role in maintaining this engagement, providing households

with the tools, knowledge, and motivation to keep recycling. One household interviewed shared that recycling had become an integral part of her monthly routine. This testimony highlights the transformative impact that knowledge and hands-on experience can have in shaping household behaviours. Once a household becomes familiar with the recycling process and begins to realize the benefits, such as its positive environmental impact, convenience, and potential incentives, they are more likely to adopt recycling as a regular habit. Research substantiates this, demonstrating that previous experience with recycling is a primary predictor of future recycling practices (Tanner and Feltz, 2022). Moreover, households that undergo this experience frequently cultivate an increased sense of responsibility and environmental stewardship, thereby reinforcing their sustained commitment to recycling (Thukral et al., 2023). This creates a self-reinforcing cycle, where knowledge, experience, and a sense of responsibility collectively drive sustained engagement in pro-environmental behaviours.



In summary, the merged results of the study highlight the interdependence of stakeholder engagement and the prior knowledge and experience of households in the context of e-waste recycling. Households that have prior experience with recycling demonstrate a higher likelihood of re-engagement, and their involvement in recycling initiatives enhances their environmental awareness and commitment. This establishes a positive feedback loop, wherein stakeholders significantly contribute to the reinforcement of household behaviours through the provision of continuous support, incentives, and information. The dialogue observed between stakeholders and households illustrates that ongoing engagement and the dissemination of knowledge are critical components for promoting long-term sustainability in the realm of e-waste

recycling. This research enhances the overall comprehension of the interplay between stakeholder engagement strategies and existing household knowledge, demonstrating how these elements can foster a recycling culture that is both self-sustaining and widely embraced.

6. Engagement and Awareness: ($\beta = 0.021$, $z = 7.972$)

The quantitative results from this study reveal a significant and symbiotic relationship between stakeholders' engagement in e-waste recycling programs and the increase in household awareness about recycling practices. Specifically, as stakeholders—such as local authorities, environmental NGOs, and waste management operators—actively engage with households through campaigns, education, and incentives, household awareness of the importance of recycling and the processes involved in e-waste disposal significantly increases. Stakeholder engagement not only raises awareness but also aligns individual behaviours with the broader goals of sustainable waste management. Research has shown that such engagement creates a ripple effect, whereby increased awareness enhances participation in recycling activities, ultimately leading to significant environmental and societal benefits (Bortoleto et al., 2012; Cecere et al., 2014).

Stakeholder engagement through various initiatives, such as community education programs, door-to-door campaigns, and providing recycling incentives, directly influences household awareness. These interactions serve as the primary mechanism for disseminating critical information regarding the environmental risks of improper e-waste disposal, as well as the benefits of recycling. NGO representative mentioned:

I13: "... we introduced door-to-door awareness campaigns and hosted community events where we explained the impact of e-waste on the environment. Over time, we saw people becoming more informed, and many started recycling regularly after that."

This testimony from the NGO representative underscores the importance of direct engagement in educating households. Direct involvement in e-waste recycling programs, in particular, provides experiential learning opportunities that deepen individuals' understanding of recycling benefits and environmental consequences. Empirical studies suggest that hands-on participation significantly enhances individuals' sense of agency and responsibility, thereby fostering a range of pro-environmental behaviours, including waste reduction, resource conservation, and the proactive adoption of circular economy principles (Kirchherr et al., 2017; Ylä-Mella et al., 2015). This behavioural shift not only benefits the immediate environment but also supports long-term sustainability goals by reducing the strain on natural resources and minimizing landfill contributions.

Furthermore, the symbiotic relationship between stakeholder engagement and individual awareness has a compounding effect, as well-informed individuals often become advocates for recycling within their communities. As households gain more awareness about the environmental importance of e-waste recycling, they begin to engage more actively with recycling programs. The increased awareness results from continuous exposure to the information provided by stakeholders and from the personal experiences of households in recycling. This demonstrates a symbiotic dynamic where engagement leads to greater knowledge, and greater knowledge results in further engagement. Some householders agreed on this particular subject by stating that:

I16: "After attending a local workshop about e-waste recycling, I realized how harmful it is to the environment to just throw electronics in the trash. Now I make sure to recycle everything I can, and I encourage my friends and neighbours to do the same."

The householder's statement illustrates the shift in awareness that occurs when households are exposed to educational outreach and first-hand experiences with recycling programs. This aligns with findings from research on environmental behaviour change, which suggests that increased awareness directly leads to increased recycling participation (Tanner and Feltz, 2022). Once households are aware of the environmental impact of improper disposal, they are more motivated to participate in recycling initiatives. As this feedback loop grows, the relationship between stakeholder engagement and household awareness becomes even stronger, as households not only recycle but also become advocates for recycling within their community.

Additionally, participatory approaches have been shown to strengthen this relationship, with households that actively engage in discussions and activities becoming more informed and committed to sustainable practices (Shevchenko et al., 2019). These findings reinforce the idea that stakeholder engagement, when paired with educational outreach, creates a powerful platform for increasing household awareness and driving long-term behaviour change. The feedback loop between household awareness and engagement from their local stakeholder ensures that households are not only better informed but also more motivated to participate in environmental initiatives.

7. Engagement and Psychological Ownership: ($\beta = 0.015, z = 2.425$)

The findings from this study underscore the critical role that stakeholder engagement plays in fostering psychological ownership, which, in turn, drives sustained household participation in e-waste recycling initiatives. Quantitative results revealed a significant relationship between stakeholder engagement and household psychological ownership, reflected in the increased commitment to recycling. This finding highlights the symbiotic effect between engagement efforts and psychological ownership. Psychological ownership is a concept rooted in behavioural psychology that refers to the feeling of possession and responsibility toward a target or activity, even in the absence of legal ownership (Pierce et al., 2001). This sense of ownership is critical for driving sustained behavioural change and ensuring long-term commitment to pro-environmental practices. Stakeholder engagement amplifies this effect by fostering a shared sense of purpose, aligning individual actions with broader environmental objectives.

In the context of e-waste, psychological ownership influences recycling behaviour, as households with a strong emotional connection to their electronic devices are more likely to either recycle the items to benefit others or the environment, or choose to retain and accumulate obsolete items. This dual behaviour demonstrates the complex nature of psychological ownership in recycling practices. Therefore, through engagement efforts from local stakeholders such as awareness campaigns, workshops, and providing accessible recycling services, stakeholders facilitate households' connection to their e-waste. This process allows households to understand the broader environmental and societal benefits of proper disposal. Moreover, stakeholders help households overcome

emotional barriers, particularly sentimental attachments, that may prevent them from recycling their old devices. Waste management authority representative shared insight regarding this issue:

I06: "...we created an e-waste disposal campaign that focuses on the environmental benefits, but also on the idea that by recycling, they can help make a positive impact for future generations. It's about shifting that attachment from the object itself to the greater good."

The waste management representative's statement highlights the challenge that emotional attachments, particularly to sentimental items, pose to effective e-waste recycling. According to research by Ofori (2020), emotional ties to e-waste can be one of the key factors hindering recycling behaviours, as individuals may prefer to keep obsolete items that have perceived personal value. However, through targeted stakeholder engagement, households are encouraged to shift their emotional attachment towards the collective environmental benefits of recycling, fostering a sense of responsibility and ownership over their actions.

The qualitative findings from the households interviewed revealed two distinct behaviours among those with a high sense of psychological ownership toward their e-waste. On one hand, some households choose to recycle their electronic items as a means of benefiting others or the environment. They view their old devices not just as obsolete objects, but as items that can be repurposed, recycled, or reused, contributing to sustainability and circular economy practices.

I15: I've had this old phone for years, and it's full of memories. I recycled it because I wanted to contribute to a cleaner environment, and I know the materials can be used again for something else."

This householder's decision to recycle, despite the sentimental value attached to the phone, reflects the shift from individual emotional attachment to a broader environmental responsibility. On the other hand, some households choose to keep obsolete items, even when they no longer serve a functional purpose, due to their sentimental value. These individuals may feel that holding onto their old electronics maintains a connection to their past, and recycling may feel like an irreversible loss.

I17: "I know my old television doesn't work anymore, and I'm not even sure how to dispose of it. But I can't bring myself to recycle it. It feels like letting go of those memories. I'm holding onto it for now, even though it's just taking up space."

This testimony illustrates the other side of psychological ownership, where the emotional connection to the device prevents the household from engaging in recycling. The individual's attachment is so strong that it overrides the understanding of environmental impacts, leading to the accumulation of obsolete e-waste. In summary, the findings from this study highlight the complex role of psychological ownership in household e-waste recycling behaviours. Stakeholder engagement plays a critical role in shaping this ownership, helping households navigate their emotional attachments to obsolete electronic devices. By fostering a sense of responsibility and connecting individuals to the broader societal and environmental benefits of recycling, stakeholders can help mitigate the emotional barriers that prevent e-waste recycling.

8. Advertising and Awareness: ($\beta = 0.022$, $z = 5.580$)

The results from Phase 1 of this study validate the existence of a symbiotic relationship between advertising and awareness, highlighting their critical role in enhancing household participation in e-waste recycling practices. Advertising is a crucial mechanism for enhancing public awareness, operating simultaneously as both an informational and motivational instrument. Strategically designed advertising campaigns, utilising mass media, social media platforms, or localised outreach initiatives, successfully convey the importance and advantages of recycling. This approach translates vague environmental issues into specific, actionable behaviours for a diverse range of audiences.

As local stakeholders and waste management representatives have shared, the role of advertising goes beyond merely disseminating information; it is an essential tool for instigating behavioural change by fostering a deeper understanding of recycling's importance.

I04: "We've found that advertising is crucial in getting the word out. A well-crafted ad campaign helps break down the barriers, whether it's about convenience, environmental impact, or the benefits household will receive in exchange. It's the first step in making the issue real for them."

The representative's comment underscores that advertising is not just about providing information; it also helps to demystify the recycling process and demonstrates the tangible benefits of participation. This aligns with Menikpura and Hotta (2014), who argued that media campaigns do more than increase awareness; they are instrumental

in shifting social norms and influencing attitudes toward pro-environmental behaviours. In this study, media and communication efforts were recognized as integral in bridging the awareness gap between policymakers, waste management authorities, and the general public. Stakeholder-driven advertising campaigns, when strategically designed, can influence public perception by presenting recycling as a straightforward and beneficial action, aligned with broader environmental goals. As emphasized by Menikpura et al. (2016), advertising initiatives with clear calls to action, such as directing individuals to local recycling centres or e-waste collection events, significantly reduce the perceived barriers to recycling. The exchange received from the NGO representative highlights the effectiveness of practical, action-oriented advertising campaigns in improving participation rates. By simplifying the process and reducing any barriers to entry, advertising becomes a vital tool in bridging the knowledge-action gap (Menikpura et al., 2016). The targeted approach to advertising allows households to see the benefits of recycling in concrete terms, reinforcing the idea that small individual actions can contribute to larger environmental goals.

The relationship between advertising and awareness in enhancing e-waste recycling participation is undeniably symbiotic. On one hand, advertising campaigns raise awareness by informing households about the environmental impacts of e-waste and the practicalities of recycling. On the other hand, heightened awareness generated by these campaigns strengthens the effectiveness of advertising, creating a feedback loop in which increased understanding leads to greater participation, which in turn provides more opportunities for awareness-building. One householder highlighted:

I16: "I saw an ad on TV about the importance of e-waste recycling, and it made me think twice about just throwing things away. It wasn't just about what I could do; it was about what we could do as a community. I started looking for local recycling options and even started talking to my neighbours about it."

This statement highlights the deeper effect that advertising has on individuals when it goes beyond the individual level and taps into the collective mindset. The feedback from householders also illustrates that when advertising efforts are integrated into local contexts and combined with clear, actionable steps, they not only raise awareness but also create a lasting, positive shift in behaviour. In summary, the symbiotic relationship between advertising and awareness drives sustained household participation in e-waste management by offering clear, actionable steps and fostering a sense of recycling responsibility.



9. Education and Attitude: ($\beta = 0.012$, $z = 2.090$)

The results from this study validate the existence of a symbiotic relationship between education provided by local stakeholders through e-waste recycling systems and household attitudes, significantly promoting household participation in e-waste recycling. The effectiveness of education in this context is amplified when it is delivered through participatory and community-driven approaches. Interactive workshops, school-based recycling curricula, and digital learning platforms that incorporate gamification and experiential activities are particularly impactful in cultivating environmental literacy (Hartley et al., 2022; Zhao and Chen, 2021). The findings highlight the role of educational strategies that draw upon principles of

behavioural science, such as framing recycling as a social norm and emphasizing collective benefits. These approaches help shift individual attitudes and behaviours by highlighting the broader impact of recycling on the community and environment. Research by Cialdini and Jacobson (2021) and Schultz (2014) indicates that framing recycling as a norm, emphasizing that "everyone is doing it", increases individual motivation to participate, particularly when there is a clear understanding of the recycling benefits. For instance, campaigns that emphasize how local recycling efforts contribute to reducing the environmental footprint or conserving valuable resources may make individuals feel like they are part of a larger, impactful movement, enhancing their motivation. One householder stated that:

I15: "At first, I didn't think recycling was that important, but after attending e-waste recycling program at my university, I realized how much it can help the environment and even save money in the long run. It feels good to know I am now part of this change."

This testimony reflects the shift in attitude observed after participating in educational initiatives, supporting the notion that when individuals understand the collective benefits of recycling, they are more likely to engage. By framing recycling not only as an individual responsibility but as a collective action that benefits the whole community, educational programs can instill a sense of shared purpose and belonging. This sense of social belonging and collective responsibility, in turn, enhances the likelihood of sustained participation in recycling programs. This reciprocal relationship creates a positive feedback loop: as households become more informed and motivated to recycle, local stakeholders can refine their educational efforts based on community

engagement levels, further enhancing recycling participation. As local NGOs mentioned:

III: "We've observed that once people understand the environmental and economic benefits of recycling through our campaigns, they take the next step to make it a part of their lives. More people volunteering to help us organize events, which reinforces the community's investment in the program."

The NGO representative highlights a key feature of the symbiotic relationship between education and household attitudes: as individuals gain knowledge and adopt pro-environmental behaviours, they not only participate in recycling but also become advocates within their community. These findings support the argument that effective education not only informs but also transforms household attitudes, making recycling a meaningful and lasting behaviour. When households feel personally connected to the environmental benefits of recycling and recognize the collective impact of their actions, they are more likely to adopt and maintain sustainable recycling practices, contributing to the broader goals of environmental sustainability.

10. Education and Knowledge and Experience: ($\beta = 0.016$, $z = 6.530$)

This interdependence suggests that as households acquire knowledge and gain experience through educational programs, their engagement in recycling behaviours deepens, creating a positive feedback loop. Educational initiatives, particularly those that target the specific challenges and opportunities associated with e-waste recycling, play a pivotal role in bridging the knowledge gap and driving participation in recycling programs. Local stakeholders unfolded the insights for this dynamic:

III: "We've focused on educational initiatives that target specific e-waste challenges, like the dangers of toxic materials in improperly disposed electronics. This knowledge might empower residents to understand the consequences and the importance of recycling."

This statement highlights how local stakeholders recognize the value of education in linking the broader environmental consequences of e-waste disposal to everyday household behaviours. By framing improper disposal as an immediate concern—linked to environmental damage like soil contamination and water pollution—these initiatives help individuals feel the urgency of recycling. As Zhao and Chen (2021) assert, educating the public on the environmental hazards of e-waste significantly increases engagement in recycling behaviours, as it provides the knowledge needed to act responsibly.

Educational interventions not only enhance individuals' understanding of recycling processes but also increase their familiarity and experience with practical recycling behaviours. For instance, hands-on training programs, community workshops, and digital platforms have been shown to improve individuals' ability to manage e-waste effectively and confidently (Hartley et al., 2022; Kahrman Öztürk and Olgan, 2016). These initiatives provide opportunities for individuals to directly engage with the materials, thereby reinforcing the connection between knowledge and experience. Local stakeholders shared activities they conducted to educate students in waste recycling:

I04: "We've added hands-on activities in our workshops, like actually sorting the e-waste into recyclable categories. People get to touch and feel the materials they're dealing with. This type of learning, where they're physically involved, seems to stick better."

As highlighted in this statement, local stakeholders recognize that experiential learning, where participants physically interact with e-waste materials, reinforces the educational process and makes recycling feel more practical and achievable. Such interventions not only inform recyclers but also give them the tools and confidence to engage in sustainable e-waste recycling participation. Moreover, experiential learning fosters a deeper sense of ownership and responsibility towards recycling practices, as individuals become more involved in the logistics of e-waste disposal (Schultz, 2014). In conclusion, the symbiotic relationship between education, knowledge, and experience plays a crucial role in enhancing household participation in e-waste recycling. Educational programs that improve knowledge not only foster increased awareness but also build the practical experience necessary for households to engage confidently in sustainable recycling practices.

11. Education and Awareness: ($\beta = 0.014$, $z = 6.313$)

The intricate relationship between education and public awareness in e-waste recycling is fundamentally symbiotic, with each element reinforcing and amplifying the other. This dynamic interplay is crucial for fostering effective e-waste management practices within communities. When local authorities, NGOs, and waste recycling centres invest in educational programs, households become more informed and engaged in

responsible e-waste disposal. Conversely, as households become more aware of proper recycling practices, they demand better infrastructure and policies, which further encourages local stakeholders to enhance their educational and recycling initiatives thus promote household e-waste recycling participation. Governments benefit from a more environmentally conscious and active public engagement in e-waste recycling initiatives, which ultimately leads to greater compliance with recycling regulations and an increase in the volume of e-waste being properly recycled.

In this merged triangulation analysis, researcher delve into the perspectives of various stakeholders, including federal government representatives, NGOs, private waste operators and householders, to elucidate this symbiosis. The insights gathered provides a comprehensive understanding of the mutual reinforcement between education and public awareness in promoting e-waste recycling. Representatives from municipal offices offered their perspectives on the influence of education on household participation in e-waste recycling initiatives:

I04: "We have observed that when we conduct awareness campaigns, there is a noticeable increase in proper e-waste disposal by households. People start bringing their old electronics to designated collection points instead of throwing them with their daily trash."

The municipal officer's observation that community workshops lead to increased proper e-waste disposal aligns with findings that educational initiatives significantly influence recycling participation. A study on factors influencing household e-waste recycling participation found that socioeconomic factors, including education, are strong predictors of recycling behaviour (Haron et al., 2018). This suggests that targeted

educational programs can effectively enhance household engagement in e-waste recycling. The symbiotic relationship between education and household awareness plays a pivotal role in enhancing participation in e-waste recycling because educational initiatives not only inform households about the environmental and health implications of improper e-waste disposal but also empower them to engage actively in recycling programs. Conversely, as households become more aware and participate in recycling, they provide feedback and demand better services, prompting stakeholders to improve and expand educational efforts. A senior official from the federal DOE emphasized the government's role in initiating educational campaigns to raise public awareness about e-waste recycling. The official stated:

I01: "Our nationwide programs aim to inform citizens about the environmental and health hazards of improper e-waste disposal. We've observed that informed citizens are more likely to participate in recycling initiatives."

One NGO program coordinator highlighted the organization's efforts in community-based education, noting:

I09: "We conduct workshops that not only educate but also empower communities to take charge of their e-waste. When people understand the value and impact of proper e-waste management, their participation increases markedly."

Householders also provided valuable insights into the impact of education on their recycling practices. One resident shared:

I16: "After attending a local seminar on e-waste, I became more conscious of how I dispose of old electronics. Now, I make it a point to recycle them properly."

The dialogues above illustrate a clear symbiotic relationship between education and public awareness in e-waste recycling. Government-led educational campaigns raise awareness, leading to increased public participation in recycling programs. NGOs complement these efforts by providing localized, community-focused education, further reinforcing the message and encouraging grassroots involvement. Householders, when equipped with knowledge, become active participants in recycling initiatives, thereby closing the loop. This symbiosis is supported by academic literature. For instance, a study by Aksan and Çelikler (2019) demonstrated that recycling awareness education positively impacts individuals' knowledge levels, leading to increased recycling participation.

Additionally, research has shown that public attitudes towards recycling are significantly influenced by educational interventions, which in turn affect participation rates (Speake and Yangke, 2015). In summary, the mutual reinforcement between education and public awareness creates a virtuous cycle that enhances e-waste recycling efforts. Educational initiatives inform and empower individuals, leading to increased awareness and participation, which further justifies and encourages the continuation and expansion of educational programs. This symbiotic relationship is essential for the development of sustainable e-waste management practices.

12. Education and Psychological Ownership: ($\beta = 0.013, z = 2.187$)

Education and psychological ownership exhibit a robust symbiotic relationship in influencing household participation in e-waste recycling, where education serves as a key situational factor, and psychological ownership is a vital personal driver. Psychological ownership refers to the sense of possession individuals feel towards items, often leading to strong emotional attachments, especially with personal electronics. These attachments can result in individuals either retaining outdated devices due to sentimental value or choosing to recycle them, recognizing the broader environmental benefits. The interaction between these elements underscores the significance of both cognitive and emotional engagement in promoting long-term, sustainable recycling behaviours. Within the realm of e-waste recycling, education plays an instrumental role in fostering psychological ownership by raising awareness about the environmental consequences of improper disposal and equipping individuals with the necessary knowledge and tools to engage in responsible recycling practices (Baldé et al., 2024; Oke et al., 2021).

Through both formal and informal educational initiatives, individuals are not only made aware of the environmental dangers linked to e-waste but are also empowered to adopt proactive recycling behaviours. A representative from the E-Idaman Group, a company involved in solid waste management and recycling, emphasized the role of education in influencing recycling behaviours:

I02: "We've observed that when households are educated about the environmental impact of e-waste, they are more inclined to recycle their old devices rather than store them."

This observation aligns with research indicating that educational initiatives can reshape individuals' perceptions of their possessions, encouraging responsible disposal practices (Xiang and Mangmeechai, 2023). One resident shared their experience regarding the same context:

I17: "I used to keep my old phones because they held sentimental value. After learning about the environmental harm caused by e-waste, I decided to recycle them, knowing it contributes to a healthier planet."

This personal account reflects findings that education can alter the emotional attachment individuals have to their electronic devices, promoting recycling behaviours. The dialogues illustrate that education enhances psychological ownership by informing individuals about the environmental consequences of e-waste, thereby transforming sentimental attachments into motivations for responsible recycling. This transformation is crucial for promoting sustainable recycling behaviours. In conclusion, integrating educational initiatives that address psychological ownership can effectively increase household participation in e-waste recycling. By acknowledging and reshaping the emotional connections individuals have with their electronic devices, stakeholders can foster a more environmentally conscious community.

13. Policy and Regulations and Attitude: ($\beta = 0.019$, $z = 6.228$)

Policies and regulations are integral to shaping pro-environmental behaviour, fostering a symbiotic relationship with householders' attitudes by establishing behavioural norms and providing external incentives for compliance. Policies and regulations establish behavioural norms and provide external incentives, which, in turn, shape public

attitudes toward recycling practices. Conversely, positive household attitudes can bolster the effectiveness of these policies, creating a mutually reinforcing cycle. In the context of e-waste recycling, the enactment and enforcement of well-defined policies can substantially influence public attitudes, promoting more favourable views toward recycling practices (Askari et al., 2014; Pariatamby and Victor, 2013). A representative from the local waste management authority emphasized the importance of clear policies in influencing household behaviours:

I14: "When we implement well-defined recycling guidelines and provide convenient facilities, residents are more likely to participate actively in e-waste recycling."

This perspective aligns with findings that effective policy measures, coupled with accessible recycling infrastructure, significantly enhance public engagement in recycling programs. However, the representative also acknowledged the need for public awareness:

I14: "It's not just about having policies in place; we must ensure that residents are fully informed about these regulations and understand the benefits of compliance."

This insight is supported by research indicating that awareness and understanding of environmental policies are crucial for public participation in recycling initiatives (Halvorsen, 2010). Moreover, the effectiveness of these regulations is often augmented by external incentives, such as financial rewards or penalties, which further reinforce individuals' commitment to compliance. For instance, deposit-refund systems or subsidies for recycling services have demonstrated effectiveness in motivating responsible recycling behaviours by reshaping individuals' cost-benefit assessments (Abila and Kantola, 2019; Dixit and Vaish, 2015; Rajapaksa et al., 2019). These

external incentives not only encourage initial compliance but also foster long-term habitual engagement with recycling by integrating it into individuals' everyday routines. Some residents express concerns about the enforcement of penalties for non-compliance without adequate support and information. One householder remarked:

I17: "Before imposing fines on those who don't recycle properly, it's essential to ensure that recycling facilities are efficient and that everyone is fully aware of the policies. Enforcing penalties without providing adequate knowledge and resources seems unfair."

This sentiment reflects findings that punitive measures may be less effective if not accompanied by sufficient public education and accessible recycling options (Halvorsen, 2010). The dialogues highlight a symbiotic relationship between policy regulations and household attitudes in promoting e-waste recycling. Well-crafted policies and regulations can positively influence household attitudes by establishing clear behavioural expectations and providing incentives for compliance. In turn, when households hold favorable attitudes toward recycling, they are more likely to adhere to these policies, enhancing their effectiveness. However, the effectiveness of policies is contingent upon public awareness and the availability of efficient recycling facilities. Without adequate education and infrastructure, even well-intentioned policies may fail to achieve desired outcomes. Therefore, a comprehensive approach that combines clear regulations, public education, and accessible recycling services is essential for fostering sustainable e-waste recycling behaviours. This merged analysis underscores the importance of a holistic strategy in e-waste management, where policy frameworks and household attitudes mutually reinforce each other to promote environmental sustainability.

14. Policy and Regulations and Awareness: ($\beta = 0.011$, $z = -3.533$)

In the initial phase of this research, the symbiotic relationship between policy regulations enacted by stakeholders and household attitudes toward e-waste recycling was validated. The statistical analysis revealed a significant interaction between these variables, with a coefficient (β) of 0.011 and a z-value of -3.533, indicating that well-structured policies can positively influence household attitudes, thereby enhancing participation in e-waste recycling. Well-designed policy frameworks, including regulations that mandate recycling practices and impose penalties for non-compliance, serve not only to raise awareness about the importance of recycling but also to underscore the environmental consequences of improper e-waste disposal (Chen and Lee, 2020; Forti et al., 2020; Yusop and Othman, 2019). Such integrated efforts ensure that the benefits of recycling are felt both by local authorities and residents within their jurisdiction, creating a mutually beneficial dynamic that enhances the overall effectiveness of e-waste management.

Divergent views among householders regarding the implementation of penalties for improper recycling practices were evident. One resident expressed concerns about enforcing penalties without ensuring adequate infrastructure and awareness:

I16: "Before fining improper recyclers, recycling facilities must be efficient and rules must be clear. Imposing punishments without sufficient information and resources seems unreasonable."

This perspective aligns with findings that the effectiveness of recycling policies is contingent upon public awareness and the availability of efficient recycling facilities (Biswas, 2018). Without adequate education and infrastructure, even well-intentioned policies may fail to achieve desired outcomes. Conversely, another householder supported the idea of penalties as a means to encourage compliance:

I15: "I believe that implementing fines for not recycling can be effective. It holds people accountable and emphasizes the importance of proper e-waste disposal."

This viewpoint is supported by research indicating that external incentives, such as financial rewards or penalties, can effectively motivate responsible recycling behaviours by reshaping individuals' cost-benefit assessments (F. Xu et al., 2014).

In conclusion, the symbiotic relationship between policy regulations and household awareness is pivotal in enhancing e-waste recycling participation. Policies can change individuals' attitudes, making them feel more responsible for recycling their e-waste because they see the process as supported by the government, possibly incentivized, and beneficial to the environment. On the other hand, positive attitudes can enhance the effectiveness of policies. If individuals already value recycling, they are more likely to comply with regulations and engage in e-waste recycling, thus making the policies more successful.

15. Policy and Regulations and Psychological Ownership: ($\beta = 0.015$, $z = 2.719$)

In phase 1 of the research, the results provided strong evidence for the existence of a symbiotic effect between policy and regulations imposed by stakeholders and household psychological ownership in e-waste recycling. The interaction between policy-driven mandates and household psychological ownership is crucial in shaping individuals' e-waste disposal behaviours. Psychological ownership refers to the emotional attachment that individuals form towards their obsolete EEE. This phenomenon can elicit two contrasting responses: individuals may choose to retain these items because of their sentimental value, or they may opt to recycle them responsibly when influenced by external factors, such as the implementation of effective policies (Ofori, 2020).

The coexistence of these behaviours highlights the necessity of implementing policies that promote a sense of accountability, while also acknowledging the emotional connections individuals have with electronic products. A municipal waste management officer explained the relationship between policies and household engagement with e-waste recycling:

I14: "The more people feel that they are responsible for the items they own, the more likely they are to engage in proper disposal. Policies that enforce responsible recycling work best when individuals feel connected to the process, seeing it as an extension of their role as environmental stewards."

This statement reflects the idea that individuals' perceived psychological ownership of their electronic items increases their willingness to adhere to policy guidelines. (Bennett et al., 2020; Puluhalawa and Puluhalawa, 2021) assert that individuals are more likely to participate in recycling programs when they perceive a personal stake in the process, suggesting that policies should not only enforce rules but also aim to strengthen personal attachment and responsibility toward the environmental impact of e-waste. (Puluhalawa and Puluhalawa, 2021) further emphasize that policies that link personal ownership to broader environmental goals cultivate civic duty and community engagement. When engaging with local householders, several expressed their attitudes towards policy and psychological ownership. One householder stated:

I17: "I know I should recycle my old phones, but sometimes I can't bring myself to get rid of them because they hold personal memories. However, knowing that there are laws to help ensure that electronics don't harm the environment makes me feel more responsible to dispose of them properly."

This dialogue illustrates how psychological ownership can conflict with e-waste recycling behaviour, with attachment to objects often preventing responsible disposal. However, the householder also acknowledged that awareness of policies encouraging responsible recycling can shift attitudes toward more sustainable practices. According to Ofori (2020), emotional attachment often drives resistance to e-waste recycling, but well-designed policies can mitigate these effects by aligning personal ownership with environmental responsibility. Another householder shared:

I15: "I feel like it's my duty to recycle my electronics properly, especially after learning about the environmental dangers of e-waste. The government's efforts to enforce recycling laws make me feel more connected to the issue. It's a shared responsibility."

This statement suggests that the policy interventions have successfully cultivated a sense of psychological ownership and responsibility among householders. Policies, particularly when well-communicated, can play a crucial role in reframing individuals' perspectives on their role in environmental conservation, transforming personal attachment to e-waste into a greater sense of duty and accountability. As Bennett et al. (2020) highlight, policies that trigger an emotional connection to the recycling process enable individuals to see themselves as part of a collective effort to manage e-waste sustainably. The dialogues from both stakeholders and householders demonstrate the interconnection between effective policy regulations and psychological ownership in enhancing e-waste recycling participation. As both Bennett et al. (2020) and Puluhalawa and Puluhalawa (2021) argue, policies that emphasize responsible recycling can tap into individuals' sense of personal attachment to their items, thereby encouraging greater participation. Furthermore, these findings indicate that the emotional connection to electronic goods, often a barrier to recycling, can be transformed into a motivation for responsible behaviour when policies align personal values with collective environmental goals.

In conclusion, the interaction between policy regulations and household psychological ownership is critical in determining the success of e-waste recycling initiatives. As individuals feel a deeper connection to their e-waste and perceive their recycling actions as both a personal and collective responsibility, they are more likely to comply with

government-enforced recycling policies. This symbiotic relationship not only benefits local authorities by improving waste management practices but also cultivates a more environmentally conscious public that recognizes the importance of responsible disposal in safeguarding the environment (Bennett et al., 2020; Puluhalawa and Puluhalawa, 2021).

5.5.2 Validation on the Existence of Symbiosis Effect between HERS and HERB

The findings from both the quantitative and qualitative phases of this study validate the existence of a symbiotic relationship between HERS and HERB. Through a comprehensive analysis, 15 distinct pathways were identified that illustrate the mutually interdependent connection between situational and personal factors influencing recycling behaviours. The mutual benefit that exists between local stakeholders and householders, when they symbiotically engage with each other, plays a crucial role in enhancing household e-waste recycling participation. This mutually reinforcing relationship fosters a dynamic and sustainable model where both parties contribute to, and benefit from, improved e-waste management practices.

From the stakeholders' perspective, the effective implementation and enforcement of policies, ranging from regulations to incentives, create an environment that promotes responsible e-waste recycling behaviours. Stakeholders such as municipalities, waste management companies, and government agencies benefit from increased recycling rates, improved waste management, and the achievement of environmental sustainability goals. For example, when stakeholders design policies that consider householders' psychological ownership and emotional attachment to their e-waste, they

can significantly increase compliance with recycling mandates. In turn, this leads to more efficient waste processing, reducing the environmental impact of improperly disposed e-waste and fostering a sense of collective environmental responsibility within the community.

For householders, this symbiotic relationship also brings considerable benefits. When local authorities establish accessible recycling infrastructure, provide adequate information, and create policies that encourage responsible recycling through incentives, households are empowered to make informed decisions about e-waste disposal. Policies that incentivize recycling, such as deposit-refund systems, align with householders' values and can effectively transform their psychological ownership of old electronic devices into actions that benefit both the environment and the community. Furthermore, increased awareness and knowledge about the environmental hazards of improper e-waste disposal, often facilitated by education campaigns, motivate households to engage in responsible recycling practices. As households adopt more sustainable behaviours, they also contribute to the broader community's efforts, enhancing the effectiveness of local waste management strategies and reinforcing a shared commitment to environmental protection.

The symbiotic interaction between situational factors such as policies, infrastructure, and public engagement and personal factors like attitude, knowledge, and psychological ownership creates a feedback loop that benefits both local stakeholders and households. As households participate more actively in e-waste recycling, they generate more recyclable material, which helps stakeholders meet their recycling targets and improve waste management systems. In return, stakeholders provide the necessary tools,

policies, and infrastructure that encourage and facilitate continued household participation. This continuous cycle not only strengthens household recycling behaviours but also contributes to the sustainability goals of local authorities. In essence, the mutual benefits of this symbiotic relationship, where stakeholders and households work together towards common goals, result in enhanced e-waste recycling participation. By aligning policy frameworks with householders' needs and values, stakeholders can foster long-term, sustainable recycling behaviours that benefit both the environment and the community. This collaborative approach ensures the success of e-waste recycling initiatives and underscores the critical importance of integrating both situational and personal factors in the design of effective environmental policies and programs.

The analysis confirms that there is a confirmed symbiosis effect between situational and personal factors, which collectively enhance household e-waste recycling participation. This validation fully answers and substantiates RQ3, providing strong empirical evidence for the intertwined roles of both situational and personal factors in shaping pro-environmental behaviours related to e-waste recycling. The results on the existence of symbiotic relation between HERS and HERB offer practical insights for policymakers and stakeholders, demonstrating that sustainable and effective e-waste recycling programs must address both external incentives such as policies and infrastructure and internal motivators such as awareness and psychological ownership to create a holistic approach that fosters long-term participation in recycling behaviours.

5.6 Verification in addressing RQ 4 *Does the interactions between both factors (situational and personal) and household e-waste recycling participation vary depending on demographic profiles?*

5.6.1 Merge Discussion for Quantitative and Qualitative Phase

Merged findings

- Demographic profiles among households which includes residential areas, age and gender have a significant influence in altering the relationship between situational and personal factors to enhance household e-waste recycling factors.

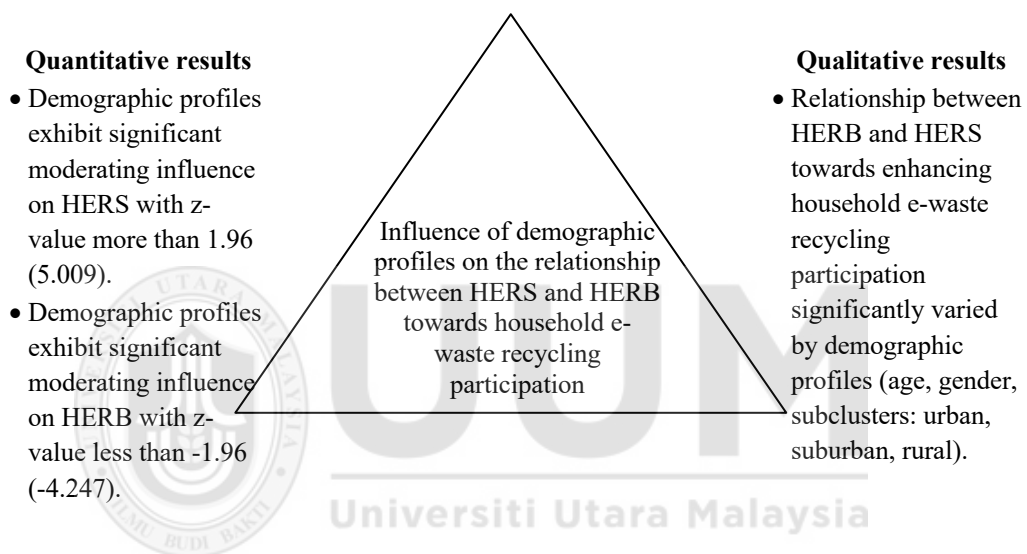


Figure 5.5

Triangulation analysis on the influence of demographic profiles on HERS and HERB relationship in enhancing household e-waste recycling participation

Triangulation in qualitative research strengthens the credibility and validity of findings by integrating multiple sources of data, perspectives, and theoretical frameworks (Denzin, 2017). This study employs methodological triangulation by analysing dialogues from key stakeholders and householders while also incorporating demographic profiles as a moderating variable affecting situational factors that enhance household e-waste recycling participation. This section further expands on the integrated findings regarding the moderating role of demographic profiles in shaping

the relationship between situational and personal factors in promoting household e-waste recycling participation. Within the research framework, demographic profiles function as a moderating variable, yielding two distinct effects on situational and personal factors. As illustrate in Figure 5.5, the synthesized discussion highlights a significant moderating influence of demographic profiles on both situational and personal factors, reinforcing their role in facilitating household e-waste recycling participation.

The statistical evidence of $z = 5.009$ and -4.247 , which were extracted from Phase 1 showed a significant moderating effect of demographic profiles on both situational and personal factors, reinforcing the notion that individual and contextual differences shape recycling behaviours. Demographic characteristics such as residential location (urban, suburban, rural), age, and gender influence the effectiveness of situational factors; convenience, engagement, advertising, education, and policy, and personal factors; attitude, knowledge and experience, awareness, and psychological ownership, in promoting household e-waste recycling participation. The moderating role of demographic profiles in influencing household e-waste recycling participation is evident across various sociodemographic dimensions, including geographic location, age, and gender. Urban residents typically benefit from greater accessibility to formal e-waste disposal facilities, structured recycling programs, and public awareness campaigns, which collectively encourage higher participation rates. In contrast, individuals in suburban and rural areas often face logistical challenges due to limited infrastructure, fewer designated collection centres, and reliance on informal or periodic collection events, which may hinder consistent recycling behaviours (Mohamad et al., 2022). Beyond geographic disparities, demographic variables such as age and gender

further shape e-waste disposal practices. According to Delcea et al. (2020), younger individuals, who are generally more technologically literate and environmentally conscious, are more inclined to engage in e-waste recycling, often leveraging digital platforms and online services for proper disposal. Conversely, older generations may demonstrate lower participation rates, potentially due to limited digital literacy, a lack of awareness regarding disposal options, or ingrained habits of stockpiling outdated electronics rather than recycling them.

Gender differences also play a role, with studies suggesting that men and women exhibit distinct recycling behaviours influenced by varying environmental attitudes, risk perceptions, and household decision-making roles (Tengku Hamzah et al., 2022). Understanding these demographic influences is crucial for developing targeted policies and interventions that enhance household participation in e-waste recycling. The influence of demographic profiles that altered the household recycling behaviour were further explained through the results obtained in Phase 2, as outlined below. This section expands on the role of demographic profiles; residential subclusters, and gender as a moderator to situational and personal factors in improving household e-waste recycling participation, with detailed discussions drawn from dialogue with local waste management authorities, stakeholders, and householders from three different subclusters; urban, suburban and rural.

i. Residential Subclusters (urban, suburban, rural)

Urban Perspective

Urban respondents, often living in densely populated areas with relatively accessible infrastructure, demonstrated a keen awareness of recycling services available to them. However, despite having sufficient recycling facilities, participants emphasized a critical barrier which were lack of motivation and awareness. One urban participant highlighted this issue succinctly, stating:

I15: “Even if the facilities are there, what’s the point if people don’t care? Campaigns should make recycling feel essential.”

This sentiment was echoed in the FGD with local waste management authorities, who noted that urban areas tend to have established infrastructure but still struggle with participation rates due to insufficient public awareness. According to research by Abdullah et al. (2022), the effectiveness of recycling programs in urban areas is strongly influenced by the degree of public engagement and education. This aligns with the urban perspective in this study, where the need for comprehensive public awareness campaigns was emphasized. The stakeholders, including municipal waste managers, advocate for shifting attitudes through behaviour modification strategies, such as community workshops and media outreach programs. The interview with an urban waste management municipal reinforced this view, with one participant stated:

I05: “...public engagement is essential. People need to feel that recycling is part of their civic responsibility towards environment.”

This point underscores the role of attitudes in urban recycling behaviour. Previous studies have found that urban dwellers often demonstrate a higher awareness of environmental issues, yet this awareness does not always translate into action (Lehmann, 2011). The urban households in this study indicated that they were more likely to engage in recycling when they perceived it as a socially desirable behaviour, suggesting the influence of education, knowledge and past recycling experience, and attitudes.

Suburban Perspective

In suburban areas, participants expressed a need for both education and improved infrastructure. A typical response from suburban householders was:

I16: "Educate people, yes, but also make sure everyone has a recycling bin or knows where to go."

This statement highlights the dual challenge faced by suburban areas which are insufficient infrastructure alongside a lack of comprehensive education in ensuring awareness among householders in e-waste recycling process. The findings indicate that suburban respondents are more likely to participate in recycling when they have access to both adequate resources and targeted information. Stakeholders involved in waste management in suburban areas advocate for a hybrid approach that combines awareness-raising efforts with infrastructural improvements. One local waste authority representative emphasized the need for a two-pronged strategy, suggesting that enhancing both the physical availability of recycling bins and the communication of the recycling process would address the barriers to participation. This view is supported by studies that suggest mixed strategies, combining both education and infrastructure improvements, tend to be most effective in suburban settings (Qiao et al., 2022). For

instance, the introduction of clear, user-friendly signage in suburban neighbourhoods and easily accessible drop-off points for recyclables could bridge the gap between awareness and action.

Suburban areas, with their relatively higher availability of recycling services compared to rural areas, reflect a middle ground where situational and personal factors intersect. This suggests that both infrastructure and attitudinal shifts must be prioritized simultaneously, a finding supported by previous research that suggests that suburban residents often have more diverse needs and preferences than their urban or rural counterparts (Kudelko and Musiał-Malago, 2022).

Rural Perspective

Rural respondents presented a different set of challenges, primarily related to the accessibility of recycling facilities. One rural participant remarked:

I17: “We’re ready to recycle, but how can we if the nearest centre is more than 5 kilometres away? Stakeholders should think about mobile collection services or village drop-off points.”

This comment highlights the critical role of situational factors, particularly infrastructure, in rural recycling participation. In contrast to urban and suburban participants, rural residents face the dilemma of long travel distances to access recycling facilities, which significantly limits their willingness to participate in recycling programs. Stakeholders in rural areas, including local waste management officials, have consistently advocated for infrastructure-focused interventions. According to a regional waste manager:

I02: “Rural areas need more accessible services for example, mobile collection units or local drop-off points could make a significant difference.”

Academic literature supports this notion, noting that rural areas often require tailored solutions, such as mobile recycling programs or decentralized collection systems, to overcome geographical barriers (Lu et al., 2022). Rural respondents indicated that while they were motivated to recycle, the absence of convenient services deterred their participation, aligning with the findings of (Cai et al., 2021), who identified accessibility as a key barrier to rural recycling behaviour.

The findings from this study suggest that a one-size-fits-all approach to e-waste recycling is unlikely to be effective. Stakeholders must adopt differentiated strategies tailored to the unique needs of urban, suburban, and rural areas. For urban areas, the focus should be on behavioural change campaigns aimed at shifting attitudes toward recycling. In suburban areas, a hybrid approach that combines education with infrastructure development is essential. Finally, rural areas require targeted efforts to improve accessibility, such as mobile collection services or decentralized recycling points. These merged findings can guide the design of more effective and context-sensitive recycling programs that cater to the unique needs of each residential subcluster, ultimately leading to higher participation rates and more sustainable waste management practices. In summary, the nuanced perspectives of urban, suburban, and rural households, as well as the insights from stakeholders, demonstrate the complexity of recycling behaviours. Understanding the interplay of situational and personal factors in these areas is crucial for the development of targeted interventions that can enhance recycling participation across all residential subclusters.

ii. Age

This chapter explores the significant role that age plays in shaping household e-waste recycling behaviours. Through in-depth interviews with waste management authorities, municipalities, and householders, this study uncovers actionable strategies aimed at enhancing recycling participation across different age groups. The following analysis and discussion delve into the dialogues gathered from key stakeholders and residents from different age groups. A recurring theme in the discussions with municipal waste management officials was the importance of bridging generational gaps in recycling education. One municipal official remarked:

I12: “We need to align school programs with community outreach. If children are learning about recycling, we should provide resources for parents and grandparents to join the effort. A unified family approach would have a greater impact.”

This statement underscores the idea that recycling habits instilled early in life have the potential to influence broader household participation, particularly when family dynamics are involved. Research supports this perspective, highlighting that younger generations, especially children, can play a pivotal role in fostering environmental consciousness within households. According to Deng et al. (2022), children often serve as powerful agents of change, influencing parental behaviours through knowledge acquisition and socialization. Their study on intergenerational recycling behaviours revealed that children who were educated about recycling at school frequently became the driving force behind initiating recycling efforts at home.

The municipal approach of aligning school programs with community initiatives mirrors the strategy of fostering "family-centered" environmental education. Such an approach not only empowers younger individuals but also creates opportunities for older generations to participate in recycling, especially if they are actively encouraged by their children or grandchildren. This generational approach to recycling education aligns with findings by Cialdini and Jacobson (2021), who noted that when both children and adults engage in environmental education together, the overall household commitment to sustainable practices increases.

The role of age in shaping recycling behaviours is also influenced by the accessibility and convenience of recycling programs. Waste operators, who manage the logistics of recycling infrastructure, consistently highlighted the importance of tailoring services to accommodate the specific needs of different age groups. One waste operator emphasized:

I06: "Accessibility is key. Young people are tech-savvy, so we've introduced apps to locate recycling centres and schedule pickups. For older generations, we're testing physical drop-off points in community centres, making it easier for them to participate."

This distinction in the approach to age groups is grounded in the understanding that younger generations, particularly millennials and Gen Z, are more likely to engage with digital tools, while older generations, such as Baby Boomers and the Silent Generation, may prefer more traditional methods of participation (Jensen, 2024). The introduction of digital applications for younger participants, as mentioned by the waste operator, aligns with studies that show how digital platforms can facilitate engagement by

providing real-time information and increasing convenience (Anderson and Rainie, 2021). Conversely, the creation of physical drop-off points at community centres for older individuals highlights the necessity of considering physical access barriers. This targeted approach recognizes that older individuals, particularly those who may have mobility limitations or lack familiarity with technology, require more accessible options to ensure their participation.

Additionally, the introduction of hybrid strategies that combine both digital and physical options for recycling aligns with broader trends in waste management research, which stress the importance of providing multiple touchpoints for engagement to accommodate a diverse range of users (Awasthi and Li, 2017). The varying needs of different age groups in relation to technology and physical access necessitate a multi-pronged approach to ensure high participation rates across all demographics. In the interviews with householders, the role of age as a motivator or barrier to recycling participation was clearly articulated. Younger participants expressed a strong preference for digital tools, with one young respondent stated:

I15: "I use an app to find the nearest recycling centre and schedule a pick-up for my e-waste. It's super convenient, and I feel like I'm contributing to the environment."

This reflects the growing trend among younger generations to embrace technology as an enabler of sustainable behaviours (Stieglitz et al., 2023). Digital platforms that allow users to easily locate recycling centres or schedule waste collection have been identified as effective means of promoting recycling participation in younger populations (Ramzan et al., 2020). In contrast, older participants frequently cited difficulties in

accessing recycling services, either due to the lack of convenient locations or their unfamiliarity with digital tools. One older respondent shared:

I17: "I'd recycle more if there was a nearby drop-off point. It's hard for me to get around, and I don't use apps or the internet much."

This sentiment was echoed by others in the older age group, who emphasized the importance of physical access to recycling facilities. For these individuals, situational factors specifically the convenience and proximity of recycling facilities, emerged as the most significant barrier to recycling participation. These findings align with studies such as those by Tomczyk et al. (2023), which highlight how older adults are often excluded from digital-first recycling initiatives due to technological and mobility barriers. This generational divide in the experience of recycling participation highlights the need for tailored interventions that address the unique challenges faced by different age groups. For example, while younger participants are motivated by the convenience and technological innovations in recycling, older participants are more likely to engage when services are physically accessible and easy to use.

The analysis of age as a moderator in recycling behaviour reveals that both situational and personal factors interact differently across age groups. Younger participants, with their greater familiarity with technology, are more influenced by the situational factor of accessibility through digital tools. In contrast, older generations are more influenced by the situational factor of physical accessibility to recycling centres, with personal factors such as technological discomfort acting as a barrier. The findings suggest that municipalities and waste operators must recognize these differences and implement age-specific strategies. For younger generations, the introduction of digital solutions

and the promotion of technology-based recycling tools may increase participation. For older generations, however, efforts should be directed toward providing more accessible physical facilities and resources that are less reliant on technology.

iii. Gender

The role of gender in shaping environmental behaviours, particularly household e-waste recycling participation, is an area of increasing academic interest in waste management behavioural context. Existing literature suggests that men and women often exhibit different attitudes, motivations, and behavioural tendencies toward environmental engagement (Milfont and Sibley, 2016; Z. Zhao et al., 2021). Gendered divisions of labor within households and gender-specific socialization processes influence waste management practices (Fathonah and Nastiti, 2024). This final demographic role examines the moderating influence of gender on situational and personal factors affecting e-waste recycling behaviour through qualitative dialogues with waste management authorities, municipalities, and householders. The findings are further analysed within the broader framework of gender and environmental psychology, emphasizing the intersectionality of gender roles and sustainability initiatives.

Municipalities play a pivotal role in promoting inclusive and effective recycling programs. A recurring theme in discussions with municipal waste management officials was the need to balance gender dynamics to ensure equitable participation. One municipal officer stated:

I05: "We have noticed a gendered trend in recycling behaviour. Women are often more engaged in household waste management, but we cannot assume that sustainability should be their responsibility alone. We need initiatives that encourage shared household responsibility and male participation in recycling efforts."

This statement aligns with findings from recent studies, which indicate that women are more likely than men to engage in domestic environmental behaviours, including recycling (Baraldi et al., 2024; Tien and Huang, 2023). Such gendered behaviour is often attributed to traditional household roles, where women tend to oversee domestic responsibilities, including waste disposal and management. However, as the municipal officer noted, a reliance on women as primary recyclers can reinforce gendered labor divisions rather than fostering collective environmental responsibility. To address this, municipalities have begun implementing gender-sensitive awareness campaigns. As another municipal officer remarked:

I12: "We recently launched a campaign targeting male household members, emphasizing that sustainability is a shared duty. We framed recycling as a civic responsibility rather than a household chore, and we observed a positive shift in male engagement."

This strategy aligns with research by Bloodhart and Swim (2020), which found that reframing environmental behaviours as civic rather than domestic significantly increased male participation in sustainability initiatives. Social norms and gender expectations influence environmental behaviours, and targeted messaging that deconstructs traditional gender roles may help balance household participation. Waste

operators highlighted logistical and psychological barriers affecting male and female recycling behaviours differently. One operator explained:

I09: "Women tend to be more proactive about recycling e-waste, but they often struggle with the physical aspects, such as transporting heavy items. On the other hand, men are more likely to handle bulk disposal, but they may not prioritize recycling or be aware of designated recycling facilities."

These observations resonate with studies showing that women generally express stronger pro-environmental attitudes but may encounter physical or structural constraints that hinder their participation in certain recycling activities (Ari and Yilmaz, 2016). To address these challenges, waste operators have been piloting gender-sensitive interventions. One representative from the federal government involved in waste management described a recent initiative:

I11: "We've introduced scheduled e-waste collection services in suburban areas to support women who might have difficulty transporting electronic waste. At the same time, we've planned to implement workplace recycling programs to engage more men, particularly in industries where e-waste disposal is a concern."

Research supports these gender-specific interventions. A study by Simpson et al. (2021) found that convenience significantly influences male engagement in environmental behaviours. Programs that integrate recycling within male-dominated spaces, such as workplaces or sports clubs have proven effective in increasing male participation. Meanwhile, accessibility-focused solutions, such as home collection services, address structural barriers that disproportionately affect women (Ari and Yilmaz, 2016).

Interviews with female householders revealed a strong sense of environmental awareness and responsibility. One respondent shared:

I16: "I always make sure we separate our waste and take our old electronics to the designated centre. But sometimes, it's a hassle, especially if the drop-off points are far or the items are too heavy to carry."

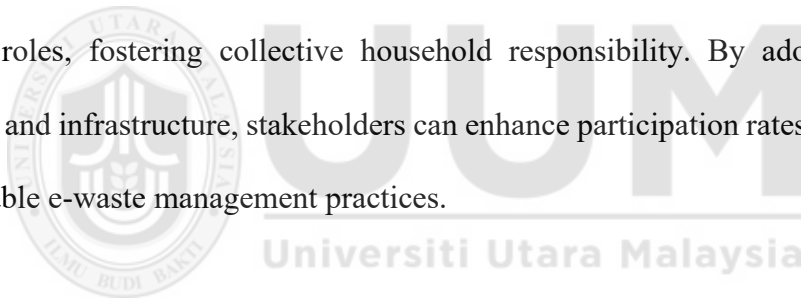
This perspective aligns with research indicating that women are more likely than men to engage in recycling behaviours due to heightened environmental concern and social responsibility (Ari and Yilmaz, 2016). However, practical barriers such as access to transportation, the physical burden of handling e-waste, and time constraints disproportionately affect female recyclers (Ari and Yilmaz, 2016). Another respondent highlighted the emotional aspect of recycling:

I03: "I feel guilty if we don't recycle properly. But I also wish my husband would take more initiative instead of assuming it's my job."

This sentiment underscores the gendered emotional labour associated with environmental responsibility, a phenomenon widely documented in ecofeminist research (Bloodhart and Swim, 2020). When sustainability becomes feminized, men may disengage from recycling due to perceived gender norms. In contrast, male respondents cited convenience as a primary factor influencing their recycling behaviours. One male respondent among householders remarked:

I17: "I'll recycle if it's easy and straightforward. If there's a designated bin or collection service, I'll use it. But I don't go out of my way to figure out where to drop off old electronics."

This response reflects findings by White et al. (2019), who argue that men's recycling behaviours are more strongly influenced by structural convenience than by intrinsic environmental concern. This studies also mentioned that men are more likely to engage in sustainability behaviours when framed as practical, hands-on tasks rather than domestic chores. In summary, promoting gender-equitable recycling participation requires addressing the distinct motivations and barriers faced by men and women. While women are often more environmentally conscious, logistical challenges hinder their full participation, whereas men's engagement is influenced by convenience and social framing. To bridge this gap, recycling must be reframed as a shared civic duty, with targeted initiatives such as workplace programs for men and improved accessibility for women. Public awareness campaigns should challenge traditional gender roles, fostering collective household responsibility. By adopting inclusive policies and infrastructure, stakeholders can enhance participation rates and drive more sustainable e-waste management practices.



5.7 Chapter Summary

Chapter 5 presents a comprehensive four-part triangulation analysis, synthesizing the key arguments derived from all stages of the explanatory sequential design. Each component of the triangulation was meticulously structured to address the research questions formulated in the preliminary phase of this study. The third phase of the explanatory sequential design; triangulation analysis, aimed to integrate findings from Phase 1 (statistical analysis) and Phase 2 (qualitative inquiry) to achieve a holistic understanding of household e-waste recycling behaviour. This phase employed a mixed-methods approach, merging quantitative data with qualitative insights drawn from semi-structured interviews with local stakeholders and households to explore their experiences and behaviours regarding e-waste recycling.

Phase 3 served as a critical mechanism for validating and verifying the findings from the preceding phases. Notably, personal factors including attitudes, knowledge, experience, awareness, and psychological ownership which emerged as predominant themes in the discourses. Simultaneously, situational factors, such as convenience, stakeholder engagement, education, advertising, and policy and regulatory frameworks, were identified as essential preconditions for the household e-waste recycling participation framework to take effect. In Phase 1 of the quantitative analysis, one component from both situational and personal factors was excluded due to its insignificant influence on household e-waste recycling participation. Specifically, "accessibility and availability" were removed from the situational factors, while "social norms" was excluded from the personal factors. These exclusions were further validated through qualitative insights gathered in Phase 2, which involved in-depth discussions with key stakeholders through FGD conducted and private interview sessions with

householders from the three distinct residential subclusters. The final research framework, refined based on these findings, incorporates the validated situational and personal factors and is presented in Figure 5.6.

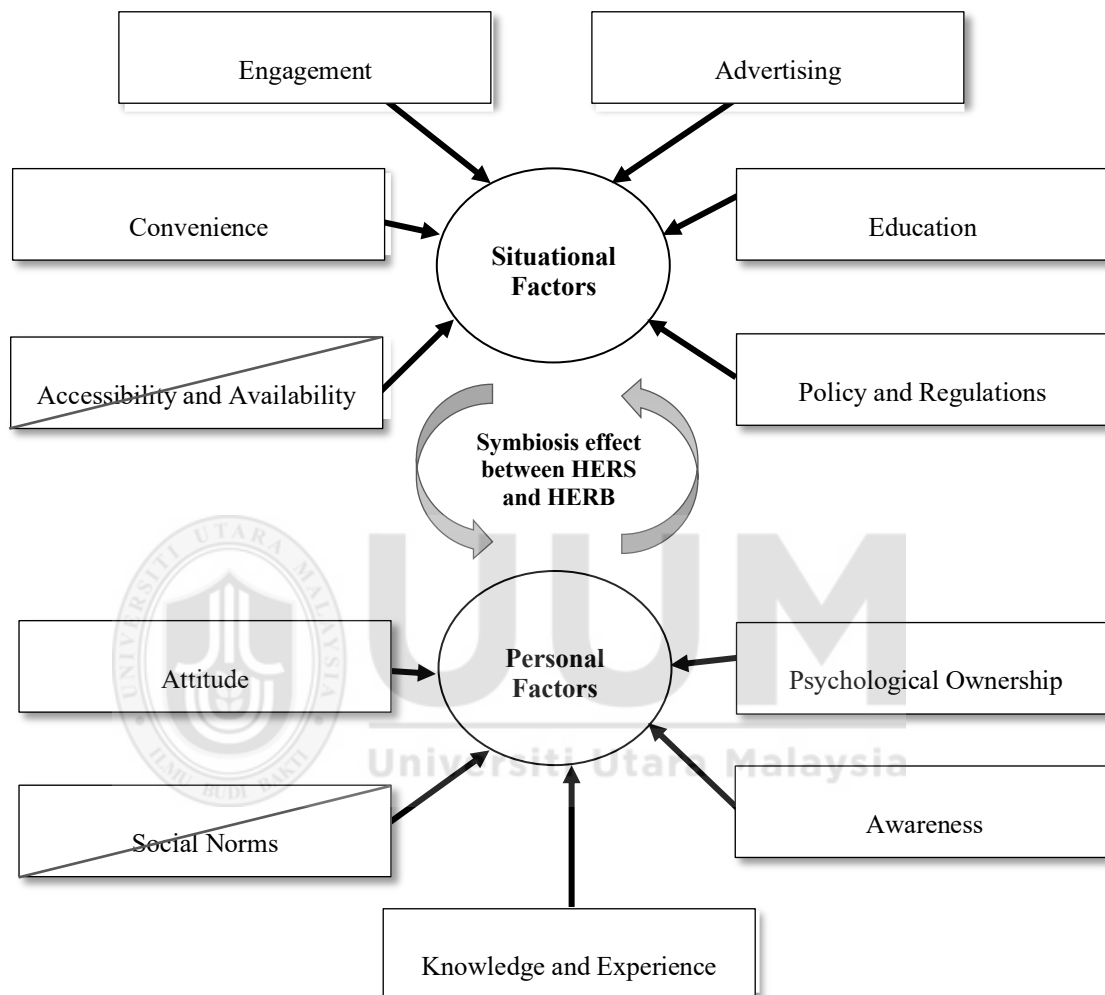


Figure 5.6
The validation of factors between HERS and HERB

This triangulation phase provided a deeper interpretive analysis of the most influential and least influential factors shaping household participation in e-waste recycling. The responses from participants collectively demonstrated a cohesive relationship between the HERS and HERB. Additionally, Phase 3 offered an in-depth validation of the symbiotic relationship between HERS and HERB in fostering and sustaining household

engagement in e-waste recycling. The application of behavioural theories including the Norm Activation Model, the TPB, the underpinned the conceptualization of the Symbiosis Effect Theory. The findings indicate that personal factors interact dynamically with situational factors, suggesting that the efficacy of HERB is contingent upon the strategic design and implementation of situational factors by local stakeholders.

Furthermore, Phase 3 provides deeper insights into the moderating effects of demographic factors specifically residential subclusters (urban, suburban, and rural), age, and gender on HERS and HERB. This phase enhances the understanding of how these factors influence household participation in e-waste recycling. The final discussion employs a triangulation analysis approach to validate and verify each RQ developed in the study. By integrating strong numerical data with qualitative insights from local waste management stakeholders and householders across the three residential subclusters, this phase ensures a comprehensive and well-supported conclusion to the research.

Ultimately, the final stage of the triangulation analysis underscores the methodological rigor and efficacy of the mixed-methods approach in investigating complex, multidimensional, and interdisciplinary phenomena. The inductive-deductive methodological phasing incorporated distinct ontological assumptions, reinforcing the robustness of the mixed-methods framework in addressing the intricacies of household e-waste recycling behaviour.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Introduction

In this final chapter, the key findings in relation to the RQs are summarized, and overarching conclusions drawn from the studies presented throughout this thesis are discussed. Additionally, the strengths and limitations of the research are acknowledged, with suggestions for future studies exploring the interdisciplinary dimensions through mixed methodologies. The chapter concludes with targeted recommendations for three key stakeholders in household recycling waste management: policymakers, municipalities, and householders. Given the complexity of household e-waste recycling behaviour, shaped by both situational and personal factors, a comprehensive and integrated approach is essential to effectively tackle the multifaceted challenges in this field.

6.2 Summary of Key Findings in Relation to the RQs

The research was conducted in two phases. The first phase, a quantitative approach, aimed to enhance generalizability by conducting various statistical tests on samples from stakeholders and households across two states in Malaysia, which included three distinct subclusters: urban, suburban, and rural households. The second phase, following an explanatory sequential design, built upon the themes identified in Qualitative Phase 2 (Figure 4.28) and sought to further generalize the findings from the first phase. This phase aimed to validate the factors influencing household e-waste recycling participation and the symbiosis effect in two different residential states under

municipal jurisdiction. Descriptive analysis of response bias tests revealed no significant bias among the groups in terms of the items and constructs analysed between households in Kedah and Penang. Additionally, demographic profiles were examined by segmenting the two cities into urban, suburban, and rural subclusters to assess their influence on both HERS and HERB, contributing to household e-waste recycling participation.

In Phase 1, the structural model analysis identified positive relationships between both situational and personal factors in fostering household e-waste recycling participation. After validating the measurement and structural models, a reciprocal loops analysis was applied to further substantiate the presence of a symbiosis effect between HERS and HERB. The results revealed a robust reciprocal interdependence between personal and situational factors, significantly enhancing household e-waste recycling participation. These findings highlight the critical importance of considering the interaction between situational and personal factors when assessing the overall effectiveness of household e-waste recycling management systems.

To further investigate HERB, a structural moderating analysis was conducted to examine the role of situational factors as a precursor (precondition) and explore their relationship with personal factors across three key demographic profiles: residential subclusters, age, and gender. The results reveal that situational factors positively interact with certain demographic characteristics, encouraging households to participate in e-waste recycling. The structural moderating model analysis showed that moderating variables, such as demographic factors and situational elements, significantly influence respondents' motivation to engage in e-waste recycling activities. Household recycling

behaviour, particularly regarding specific recyclable materials, was activated through the interaction of these factors. Notably, the interplay between demographic variables, situational factors, and personal factors emerged as a critical factor in understanding recycling behaviour during the analysis.

Next, Qualitative Phase 2 aimed to both validate constructs and ideas derived from multiple disciplinary perspectives and identify emergent themes that have not been extensively discussed within the existing body of work. This phase identified five key situational factors; convenience, engagement, advertising, education, and policy and regulations, and four personal factors; attitude, knowledge and experience, awareness, and psychological ownership. Through an inductive analysis process, two factors, one situational (accessibility and availability) and one personal (social norms), were excluded from the data due to their insignificant impact on HERS and HERB in relation to household e-waste recycling participation. The remaining factors, however, were consistent with and validated by existing literature.

The third stage of the explanatory sequential design, the Triangulation Analysis Phase, aimed to integrate the findings from Phase 1 and Phase 2. This triangulation process involved merging the statistical data from structured questionnaires distributed to householders with insights gained from FGDs with local stakeholders in waste management, as well as semi-structured interviews with householders. This final triangulation approach effectively validated the results of both phases. Through this process, all RQs were addressed and confirmed, with a particular focus on the situational and personal factors that enhance household e-waste recycling participation. The analysis also verified the existence of the symbiosis effect between the two

independent variables and highlighted the influence of demographic profiles, which caused variations in the impact of HERS and HERB on household e-waste recycling behaviour. The findings from the discourses clearly indicated that all aspects of situational and personal factors are equally important as pre-conditions for initiating household e-waste recycling participation. Moreover, the symbiotic relationship between HERS and HERB was consistently reflected throughout the discourses, demonstrating their interdependent influence on recycling behaviour.

Behavioural theories such as norm activation theory and the TPB were found to be crucial in encapsulating and explaining the adapted Symbiosis Effect Theory. The overall findings reveal that personal factors and situational factors are interdependent, with household e-waste recycling participation transforming based on how effectively situational factors such as convenience, engagement, advertising, education, and policy and regulations are designed and implemented by municipalities. Equally important is how household behaviour encompassing attitude, knowledge and experience, awareness, and psychological ownership responds to the recycling systems in place. The research framework culminated in the finalization of Model A (Figure 4.13), which was further expanded and verified to include the moderating effect of demographic profiles on HERS and HERB, contributing to household e-waste recycling participation. This evolution resulted in the development of Model B (Figure 4.25). In conclusion, the final stage of triangulation underscores the effectiveness of employing a mixed methodology approach to investigate complex, multi-dimensional, and interdisciplinary issues in household e-waste recycling.

6.2.1 RQ1: How does the situational factors influence households to participate in e-waste recycling in Malaysia?

The first RQ was concerned with the influences of situational factors to household e-waste recycling participation. This study identified five key situational factors related to e-waste recycling systems, developed and provided by local stakeholders, that significantly enhance household participation in e-waste recycling efforts. The first situational factor is convenience. The accessibility of recycling facilities and services, such as the proximity of recycling drop-off centres, plays a crucial role in facilitating household participation, particularly in rural areas where ease of access significantly impacts recycling behaviour. The second factor, engagement, underscores the importance of collaboration among key stakeholders, including local municipalities, authorized waste recycling operators, and licensed NGOs. Findings from Qualitative Phase 2 confirmed that household participation increased when municipalities and NGOs actively organized e-waste recycling programs and awareness campaigns. The third factor, advertising, highlights the role of awareness initiatives in promoting sustainable e-waste recycling practices. Efforts by local stakeholders to advertise the environmental and economic benefits of proper e-waste disposal were found to positively influence household recycling behaviour.

Next, the fourth factor, education, emerged as the most influential determinant in boosting household participation. This study found that environmental education, particularly when integrated into formal education systems, fosters long-term behavioural change. The FGD in Phase 2 further validated this finding, revealing that prior education on waste management can create a positive feedback loop, reinforcing sustainable recycling behaviours within communities. Moreover, social learning theory

suggests that education influences not only individual recycling behaviour but also collective community participation. Households that engage in recycling due to prior environmental education can act as behavioural role models, influencing peers, family members, and neighbours to adopt similar sustainable practices. This cascading effect strengthens community-wide recycling habits, leading to a more deeply embedded culture of waste separation and e-waste recycling participation.

Lastly, policy and regulations were identified as critical in establishing a structured and enforceable e-waste management system. The implementation of robust policies mandating household participation in e-waste recycling ensures long-term sustainability and accountability in the recycling process. Collectively, these five situational factors play a pivotal role in reinforcing the commitment of local stakeholders to sustain an effective and efficient e-waste recycling system. Their integration into policy frameworks and operational strategies is essential for fostering widespread household participation and ensuring the long-term sustainability of e-waste management practices.

6.2.2 RQ2: How does the personal factors influence households to participate in e-waste recycling in Malaysia?

The second RQ examined the influence of personal factors on household participation in e-waste recycling. The findings revealed that four key personal factors significantly affected household engagement in e-waste recycling activities. Firstly, household attitudes toward environmental sustainability initiatives were found to play a crucial role in shaping recycling behaviour. As highlighted in FGD Phase 2, attitudes strongly influence individual behaviour, with households demonstrating a positive attitude towards pro-environmental practices being more likely to willingly participate in e-waste recycling. Secondly, environmental knowledge, coupled with prior experience in recycling activities, emerged as the most influential factor in household e-waste recycling participation.

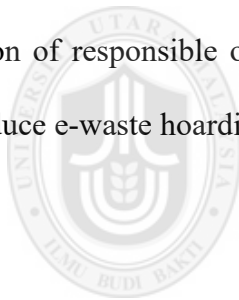
Findings from Phase 2 indicated that individuals who had previously engaged in recycling and internalized the importance of sustainable waste management were more likely to develop habitual recycling behaviours. Households that possessed a higher level of environmental awareness demonstrated a stronger sense of responsibility toward proper e-waste disposal, as they understood the long-term ecological and health consequences of improper disposal practices. Furthermore, participants with prior recycling experience exhibited greater confidence in navigating the recycling process, including identifying appropriate recycling facilities and understanding the categorization of e-waste materials. This suggests that fostering environmental awareness and promoting recycling education through community initiatives, school programs, and public campaigns can significantly enhance household engagement in sustainable e-waste management practices. By equipping individuals with the necessary

knowledge and experience, policymakers and stakeholders can cultivate a more proactive and environmentally responsible society, ultimately increasing e-waste recycling rates.

Thirdly, awareness of recycling procedures was found to have a significant influence on household participation in e-waste recycling. Households with a higher level of awareness were more likely to engage in proper recycling practices, as they possessed a clear understanding of how to sort, handle, and dispose of e-waste responsibly. The findings from Phase 2 indicated that a lack of awareness often led to uncertainty and hesitation, with some households discarding e-waste improperly due to misconceptions about recycling processes. Participants who were well-informed about the environmental and health risks associated with improper e-waste disposal exhibited a stronger commitment to recycling, as they recognized its broader impact on sustainability.

Moreover, exposure to recycling awareness campaigns, whether through educational institutions, government initiatives, or media, was found to positively shape household behaviour by reinforcing the importance of responsible e-waste management. These findings underscore the need for continuous public education efforts to enhance awareness and encourage long-term engagement in sustainable recycling practices. Lastly, psychological ownership of e-waste; the emotional and cognitive attachment individuals develop toward their discarded electronic items, was found to significantly influence household decisions regarding e-waste recycling. The findings revealed two distinct behavioural outcomes: some households perceived recycling as a meaningful way to part with their valued electronic items, believing that repurposing or recycling

them contributed to environmental sustainability and extended their usefulness. For these individuals, recycling served as a positive means of letting go, allowing them to find reassurance in the idea that their once-cherished devices could be put to better use. Conversely, other households exhibited a tendency to retain outdated or non-functional electronics due to sentimental attachment, perceived future utility, or uncertainty about disposal options. This reluctance to part with e-waste often resulted in prolonged storage at home rather than active participation in recycling initiatives. The study findings suggest that addressing psychological ownership through awareness campaigns emphasizing the benefits of responsible disposal, such as the potential for reuse, refurbishment, or material recovery, could help encourage greater household participation in e-waste recycling. By fostering a mindset that views recycling as an extension of responsible ownership, policymakers and environmental advocates can help reduce e-waste hoarding behaviour and promote sustainable disposal practices.



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6.2.3 RQ3: How does the interactions between situational and personal factors can support the existence of symbiosis effects between HERS and HERB?

The third research question aimed to investigate and explain the symbiotic effect between HERS and HERB. The study confirmed the presence of this effect through 15 distinct influential pathways that integrate situational and personal factors. In Phase 2, thematic analysis was employed to further validate the statistical findings from the quantitative analysis conducted in Phase 1. The thematic network illustrated in Figure 4.27 showcases the reciprocal interactions between HERS and HERB, highlighting their role in fostering household participation in e-waste recycling. This study underscores the importance of collaborative engagement among local stakeholders and households in promoting and enhancing e-waste recycling participation. The findings emphasize the symbiotic relationship between situational and personal factors in shaping household recycling behaviours. Households often dispose of or sell e-waste due to emotional attachments to electronic devices, which, combined with inadequate recycling infrastructure, contributes to improper disposal. This study reveals that both the availability of accessible recycling services and personal factors such as attitudes and psychological ownership significantly influence participation in recycling initiatives. A key finding is that reliance on favourable household behaviour alone is insufficient to drive widespread participation. Stakeholder collaboration, including government agencies, private entities, and local organizations, is vital to improving recycling infrastructure and accessibility. This is particularly crucial in rural areas where limited access to recycling facilities hinders engagement.

Next, this study highlights the need for convenient, accessible services, such as drive-through options and designated collection points, provided by licensed e-waste

collectors in collaboration with various stakeholders. Moreover, public awareness campaigns and media engagement play a critical role in shaping attitudes and promoting recycling behaviours. Positive reinforcement, such as monetary or non-monetary incentives, has been identified as an effective strategy to increase participation, especially in more isolated regions. Social and cultural factors, including societal expectations and peer influence, also contribute to motivating individuals to engage in recycling practices.

In addition, this study emphasizes that overcoming infrastructure barriers, such as the distance to recycling centres, is essential for increasing participation. In rural areas, long travel times to recycling facilities were reported as a significant deterrent. Additionally, the study highlights the importance of education and enforcement in ensuring compliance with recycling regulations. Ensuring that households are well-informed about the rules and regulations before penalties are enforced is crucial for fostering a culture of responsible recycling. In summary, the findings highlight that a symbiotic relationship between HERS and HERB is crucial for enhancing e-waste recycling participation. The successful promotion of e-waste recycling requires a multi-faceted approach that integrates convenient infrastructure, public awareness, positive incentives, and a robust regulatory framework. Collaboration among local stakeholders, government bodies, and the public is essential to create an environment that encourages sustainable recycling practices and addresses the challenges of infrastructure limitations. By removing access barriers and providing educational initiatives, it is possible to enhance household participation in e-waste recycling and contribute to a more sustainable future.

6.2.4 RQ4: Does the interactions between both factors (situational and personal) and household e-waste recycling participation vary depending on demographic profiles?

The goal of the final RQ was to investigate how the interaction between situational and personal factors influences household e-waste recycling participation, particularly with regard to demographic profiles. The study confirmed that demographic factors significantly impact the relationship between situational and personal influences, which in turn shape recycling behaviour across different household groups. Notably, the relationship between HERS and HERB varied depending on moderating demographic factors, including residential subclusters (urban, suburban, rural), age, and gender.

In urban areas, respondents, residing in dense and infrastructure-rich settings, expressed a strong awareness of recycling services. However, a critical barrier identified was the lack of motivation and public awareness. Despite the presence of recycling facilities, participants highlighted that recycling was not perceived as essential without sufficient community engagement and educational efforts. Findings from this study confirmed the success of urban recycling programs hinges on public awareness. Urban respondents were more likely to engage in recycling when they perceived it as a socially responsible behaviour, emphasizing the role of attitudes and educational interventions in fostering e-waste recycling participation. The suburban respondents faced dual challenges of insufficient infrastructure and a lack of targeted educational efforts. A typical response from suburban participants suggested that both education and better recycling facilities were needed.

This study found that suburban households were more likely to participate in recycling when both resources and information were available. The findings indicate that suburban areas, with their middle-ground availability of resources, require a hybrid approach that combines both attitudinal and infrastructural improvements. However, in rural areas, respondents cited accessibility issues as a primary obstacle, with many participants noting the long travel distances to recycling facilities. Stakeholders in rural regions advocated for infrastructure-focused solutions, such as mobile collection units or decentralized drop-off points. This study found the need for more accessible services in rural areas as the householders require customized solutions to overcome the geographical barriers. Thus, the study concluded that a universal approach to e-waste recycling would be ineffective, as strategies must be tailored to the specific needs of each residential subcluster.

In addition, this study also highlighted the role of age in shaping e-waste recycling behaviours. Discussions with waste management officials and householders revealed the importance of bridging generational gaps in recycling education. Younger generations, particularly children, often serve as agents of change, influencing the recycling behaviours of older family members. Results from Phase 2 identified that children act as key influencers in household recycling practices. Municipalities have begun aligning school programs with community outreach to create a unified, family-centred approach to recycling education. Younger participants, accustomed to digital tools, demonstrated higher engagement with technology-based recycling solutions, such as apps for locating recycling centres. In contrast, older participants, who face mobility or technological barriers, preferred traditional methods, such as physical drop-off points. This study confirmed that recycling participation among older individuals is

heavily influenced by the physical accessibility of services, suggesting that municipal programs must be tailored to accommodate the specific needs of each age group.

Lastly, gender also played a significant role in shaping recycling behaviours, as men and women exhibited different motivations and barriers. Women, who are typically more engaged in household waste management, often face physical constraints, such as difficulty transporting e-waste. Meanwhile, men, who tend to handle bulk disposal, are less likely to prioritize recycling, particularly if services are not convenient. Municipalities have responded by introducing gender-sensitive interventions, such as targeting male household members through campaigns that frame recycling as a civic responsibility rather than a domestic task. This approach has been shown to increase male participation and also to support women, waste management services have introduced home collection options and localized drop-off points.

In conclusion, this study underscores the complexity of household e-waste recycling behaviours, highlighting the significant influence of demographic factors such as residential subclusters, age, and gender. The findings suggest that recycling interventions must be tailored to address the specific needs of each group. Urban areas require behavioural change campaigns to foster civic responsibility, suburban areas benefit from a hybrid approach combining education and infrastructure, and rural areas necessitate targeted solutions to improve accessibility. Additionally, age and gender-based strategies are critical for engaging diverse populations. By considering these demographic factors, policymakers and waste management authorities can design more effective, inclusive, and context-sensitive e-waste recycling programs that foster higher participation rates and contribute to sustainable waste management practices.

6.3 Contribution of the Study

The contribution of this study lies in its comprehensive examination of the symbiotic relationships within the reverse logistics system for e-waste recycling, with a specific focus on stakeholder engagement and household behaviour. The research offers a novel perspective on how various stakeholders, including households, recycling operators, and policymakers, can interact and collaborate to optimize e-waste management practices. By exploring the factors that influence household participation in e-waste recycling and the broader implications for reverse logistics, this study provides crucial insights into the operational and behavioural dynamics that underpin a sustainable e-waste recycling system. The contributions of this study are presented through two key dimensions: theoretical implications and practical implications.

6.3.1 Theoretical Implications

In the pursuit of sustainable and environmentally responsible reverse logistics practices, there has been relatively limited scholarly attention devoted to the integration of recycling within this framework. This study addresses this gap by examining the intersection of recycling and reverse logistics, an area that has only been explored in a limited number of studies. While prior research has incorporated recycling within the reverse logistics context (A-Jalil et al., 2016; Ali et al., 2018; Kianpour et al., 2017), there remains a notable paucity of studies focusing specifically on household e-waste management. This research, therefore, makes a significant contribution to the reverse logistics and recycling literature, particularly by focusing on the reverse logistics channel for e-waste generated at the household level. Given its emphasis on both reverse logistics and waste management, this study offers valuable insights for scholars

in these interdisciplinary fields, advancing the theoretical and practical understanding of e-waste recycling systems.

Furthermore, there has been limited scholarly attention given to the perception of symbiosis in examining the relationship between HERS and HERB, particularly within the context of logistics and waste management literature. While A-Jalil (2015) developed a robust Symbiosis Effect Theory to explore the relationship between local municipalities and recyclers, the focus of that study was confined to a single waste stream, specifically MSW. This study, in contrast, shifts the focus to the symbiotic relationship between local stakeholders and households within the context of household e-waste recycling management. In addition, this research extends previous work by investigating the existence of a reciprocal relationship between local stakeholders and households, rather than examining the key actors in isolation, as has been the case in prior studies (Colesca et al., 2014; Echeagaray and Hansstein, 2017; Haron et al., 2018; Miafodzyeva and Brandt, 2013; Senawi and Sheau-Ting, 2016; B. Wang et al., 2019; Yahya et al., 2021). By focusing on the interconnectedness of these actors, this study provides new insights into the dynamics of household e-waste recycling, advancing the understanding of symbiotic relationships in reverse logistics and waste management.

This research significantly advances the theoretical understanding of reverse logistics by expanding the existing conceptual framework to incorporate the impact of stakeholder engagement and household behaviour on the effectiveness of e-waste recycling systems. It offers a refined approach to integrating the roles of various actors within the reverse supply chain, thereby contributing to the growing body of literature on circular economy and sustainable waste management. Notably, this study introduces

a symbiotic model of e-waste recycling, as depicted in Figure 6.1, in which the interactions among stakeholders foster a dynamic and mutually beneficial system. The findings provide important theoretical insights into how these relationships can be optimized to enhance the efficiency and sustainability of recycling practices. This extension of reverse logistics theory is particularly valuable, as it incorporates behavioural and engagement dynamics that have not been adequately explored in prior research, thereby filling a critical gap in the field and offering a more holistic understanding of e-waste management within the reverse logistics context.

6.3.1.1 A Symbiosis-Based Framework for Reverse Logistics in E-Waste Recycling Management

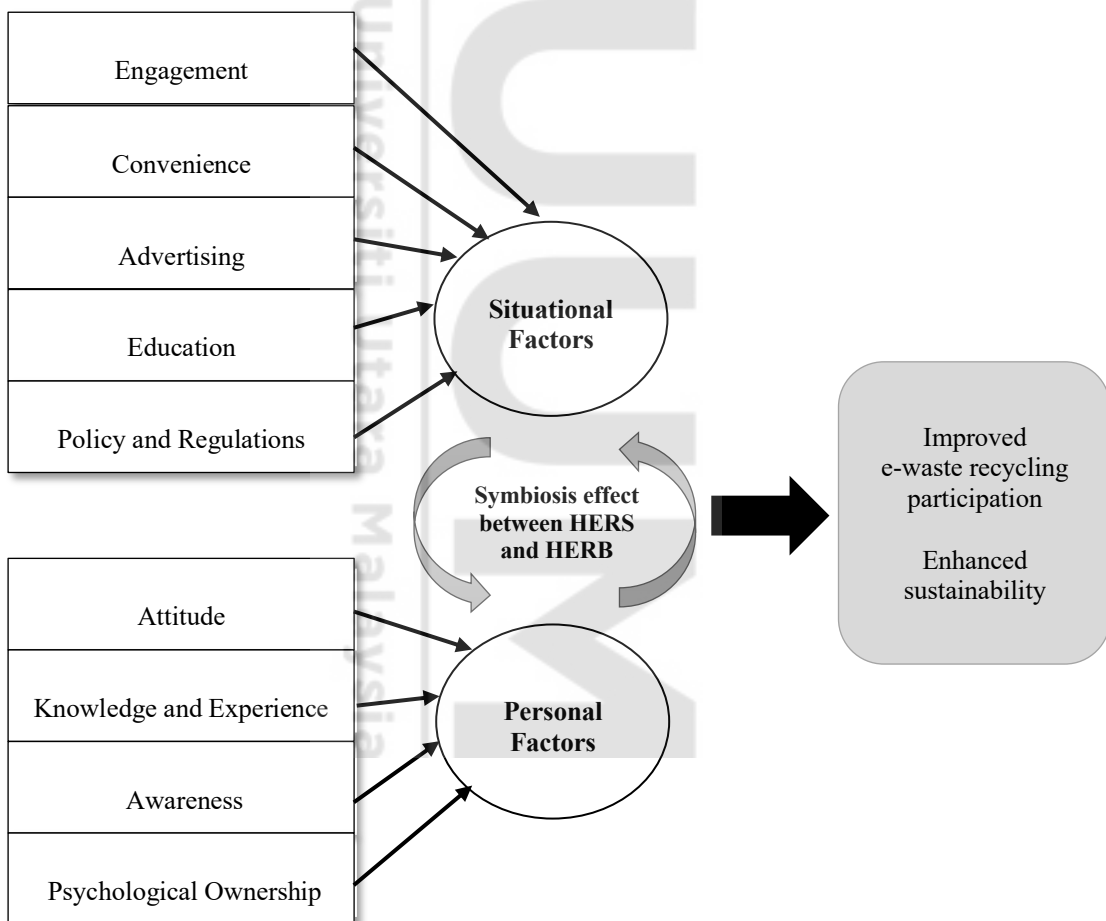


Figure 6.1
The symbiotic framework for reverse logistics in e-waste recycling management

This study contributes to the development of a symbiotic framework for reverse logistics in e-waste management, specifically focusing on the handling of e-waste at the household level, as illustrated in Figure 6.1. The convergence of robust theoretical model of Symbiosis Effect Theory developed by A-Jalil (2015), were revised and adapted into a robust reverse logistics framework for e-waste recycling management. A comprehensive symbiosis framework for household e-waste recycling has been established, based on the resolutions and discussions derived from the RQs. Both situational and personal factors, as depicted in Figure 6.1, were identified as critical elements influencing household participation in e-waste recycling. The study reveals that situational factors, shaped by the e-waste recycling systems implemented by local stakeholders (e.g., the provision of facilities and services), and personal factors, which stem from the characteristics and behaviours of households regarding recycling, are mutually interdependent. This interdependence plays a crucial role in enhancing household participation in e-waste recycling. Furthermore, the reverse flow of e-waste management, initiated by end-users (householders), provides local municipalities with valuable insights for developing systematic and robust reverse logistics systems. This process not only facilitates the effective management of e-waste but also contributes to environmental sustainability.

From the perspective of waste operators and recycling centres, the study highlights the necessity for continued engagement and collaboration among local stakeholders, including the federal government, to strengthen the reverse logistics flow of e-waste recycling. Such collaboration serves an indirect yet vital role in optimizing the e-waste management system, ensuring that it meets the federal government's goals for a sustainable environment. Moreover, local stakeholders must prioritize active

engagement with households to address household behaviour and develop more tailored, centre-based e-waste recycling facilities and infrastructure. These facilities should be designed to meet the specific needs of households and increase their participation in e-waste recycling. Through this symbiotic relationship, both local stakeholders and households can achieve superior recycling outcomes when the recycling systems are aligned with both external and internal circumstances.

The symbiotic framework developed in this research offers a strategic approach to e-waste management that balances both external infrastructure and internal household behaviours. It underscores the need for targeted policies and infrastructure designed to address household needs, overcome barriers to recycling, and promote greater participation. By understanding and leveraging the interactions between stakeholders and households, this study provides a valuable tool for enhancing the effectiveness of e-waste recycling systems and advancing environmental sustainability. In conclusion, this study contributes to the growing body of knowledge on reverse logistics in e-waste management and offers actionable recommendations for improving e-waste recycling systems. The framework developed here not only provides a theoretical foundation but also offers practical implications that can guide policymakers, waste operators, and other stakeholders in creating more efficient and sustainable recycling systems that meet both local and global environmental goals.

6.3.2 Practical Implications

Recent studies underscore an increasing emphasis on reducing household waste, with various strategies proposed to address this challenge and enhance household participation in e-waste recycling. However, there remains a significant gap in empirical research concerning the practical implementation of waste recycling management within households (Barr et al., 2013). From a practical standpoint, these findings should inform the development and implementation of HERS by municipalities, thereby optimizing waste management strategies and advancing sustainability initiatives. Given that waste collection constitutes a critical and widely recognized service provided by local authorities, fostering a more effective and cooperative engagement between service providers and recyclers is essential for increasing household participation in e-waste recycling. Reverse logistics practitioners must establish comprehensive systems that facilitate the efficient disposal of household e-waste while simultaneously integrating interactive and educational efforts to promote sustainable HERB. Furthermore, understanding the interdependencies among stakeholders within the reverse logistics framework is vital for developing holistic and efficient e-waste management systems.

The findings suggest that improving recycling efficacy in urban environments can yield substantial social and environmental benefits. Incremental advancements in HERS can significantly enhance recycling participation rates, reduce e-waste disposal, mitigate environmental pollution, lower carbon emissions, and contribute to the conservation of finite natural resources. From an applied perspective, integrating the symbiosis effect with the situational and personal factors identified in this study offers valuable insights for policymakers and practitioners seeking to transition from a singular waste collection

model to a more effective source-segregated system. Recognizing the pivotal role of household engagement in waste separation is crucial for the successful implementation of these systemic changes. This research establishes a comprehensive framework for embedding the symbiosis effect within the design of reverse logistics channels, providing a strategic approach to improving e-waste recycling systems.

From a practical standpoint, this study presents actionable recommendations to strengthen stakeholder collaboration in e-waste management. A key contribution is the emphasis on designing a sustainable reverse logistics system that aligns with public needs by incorporating precursive factors and fostering meaningful engagement. Effective engagement strategies include public education initiatives and recycling awareness campaigns that underscore the environmental and economic benefits of recycling. Moreover, the study highlights the potential for community investment in waste-to-energy recovery projects as a means of enhancing sustainability efforts. Understanding household recycling behaviours, particularly the motivations and barriers influencing participation, is essential for crafting targeted public policies, communication strategies, and incentive programs that drive higher e-waste recycling rates. These insights have significant implications for policymakers and industry leaders, offering guidance on developing more efficient and sustainable e-waste management systems that are responsive to public behaviour patterns and stakeholder capacities. By emphasizing the necessity of multi-stakeholder collaboration, this research establishes a strategic framework for improving operational efficiency, optimizing resource recovery, and advancing sustainability in e-waste reverse logistics systems.

The overall findings confirm the interdependent relationship between local stakeholders and household recyclers, reinforcing the critical link between effective waste management systems and household recycling behaviour. The study further reveals that stakeholders across different regions attribute behavioural changes to improved engagement strategies, enhanced facilities, optimized collection schedules, and consumer-oriented services. However, sustaining these improvements in HERS requires robust policy support. Effective policymaking is a cornerstone of the circular economy and should not be viewed as the exclusive responsibility of local authorities. Instead, a collaborative and integrative approach is necessary, involving multiple stakeholders, including central government agencies, waste operators, and non-governmental organizations (NGOs). This multi-faceted approach will ensure the long-term success and sustainability of household e-waste recycling initiatives.

As one municipal representative emphasized:

"To build a sustainable approach for increasing e-waste recycling participation and shifting household behaviour, we need ongoing support from everyone involved in waste management. Working together and staying engaged is key to making sure it lasts in the long run."

This underscores the imperative of shared responsibility in advancing sustainable HERS practices. The findings of this study highlight the critical interdependence between HERS and HERB, emphasizing their symbiotic relationship and the necessity of adopting this perspective in household waste recycling management. One of the primary challenges facing policymakers and local authorities is the development of a sustainable reverse logistics system that effectively incorporates household awareness,

knowledge, prior recycling experiences, and attitudes toward waste management. The proposed framework presents a dynamic and adaptable model for policymakers and practitioners, offering strategic insights to refine and enhance recycling initiatives. Achieving a circular economy in e-waste management necessitates a multi-faceted approach, integrating collaboration, technological innovation, and comprehensive policy efforts to ensure long-term sustainability. This research underscores the importance of fostering stakeholder engagement and leveraging systemic synergies to optimize resource recovery and environmental sustainability within the e-waste management sector.

6.4 Limitation and Future Implications

The findings of this study empirically establish the interaction between two distinct factors, HERS and HERB, in shaping household e-waste recycling behaviour. However, a key limitation lies in the duration of the data collection process (12 months), which, while insightful, remains relatively short for capturing long-term behavioural trends. Extending the data collection period could provide a more comprehensive understanding of sustained behavioural patterns and potential fluctuations over time. Therefore, future research would benefit from a longitudinal approach in replication of this study, conducted at multiple intervals over an extended period, to capture temporal variations and assess the stability of the observed effects. Such an approach could yield deeper insights into the long-term sustainability of recycling behaviours, mitigating the risk of overlooking transient shifts or cyclical changes.

Further research should also explore the longitudinal impact of symbiosis effects to determine their persistence and adaptability over time. Additionally, expanding the study to other municipalities across Malaysia and incorporating a broader range of demographic variables, beyond residential areas, age, and gender, could enhance the generalizability of the findings. Examining additional factors such as education level, income, and household composition may reveal previously unexamined influences on e-waste recycling participation. A nuanced understanding of how different socio-economic groups engage with e-waste management could inform targeted interventions and policy adjustments. Furthermore, incorporating demographic and cultural variations into future studies could provide valuable insights into the role of social norms, environmental values, and cultural practices in shaping recycling behaviours. Employing randomized sampling techniques alongside purposive and geographic sampling would further strengthen the robustness and external validity of future research. Beyond household e-waste management, the research framework developed in this study can be extended to other waste streams to explore broader applications in sustainable waste management. Future studies should consider additional situational and personal factors, such as economic incentives, environmental consciousness, and moral responsibility, to refine and expand the framework's applicability. These elements may significantly influence individual decision-making and contribute to more holistic waste management models.

Ultimately, achieving a circular economy in e-waste management necessitates a multifaceted approach that integrates public engagement, policy development, and infrastructure improvements. Future research should assess the scalability of this framework across diverse socio-economic and geographical contexts to evaluate its

broader applicability. Strengthening collaboration among key stakeholders including governments, businesses, and local communities are crucial in fostering a more resilient and efficient e-waste management system. Additionally, investigating the economic, environmental, and social impacts of these systems are essential in ensuring their long-term viability, particularly in an era of rapid technological advancements and evolving consumption patterns.

6.5 Conclusion

This study reinforces the significance of the symbiosis effect, which emerges as a critical enabler in household e-waste recycling management. The dynamic interplay between local stakeholders and householders represented by situational and personal factors, respectively demonstrates a mutually beneficial relationship that enhances the effectiveness of recycling systems. This symbiotic interaction fosters a collaborative ecosystem where policies, infrastructure, and community engagement align to optimize recycling behaviours and environmental outcomes.

In essence, advancing sustainability through reverse logistics in household e-waste recycling management requires a nuanced understanding of this symbiosis effect. The integration of HERS and HERB underscores the interconnectedness of structural enablers and individual actions. By recognising and strengthening these interdependencies, policymakers, industry players, and communities can develop more resilient and adaptive recycling frameworks that not only enhance material recovery but also drive long-term environmental and societal benefits.

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APPENDICES

Appendix A: Sample of questionnaire – Bilingual



QUESTIONNAIRE

REVERSE LOGISTICS SYMBIOSIS OF E-WASTE RECYCLING SYSTEM: AN INVESTIGATION ON STAKEHOLDER'S ENGAGEMENT AND HOUSEHOLD BEHAVIOUR

Dear respondent,

I am Nor Etiqah Md Radzi, PhD student from the School of Technology Management and Logistics (STML) at Universiti Utara Malaysia. Currently, I am conducting a research project studying the engagement and effectiveness of household e-waste recycling systems and household e-waste recycling behaviour.

Therefore, I appreciate your views on the issues of e-waste and grateful to get your cooperation upon the completion of this questionnaire. Your answer from this survey will be used for academic purpose only and your identity will strictly remain confidential.

The survey questions are divided into four main parts:

PART A: Demographics

PART B: Situational Factors (statements with regards to recycling systems)

PART C: Personal Factors (statements with regards to household behaviour)

PART D: Recycling Participation

PART E: Suggestions and Recommendations (an open ended questions)

Please try to fill in the following questions as precise as possible by giving intuitive answers. I appreciate you spending the time to complete this questionnaire and thank you for your consideration.

If you have any questions or concerns, please contact the researcher for this project under the supervision of **Ts. Dr. Emy Ezura A. Jalil** at the stated contact information:

Nor Etiqah Md Radzi

Phone: 011-17568598

Email: nor_etiqah_md@oyagsb.uum.edu.my

PART A: DEMOGRAPHICS

Please tick in the boxes or fill in the blank provided.

1. Gender / *Jantina*

- Male / *Lelaki*
 Female / *Wanita*

2. Age / *Umur*

- 20 years old and below / *20 tahun dan ke bawah*
 21 – 30 years old / *21 – 30 tahun*
 31 – 40 years old / *31 – 40 tahun*
 41 – 50 years old / *41 – 50 tahun*
 51 years old and above / *51 tahun dan ke atas*

3. Marital Status / *Taraf perkahwinan*

- Single / *Bujang*
 Married / *Berkahwin*
 Divorce / *Bercerai*

4. Nationality / *Warganegara*

- Malaysian
 Others / *Lain-lain* _____

5. State your level of academic qualification / *Tahap kelayakan akademik*

- High school / *Sekolah menengah*
 University / *Universiti*
 Professional Certificate / *Sijil Professional*
Others, please specify / *Lain-lain (sila nyatakan)* _____

6. Please choose your current employment status / *Status pekerjaan semasa*

- Student / *Pelajar*
 Government sector / *Sektor kerajaan*
 Private sector / *Sektor swasta*
 Unemployed / *Tidak bekerja*
 Retiree / *Pesara*

7. Please choose or stated your household number / *Jumlah isi rumah*

- Single occupant / *Seorang isi rumah*
 Double occupants / *Dua orang isi rumah*
 3 to 4 occupants / *3 ke 4 orang isi rumah*
Others, please specify / *Lain-lain (sila nyatakan)* _____

8. Current residing state / *Negeri menetap semasa*

- Kedah
 Penang

Others, please specify / *Lain-lain (sila nyatakan)* _____

9. Current residing area / *Kawasan tempat tinggal semasa*

- Urban / *Kawasan bandar*
- Suburban / *Pinggir bandar*
- Rural / *Kawasan luar bandar*

10. Please choose or stated the number of years you have lived in your state / *Sila pilih bilangan tahun anda telah menetap di negeri anda*

- Less than a year / *Kurang daripada setahun*
- 1 to 5 years / *1 ke 5 tahun*
- 6 to 10 years / *6 ke 10 tahun*
- More than 10 years / *Lebih daripada 10 tahun*

11. Type of dwelling / *Jenis kediaman yang didiami*

- Flat / *Rumah flat*
- Apartment or Condominium / *Pangsapuri atau kondominium*
- Terrace or Superlink / *Rumah teres*
- Bungalow / *Rumah banglo*

Others, please specify / *Lain-lain (sila nyatakan)* _____

12. Household income / *Pendapatan isi rumah*

- B40 (RM0 – RM4,850)
- M40 (RM4,851 – RM10,970)
- T20 (RM10,971 and above)

13. On average, how frequent do you buy a new electronic or electrical appliance? / *Secara purata, seberapa kerapkah anda membeli peralatan elektrik atau elektronik baharu?*

- Once in less than 12 months / *Sekali dalam tempoh kurang 12 bulan*
- Once a year / *Sekali dalam tempoh setahun*
- Once in 2 – 3 years / *Sekali dalam tempoh 2 – 3 tahun*
- Once in more than 3 years / *Sekali dalam tempoh lebih 3 tahun*

14. What was your main reason for purchasing new electronic or electrical appliances? / *Apakah faktor utama yang menyebabkan anda memilih untuk membeli peralatan elektronik dan elektrik yang baharu?*

- Loss of function / *Kehilangan fungsi*
- Physical damage / *Kerosakan fizikal*
- Need for greater functionality / *Memerlukan kegunaan yang lebih tinggi*
- Desire for latest technology / *Keinginan memiliki teknologi terbaru*

Others, please specify / *Lain-lain (sila nyatakan)* _____

15. What do you do with your unused electronics and electrical items that are still functioning? / *Apakah yang anda lakukan pada peralatan elektronik dan elektrik yang anda yang tidak lagi digunakan namun masih berfungsi?*

- Kept at home / *Disimpan di rumah*
 - Given or sold to informal system (family, friends, acquaintances on social media etc.) / *Dijual kepada sistem yang tidak formal (keluarga, rakan-rakan, kenalan di sosial media dsb.)*
 - Sold to formal system (shopee, electrical shops, cash converters, etc.) / *Dijual kepada sistem formal (shopee, kedai elektrik, penukar tunai, dll.)*
 - It goes straight to the bin/ *Terus dibuang ke dalam tong sampah*
- Others, please specify / *Lain-lain (sila nyatakan)* _____

16. What do you do with your electronics and electrical items that are NOT functioning? / *Apakah yang anda lakukan pada peralatan elektronik dan elektrik anda yang sudah TIDAK berfungsi?*

- Kept at home / *Disimpan di rumah*
 - Try to repair it / *Cuba untuk dibaiki*
 - Sold to second hand shops / *Dijual di kedai barangan terpakai*
 - Throw away together with daily trash / *Dibuang bersama-sama sampah harian*
 - Disposed it at recycling center / *Dibuang di pusat kitar semula*
 - Burn it at open area / *Bakar di kawasan terbuka*
- Others, please specify / *Lain-lain (sila nyatakan)* _____

17. Have you ever received any information regarding the handling of unused and obsolete electronic and electrical appliances? / *Pernahkah anda menerima sebarang maklumat mengenai cara pengendalian peralatan elektronik dan elektrik yang sudah tidak lagi digunakan dan lama?*

- Yes / *Ya*
- No / *Tidak*

18. Have you heard or know about e-waste? / *Adakah anda pernah mendengar atau mengetahui tentang e-sisa?*

- Yes / *Ya*
- No / *Tidak*

19. Are you aware that electronic and electrical items at your home are made with hazardous materials and chemicals that may cause danger to your health and environment? / *Adakah anda sedar bahawa barangan elektronik dan elektrik di rumah anda diperbuat daripada bahan berbahaya dan bahan kimia yang boleh menyebabkan bahaya kepada kesihatan dan alam sekitar anda?*

- Yes / *Ya*
- No / *Tidak*

20. My residential area has scheduled waste collection. / *Kawasan perumahan sampah terdapat servis kutipan sampah secara berjadual.*

- Yes / *Ya*
- No / *Tidak*

PART B: SITUATIONAL FACTORS

Please tick in the boxes under the numbers that applies.

- 1= Strongly Disagree
- 2= Disagree
- 3= Neutral
- 4= Agree
- 5= Strongly Agree

Statements		1	2	3	4	5
Factor 1: Accessibility and Availability						
1	I would do all that is needed to recycle my personal electronic and electrical waste if the collection centre is closer to my residential area. <i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika pusat pengumpulan lebih dekat dengan kawasan kediaman saya.</i>					
2	I would do all that is needed to recycle my personal electronic and electrical waste if periodic collection services were available in my residential area. <i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika perkhidmatan kutipan berkala tersedia di kawasan kediaman saya.</i>					
3	I would do all that is needed to recycle my personal electronic and electrical waste if the e-waste recycling bins were available in my residential area. <i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika tong kitar semula e-sisa tersedia di kawasan kediaman saya.</i>					
4	I would do all that is needed to recycle my personal electronic and electrical waste if the e-waste collection services were made available by my residence. <i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika perkhidmatan kutipan e-sisa disediakan kepada saya oleh kediaman saya.</i>					
5	If necessary, I would be willing to pay extra for e-waste collections or drop-off centers to be provided by my residential area. <i>Jika perlu, saya bersedia membayar tambahan untuk kutipan e-sisa atau pusat pengumpulan yang akan disediakan oleh kawasan kediaman saya.</i>					
Factor 2: Convenience						
6	I would do all that is needed to recycle my personal electronic and electrical waste if I can walk to the drop-off center. <i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika saya boleh berjalan kaki ke pusat pengumpulan.</i>					

7	<p>It is convenience for me to perform e-waste recycling if the e-waste recycling and drop-off centers are less than 5 kilometers away from my residential area.</p> <p><i>Adalah memudahkan saya untuk melakukan kitar semula sisa elektronik sekiranya pusat kitar semula dan pengumpulan berada kurang daripada 5-kilometer dari kawasan kediaman saya.</i></p>					
8	<p>I often find it difficult to recycle larger household electronic and electrical waste (television, refrigerator, washing machine and etc.)</p> <p><i>Saya selalu merasa sukar untuk mengitar semula sisa elektronik dan elektrik isi rumah yang lebih besar (televisyen, peti sejuk, mesin basuh dan lain-lain).</i></p>					
9	<p>I would do all that is needed to recycle my larger electronic and electrical waste if there were periodic collection services in my residential area.</p> <p><i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik saya yang lebih besar jika terdapat perkhidmatan kutipan berkala di kawasan kediaman saya.</i></p>					
10	<p>I would do all that is needed to recycle my personal electronic and electrical waste if the collection and drop-off centers closer by my residence.</p> <p><i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika pusat pengumpulan berdekatan dengan kediaman saya.</i></p>					
Factor 3: Engagement						
11	<p>I would do all that is needed to recycle my personal electronic and electrical waste if the government really enforce the laws and regulations related to e-waste recycling.</p> <p><i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika kerajaan benar-benar menguatkuasakan undang-undang dan peraturan yang berkaitan dengan kitar semula e- sisa.</i></p>					
12	<p>I would do all that is needed to recycle my personal electronic and electrical waste if government or non-governmental organizations provides all the necessary facilities by my residential area.</p> <p><i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika kerajaan benar-benar menguatkuasakan undang-undang dan peraturan yang berkaitan dengan kitar semula e-sisa.menguatkuasakan undang-undang dan peraturan yang berkaitan dengan kitar semula e-sisa.</i></p>					
13	<p>Awareness programs on household e-waste recycling held by government or non-governmental organizations influenced me to recycle my personal electronic and electrical equipment.</p> <p><i>Program kesedaran tentang kitar semula e-sisa isi rumah yang diadakan oleh organisasi kerajaan atau bukan kerajaan mempengaruhi saya untuk mengitar semula peralatan elektronik dan elektrik peribadi saya.</i></p>					

14	<p>My local authority provides detail collection and drop-off centers about household e-waste recycling on their websites (location, periodic time table, e-waste categories and etc.)</p> <p><i>Pihak berkuasa tempatan saya menyediakan pusat pengumpulan dan penghantaran terperinci tentang kitar semula e-sisa isi rumah di laman web mereka (lokasi, jadual masa berkala, kategori e-sisa dan lain-lain.)</i></p>						
15	<p>I would do all that is needed to recycle my personal electronic and electrical waste if government or non-governmental organizations provides monetary or non-monetary rewards upon e-waste recycling (coupons, cash vouchers and etc.)</p> <p><i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika kerajaan atau pertubuhan bukan kerajaan menyediakan ganjaran kewangan atau bukan kewangan apabila kitar semula e-sisa (kupon, baucar tunai dan lain-lain)</i></p>						
Factor 4: Advertising							
16	<p>I would do all that is needed to recycle my personal electronic and electrical waste if the media provides information on e-waste recycling (televisions, radio, social media and etc.)</p> <p><i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika media menyediakan maklumat tentang kitar semula e-sisa (televisyen, radio, media sosial dan lain-lain)</i></p>						
17	<p>The media influences me to recycle my household electronic and electrical waste.</p> <p><i>Media mempengaruhi saya untuk mengitar semula sisa elektronik dan elektrik rumah saya.</i></p>						
18	<p>I can find out all details on e-waste recycling through my local council's webpage.</p> <p><i>Saya boleh mengetahui semua butiran tentang kitar semula e-sisa melalui halaman web majlis tempatan saya.</i></p>						
19	<p>I would do all that is needed to recycle my personal electronic and electrical waste if the government held an awareness campaign on household e-waste recycling.</p> <p><i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika kerajaan mengadakan kempen kesedaran tentang kitar semula e-sisa bagi isi rumah.</i></p>						
20	<p>Non-governmental Organizations (NGO) are my major sources of information if I were to find out about detail information on household e-waste recycling.</p> <p><i>Badan Bukan Kerajaan (NGO) adalah sumber maklumat utama saya jika saya ingin mengetahui maklumat terperinci tentang kitar semula e-sisa bagi isi rumah.</i></p>						
Factor 5: Education							
21	<p>I would do all that is needed to recycle my personal electronic and electrical waste if I have received primary knowledge on e-waste recycling from my school years.</p>						

	<i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika saya telah mendapat pengetahuan asas tentang kitar semula e-sisa dari zaman sekolah saya.</i>					
22	Lack of knowledge about household e-waste recycling procedure is the reason householders did not recycle their personal electronic and electrical waste. <i>Kurang pengetahuan tentang prosedur kitar semula e-sisa bagi isi rumah adalah punca isi rumah tidak mengitar semula sisa elektronik dan elektrik peribadi mereka.</i>					
23	Government should introduce a specific program on handling household e-waste to educate the youngsters. <i>Kerajaan harus memperkenalkan program khusus pengendalian e-sisa bagi isi rumah untuk mendidik anak-anak muda.</i>					
24	Recycling awareness should be commenced during the school curriculum. <i>Kesedaran kitar semula harus diperkenalkan Ketika menjalankan kurikulum sekolah.</i>					
25	Parents are responsible to indicate a good household e-waste recycling behaviour towards their children. <i>Ibu bapa bertanggungjawab menunjukkan tingkah laku kitar semula e-sisa rumah yang baik terhadap anak-anak mereka.</i>					
Factor 6: Policy and Regulations						
26	I am aware about the existing state law concerning the issue of e- waste recycling. <i>Saya tahu dan sedar tentang undang-undang negara sedia ada yang berkaitan dengan e-waste.</i>					
27	I think intervention by the government is necessary to curb the e-waste issues. <i>Saya percaya penglibatan pihak kerajaan perlu melakukan langkah pencegahan untuk membendung isu e-waste.</i>					
28	I think intervention by the non-government is necessary to curb the e-waste issues. <i>Saya percaya penglibatan pihak bukan kerajaan perlu melakukan langkah pencegahan untuk membendung isu e-waste.</i>					
29	I am aware of the sanctions and penalties from local authorities about improper disposal of e-waste. <i>Saya sedar tentang sekatan dan penalti daripada pihak berkuasa tempatan mengenai pelupusan e-sisa secara tidak wajar.</i>					
30	Rather than citizens, authorities are the one whom responsible to manage e-waste issues. <i>Berbanding rakyat, pihak berkuasa adalah pihak yang sepatutnya bertanggungjawab untuk menguruskan isu e-sisa</i>					

PART C: PERSONAL FACTORS

Please tick in the boxes under the numbers that applies.

1= Strongly Disagree

2= Disagree

3= Neutral

4= Agree

5= Strongly Agree

Statements	1	2	3	4	5
Factor 1: Attitude					
1	It makes me very satisfied if I do all that is needed to recycle my personal electronic and electrical waste. <i>Saya akan berasa sangat berpuas hati jika saya melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya.</i>				
2	I believed that everyone is responsible to recycle their personal electronic and electrical waste. <i>Saya percaya bahawa semua orang bertanggungjawab untuk mengitar semula sisa elektronik dan elektrik peribadi mereka.</i>				
3	I believed that I have to contribute my energy in managing my personal electronic and electrical waste properly. <i>Saya percaya bahawa saya perlu menyumbang masa saya dalam menguruskan sisa elektronik dan elektrik peribadi saya dengan betul.</i>				
4	I believed that both myself and stakeholders are responsible managing household electronic and electrical waste (government and non-governmental organizations). <i>Saya percaya bahawa saya dan pihak berkepentingan bertanggungjawab menguruskan sisa elektronik dan elektrik isi rumah (pertubuhan kerajaan dan bukan kerajaan).</i>				
5	Generally, e-waste recycling is beneficial for both society and the environment. <i>Secara amnya, kitar semula e-sisa bermanfaat untuk masyarakat dan alam sekitar.</i>				
Factor 2: Social Norms					
6	I would do all that is needed to recycle my personal electronic and electrical waste once a week. <i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya sekali seminggu.</i>				
7	I usually recycle my household electronic and electrical waste in the exact same location. <i>Saya biasanya mengitar semula sisa elektronik dan elektrik isi rumah saya di lokasi yang sama.</i>				
8	It makes me feel weird and uncomfortable if I do not do all that is needed to recycle my personal electronic and electrical waste. <i>Saya akan berasa sangat tidak selesa jika saya tidak melakukan semua yang diperlukan untuk mengitar semula</i>				

	<i>sisa elektronik dan elektrik peribadi saya.</i>						
9	I do all that is needed to recycle my household electronic and electrical waste without needing to think about it. <i>Saya melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik isi rumah saya tanpa perlu memikirkannya.</i>						
10	I would do all that is needed to recycle my personal electronic and electrical waste if the people around me involved in e-waste recycling. <i>Saya akan melakukan semua yang diperlukan untuk mengitar semula sisa elektronik dan elektrik peribadi saya jika orang di sekeliling saya terlibat dalam kitar semula e-sisa.</i>						
Factor 3: Knowledge and Experience							
11	Recycling household electronic and electrical items is the main way to reduce the use of landfills and emissions of greenhouse gasses. <i>Kitar semula barangan elektronik dan elektrik isi rumah adalah cara utama untuk mengurangkan penggunaan tapak pelupusan sampah dan pelepasan gas rumah hijau.</i>						
12	Recycling household electronic and electrical items is very much useful to create a better community environment. <i>Kitar semula barangan elektronik dan elektrik isi rumah amat berguna untuk mewujudkan persekitaran komuniti yang lebih baik.</i>						
13	Recycling household electronic and electrical items can help to improve the quality of the environment. <i>Kitar semula barangan elektronik dan elektrik isi rumah boleh membantu meningkatkan kualiti alam sekitar.</i>						
14	I am knowledgeable about the electronic and electrical items that were suitable for recycling. <i>Saya berpengetahuan tentang barangan elektronik dan elektrik yang sesuai untuk dikitar semula.</i>						
15	I believe valuable materials from recycled e-waste could be used to make new products. <i>Saya percaya bahan berharga daripada e-waste kitar semula boleh digunakan untuk membuat produk baharu.</i>						
Factor 4: Awareness							
16	I believed that performing e-waste recycling imposed positive environmental impacts. <i>Saya percaya pengitaran semula e-sisa memberi impak positif kepada alam sekitar.</i>						
17	I believed that performing e-waste recycling helps to protect human health and the environment. <i>Saya percaya bahawa melaksanakan kitar semula e-sisa membantu melindungi kesihatan manusia dan alam sekitar.</i>						
18	I believed that performing e-waste recycling helps to reduce carbon footprint and reduces the dependency of landfills. <i>Saya percaya bahawa melaksanakan kitar semula e-sisa</i>						

	<i>membantu mengurangkan kesan karbon dan mengurangkan kebergantungan kepada tapak pelupusan sampah.</i>					
19	Improper management in e-waste disposal is harmful to the environment. <i>Pengurusan yang tidak betul dalam pelupusan e-sisa memudaratkan alam sekitar.</i>					
20	All electronic and electrical waste contains harmful substances. <i>Semua sisa elektronik dan elektrik mengandungi bahan berbahaya.</i>					
Factor 5: Psychological Ownership						
21	I prefer to keep my electronics and electrical items that are no longer in used for sentimental/nostalgic reasons. <i>Saya lebih memilih untuk menyimpan barangan elektronik dan elektrik saya yang tidak lagi digunakan atas sebab-sebab sentimental.</i>					
22	I prefer to recycle my old electronics and electrical items to ensure it will be treated in appropriate way. <i>Saya lebih memilih untuk mengitar semula barangan elektronik dan elektrik lama saya untuk memastikan ia akan dirawat dengan cara yang sesuai</i>					
23	I prefer to give my old electronics and electrical items to my close family/friends so I can still see it sometimes. <i>Saya lebih memilih untuk memberikan barangan elektronik dan elektrik lama saya kepada keluarga/rakan rapat saya supaya kadangkala saya masih boleh melihatnya.</i>					
24	I prefer to keep my broken electronic and electrical items as a collection. <i>Saya lebih suka menyimpan barangan elektronik dan elektrik saya yang sudah rosak untuk dijadikan sebagai koleksi.</i>					

PART D: RECYCLING PARTICIPATION

Please tick in the boxes under the numbers that applies.

1= Strongly Disagree

2= Disagree

3= Neutral

4= Agree

5= Strongly Agree

Statements	1	2	3	4	5
<p>1 I would definitely recycle my personal electronic and electrical waste if I received detail information on the important of e-waste recycling in protecting human health and the environment. <i>Saya pasti akan mengitar semula sisa elektronik dan elektrik peribadi saya jika saya menerima maklumat dan kesedaran tentang pentingnya kitar semula e-sisa dalam melindungi kesihatan manusia dan alam sekitar.</i></p>					
<p>2 I would definitely increase my effort to recycle household electronic and electrical equipment if my residential authority provides more e-waste recycling services. <i>Saya pasti akan meningkatkan usaha saya untuk mengitar semula peralatan elektronik dan elektrik isi rumah jika pihak berkuasa kediaman saya menyediakan lebih banyak perkhidmatan kitar semula e-sisa.</i></p>					
<p>3 I would definitely perform household e-waste recycling if there were more media exposure provides by the stakeholders on e-waste recycling. <i>Saya pasti akan melaksanakan kitar semula e-sisa isi rumah sekiranya terdapat lebih banyak pendedahan media yang disediakan oleh pihak berkepentingan mengenai kitar semula e-sisa.</i></p>					
<p>4 I would recycle my personal electronic and electrical waste if my local authority provided a simple, informative procedure for recycling household e-waste. <i>Saya pasti akan mengitar semula sisa elektronik dan elektrik peribadi saya jika pihak berkuasa tempatan saya menyediakan prosedur bermaklumat mudah tentang kitar semula e-sisa bagi isi rumah</i></p>					

PART E: SUGGESTIONS / RECOMMENDATIONS

- 1) What suggestions, if any, do you have to improve the e-waste recycling systems at your residential area? / *Apakah cadangan, jika ada, anda rasa menjadi keperluan untuk menambah baik sistem kitar semula e-sisa di kawasan kediaman anda?*

.....

.....

- 2) Are there any comments you would like to make about the e-waste recycling systems in Malaysia? / *Adakah terdapat sebarang komen yang anda ingin berikan tentang sistem kitar semula e-sisa di Malaysia?*

.....

.....



Appendix B1: Template of invitation letter for FGD



PUSAT PENGAJIAN PENGURUSAN TEKNOLOGI DAN LOGISTIK
SCHOOL OF TECHNOLOGY MANAGEMENT AND LOGISTICS (STML)
Kolej Perniagaan
Universiti Utara Malaysia
06010 UUM SINTOK
KEDAH DARUL AMAN
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Ruj: FRGS/1/2020/SS0/UUM/02/4/webinar(14)
Tarikh : 29.12.2022

Expert Discussant Unit

Dear xxx,

INVITATION AS EXPERT DISCUSSANT IN OUR FOCUS GROUP SESSION: E-WASTE FROM THE SOURCE

I kindly refer to the above matter.

2. With great pleasure, we are pleased to invite an expert discussant from your department **for the 1st session in our Focus Group Session: E-Waste from the Source** which will be held on the **18th of January, 2023**. The discussion will be held through a virtual platform via Webex application. The target audience for this focus group are industrial players, stakeholders within the e-waste landscape and the public. The Webex link of this session will later be provided via email.

3. The purpose of this focus group session is to understand the relationship between current issues and treatments of household recycling waste systems performed by your organization mainly on e-waste. The research team is seeking your comments and perspectives on current e-waste recycling systems. We would appreciate your views on the issues and your assistance is critical for a better understanding of recycling behaviour in Malaysia. The objectives of the roundtable discussion are as follows:

- i. To understand the current level of engagement between stakeholders for households in managing e-waste.
- ii. To explore the e-waste narratives from various stakeholders.
- iii. To engage stakeholders within the e-waste landscape.

4. As attached in this letter is the tentative of the focus group session for your perusal.

Thank you.

(Ts. Emy Ezura A Jalil, PhD CMILT ISWA)
Leader of Focus Group Session

CC. Dean, STML
Secretariat Living Campus Director

Universiti Pengurusan Terkemuka
The Eminent Management University



Appendix B2: Interview consent form



INTERVIEW CONSENT FORM

Focus Group Discussion with Stakeholders: E-waste from the Source

I from
(name of the discussant) (name of the organization)

hereby agree to be an informant in this study to be undertaken by Nor Etiqah binti Md Radzi under the supervision of Ts. Dr. Emy Ezura A. Jalil, and

I understand that the purpose of the research is to understand the current level of stakeholders' engagement and effectiveness of household e-waste recycling systems and household e-waste recycling behaviour.

I hereby understand the mentioned statement as below:

1. I confirm that I have read and understand the intent and purpose of this study.
2. I am aware that my participation as informant in this interview is voluntary and if, for any reason, at any time, I wish to withdraw, I may do so without having to give an explanation.
3. I expect that any confidential disclosures I make to researcher will be preserved and respected.
4. I understand that aggregated results will be used for research purposes and may be reported in scientific and academic journal.
5. Individual results will not be released to any person except at my request and on my authorisation.
6. I understand the process of the discussion for every session will be recorded.

Signature: _____

(Informant)

Signature: _____

(Researcher)

Appendix B3: Interview protocol



INTERVIEW PROTOCOL

Reverse Logistics Symbiosis of E-Waste Recycling System: An Investigation on Stakeholder's Engagement and Household Behaviour

Date :
State / Area :
Households / Stakeholders :

Introductory Protocol

To facilitate our note-taking, we would like to audio tape our conversations today. For your information, only researchers on the project will be privy to the tapes which will be eventually destroyed after they are transcribed. In addition, you must sign a consent form devised to meet our human subject requirements. Essentially, this document states that: (1) all information will be held confidential, (2) your participation is voluntary and you may stop at any time if you feel uncomfortable, and (3) this interviews session do not intend to inflict any harm. Thank you for your agreeing to participate.

We have planned this interview to last no longer than one hour. During this time, we have several questions that we would like to cover. If time begins to run short, it may be necessary to interrupt you in order to push ahead and complete this line of questioning.

Introduction

The purpose of this research is to understand the level of engagement between current household e-waste recycling **systems** and household e-waste recycling **behaviour**. It also reveals different determinants associated with household e-waste recycling systems and household e-waste recycling behaviour and how household behaviour affects the provision of household e-waste recycling systems by the authorities/stakeholders. You have been selected to be interviewed today because you have been identified as someone who has a great deal and experience to share about the e-waste recycling systems and household behaviour in Malaysia. The information you agreed to provide in this interview will be useful I revealing and explaining the interaction and level of engagement (symbiosis effects) between both household e-waste recycling systems and household e-waste recycling behaviour.

**Appendix B4: Guideline for semi-structured interview questions (Householders)
- Bilingual**

SEMI-STRUCTURED INTERVIEW QUESTIONS (FOR HOUSEHOLDERS)

Topic		Discussion Questions	Responses
A	Preliminary		
1.	On average, how frequent do you buy a new electronic or electrical appliance? <i>Secara purata, berapa kerap anda membeli peralatan elektronik atau elektrik baharu?</i>		
2.	What was your main reason for purchasing new electronic or electrical appliances? <i>Apakah sebab utama anda membeli peralatan elektronik atau elektrik baharu?</i>		
3.	Have you heard or know about e-waste? <i>Pernahkah anda mendengar atau mengetahui tentang e-sisa?</i>		
B	Situational Factors (Recycling Systems)		
	RQ1. How does the situational factors influence households to participate in e-waste recycling in Malaysia?		
	i. Accessibility and Availability		
4.	Do you believe that placing e-waste recycling facilities close to residential areas will encourage people to recycle their e-waste? <i>Adakah anda percaya bahawa meletakkan kemudahan kitar semula e-sisa berdekatan dengan kawasan kediaman akan menggalakkan orang ramai untuk mengitar semula e-sisa mereka?</i>		
5.	Do you think that the factor of accessibility and availability can influences households to recycle e-waste? How? <i>Adakah anda berpendapat bahawa faktor kebolehcapaian dan ketersediaan boleh mempengaruhi isi rumah untuk mengitar semula e-sisa? Bagaimana?</i>		
	ii. Convenience		
6.	Do you believe that you can recycle your household's e-waste easily with the current systems? Is it convenient to you? <i>Adakah anda percaya bahawa anda boleh mengitar semula sisa elektronik isi rumah anda dengan mudah dengan sistem semasa? Adakah ia selesa untuk anda?</i>		
7.	Which e-waste recycling system did you find most convenient? Either the facilities or the services offered? <i>Sistem kitar semula e-sisa manakah yang anda rasa paling mudah? Sama ada kemudahan atau perkhidmatan yang ditawarkan?</i>		
8.	What would you do with your e-waste if the e-waste recycling systems offered (either facilities or services) were not convenient? Why? <i>Apakah yang akan anda lakukan dengan e-sisa anda jika sistem kitar semula e-sisa yang ditawarkan (sama ada kemudahan atau perkhidmatan) tidak mudah? kenapa?</i>		
9.	Do you think that convenience can influences households to recycle e-waste? Why? <i>Adakah anda berpendapat bahawa kemudahan boleh mempengaruhi isi rumah untuk mengitar semula e-sisa? kenapa?</i>		
	iii. Engagement		
10.	Stakeholders' engagement was proven to motivate households to recycle their e-waste. What are your comments on the stakeholders? <i>Penglibatan pihak berkepentingan terbukti mendorong isi rumah untuk mengitar semula e-sisa mereka. Apakah komen anda tentang pihak berkepentingan?</i>		
11.	Is there any scheduled waste collection in your area provided by your local government? Are there any drop-off or e-waste collection centers in your area? <i>Adakah terdapat kutipan sisa berjadual di kawasan anda yang disediakan oleh kerajaan tempatan anda? Adakah terdapat pusat pengumpulan atau pengumpulan e-sisa di kawasan anda?</i>		
12.	What are the activities related to e-waste recycling made by the stakeholders (government or NGO) that you are aware of? Do the activities influence you to recycle your e-waste? <i>Apakah aktiviti berkaitan kitar semula e-waste yang dibuat oleh pihak berkepentingan (kerajaan atau NGO) yang anda sedia maklum? Adakah aktiviti mempengaruhi anda untuk mengitar semula e-waste anda?</i>		
	iv. Advertising		
13.	Do you think that advertising about any related information on e-waste recycling can influences households to recycle e-waste? How? <i>Adakah anda fikir pengiklanan tentang sebarang maklumat berkaitan kitar semula e-waste boleh mempengaruhi isi rumah untuk mengitar semula e-sisa? Bagaimana?</i>		
	v. Education		

14.	Do you think it is relevant if the government introduce specific programs on handling e-waste to educate the youngster or perhaps at school or university? Why? <i>Adakah anda fikir adalah relevan jika kerajaan memperkenalkan program khusus pengendalian e-waste untuk mendidik anak muda atau mungkin di sekolah atau universiti? kenapa?</i>	
vi. Policy and Regulations		
15.	Do you think having a good policy and enforcement on e-waste recycling law is important to influence household e-waste recycling behaviour? Why? <i>Adakah anda fikir mempunyai dasar dan penguatkuasaan yang baik terhadap undang-undang kitar semula e-waste adalah penting untuk mempengaruhi tingkah laku kitar semula e-waste isi rumah? kenapa?</i>	
C Personal Factors (Household Behaviour) RQ2. How does the personal factors influence households to participate in e-waste recycling in Malaysia?		
i. Attitude		
16.	Do you believe exhibiting environmentally friendly behaviour can encourage people to recycle? Why? <i>Adakah anda percaya mempamerkan tingkah laku mesra alam boleh menggalakkan orang ramai untuk mengitar semula? kenapa?</i>	
ii. Social Norms		
17.	Do you think your family members or housemates influence your e-waste recycling behaviour? How? Why? <i>Adakah anda fikir ahli keluarga atau rakan serumah anda mempengaruhi tingkah laku kitar semula e-waste anda? Bagaimana? kenapa?</i>	
18.	Do you think that people who are closer to you can influence you recycling behaviour? How? Why? <i>Adakah anda fikir orang yang lebih rapat dengan anda boleh mempengaruhi tingkah laku kitar semula anda? Bagaimana?</i>	
iii. Knowledge and Experience		
19.	Do you think knowledge is gained through family norms? <i>Adakah anda fikir ilmu diperolehi melalui norma keluarga?</i>	
20.	Do you think people will continue recycling if they have some experience doing it? Why? <i>Adakah anda fikir orang akan terus mengitar semula jika mereka mempunyai pengalaman melakukannya? kenapa?</i>	
iv. Awareness		
21.	Have you ever received any information regarding the handling of unused and obsolete electronic and electrical appliances? Where have you heard or knew about it? <i>Pernahkah anda menerima sebarang maklumat mengenai pengendalian peralatan elektronik dan elektrik yang tidak digunakan dan usang? Di manakah anda pernah mendengar atau mengetahui tentangnya?</i>	
22.	Are you aware that electronic and electrical items at your home are made with hazardous materials and chemicals that may cause danger to your health and environment? <i>Adakah anda sedar bahawa barangan elektronik dan elektrik di rumah anda diperbuat daripada bahan berbahaya dan bahan kimia yang boleh menyebabkan bahaya kepada kesihatan dan alam sekitar anda?</i>	
23.	What kinds of recycling information would be most helpful to you? Probe for communication tools flyers, TV, radio, social media, etc. <i>Apakah jenis maklumat kitar semula yang paling berguna kepada anda? Siasatan untuk risalah alat komunikasi, TV, radio, media sosial, dsb.</i>	
v. Psychological Ownership		
24.	What do you do with your unused electronics and electrical items that are still functioning? <i>Apa yang anda lakukan dengan barangan elektronik dan elektrik anda yang tidak digunakan yang masih berfungsi?</i>	
25.	What do you do with your electronics and electrical items that are NOT functioning? <i>Apa yang anda lakukan dengan barangan elektronik dan elektrik anda yang TIDAK berfungsi?</i>	
26.	Do you think psychological ownership influence people to recycle their electrical products? Why? <i>Adakah anda fikir pemilikan psikologi mempengaruhi orang ramai untuk mengitar semula produk elektrik mereka? kenapa?</i>	
D Symbiosis Effects RQ3. How does the interactions between situational and personal factors can support the existence of symbiosis effects between HERS and HERB?		
27.	Do you believe that societies and authorities are mutually benefitting each other by living in the same countries? How and why? <i>Adakah anda percaya bahawa masyarakat dan pihak berkuasa saling menguntungkan antara satu sama lain dengan tinggal di negara yang sama? Bagaimana dan mengapa?</i>	
28.	Do you believe that both stakeholders and households are mutually interdependent in providing an excellent e-waste recycling system? Why? <i>Adakah anda percaya bahawa kedua-dua pihak berkepentingan dan isi rumah saling bergantung</i>	

	<i>antara satu sama lain dalam menyediakan sistem kitar semula e-sisa yang sangat baik? kenapa?</i>	
29.	Do you think the stakeholders have to provide the e-waste recycling systems first in order to influence households to recycle their e-waste? Why? <i>Adakah anda fikir pihak berkepentingan perlu menyediakan sistem kitar semula e-waste terlebih dahulu untuk mempengaruhi isi rumah untuk mengitar semula e-waste mereka? kenapa?</i>	
30.	Do you think that households are the important entities to use all provided systems or facilities made by the government? Why? <i>Adakah anda berpendapat bahawa isi rumah adalah entiti penting untuk menggunakan semua sistem atau kemudahan yang disediakan oleh kerajaan? kenapa?</i>	
E	Demographic profiles as moderating variable RQ4. Does the interactions between both factors (situational and personal) and household e-waste recycling participation vary depending on demographic profiles?	
31.	Which gender do you think are prone to recycle? Male or female? Why? <i>Jantina manakah yang anda fikir cenderung untuk mengitar semula? Lelaki atau perempuan? kenapa?</i>	
32.	Which group—those living in wealthy neighborhoods or in less wealthy neighborhoods—do you think is more likely to recycle effectively? Why? <i>Kumpulan manakah—mereka yang tinggal di kawasan kejiranan kaya atau di kawasan kejiranan kurang kaya—adakah anda fikir lebih berkemungkinan untuk mengitar semula dengan berkesan? kenapa?</i>	
33.	Do you believe that certain demographic profiles (age, gender, income, residential area, nature of living, etc.) influence household e-waste recycling behaviour? Which demographics do you think the most influential and why? <i>Adakah anda percaya bahawa profil demografi tertentu (umur, jantina, pendapatan, kawasan kediaman, alam kediaman, dsb.) mempengaruhi tingkah laku kitar semula e-sisa isi rumah? Demografi manakah yang anda fikir paling berpengaruh dan mengapa?</i>	
F	Closing	
	Post interview comments and/or observations. Thanking the informants.	

Appendix B5: Guideline for semi-structured interview questions (Stakeholders) - Bilingual

SEMI-STRUCTURED INTERVIEW QUESTIONS (FOR STAKEHOLDERS)

Topic	Discussion Questions	Responses
A	Preliminary	
1.	Do you think Malaysia is actually ready in regards of handling e-waste from the source? Why or why not? <i>Adakah anda fikir Malaysia sebenarnya sudah bersedia dalam hal pengendalian e-waste dari sumbernya? Mengapa atau mengapa tidak?</i>	
2.	What is the current trend on Malaysian e-waste consumption? What about in Kedah and Penang? <i>Apakah trend semasa penggunaan e-waste Malaysia? Bagaimana pula di Kedah dan Pulau Pinang?</i>	
3.	Do we need a more strategic plan in handling e-waste from the source? <i>Adakah kita memerlukan pelan yang lebih strategik dalam mengendalikan e-waste dari sumbernya?</i>	
4.	Do you think the impacts from e-waste issues in Malaysia is critical? Why? <i>Adakah anda fikir kesan daripada isu e-waste di Malaysia adalah kritikal? kenapa?</i>	
B	Situational Factors (Recycling Systems) RQ1. How does the situational factors influence households to participate in e-waste recycling in Malaysia?	
	vii. Accessibility and Availability	
5.	Do you think Malaysia already prepared in regards infrastructure and facilities to address this issue? What about in Kedah / Penang? <i>Adakah anda fikir Malaysia sudah bersedia dari segi infrastruktur dan kemudahan untuk menangani isu ini? Bagaimana pula di Kedah / Pulau Pinang?</i>	
6.	Do you think government should provide proper channels for e-waste such as drop-off bins and walkable collection center. Do you think the government should provide it through KPKT? <i>Adakah anda fikir kerajaan perlu menyediakan saluran yang sesuai untuk e-sisa seperti tong sampah dan pusat pengumpulan boleh berjalan kaki. Adakah anda rasa kerajaan patut menyediakannya melalui KPKT?</i>	
7.	Do you think that the factor of accessibility and availability can influences households to recycle e-waste? How? <i>Adakah anda berpendapat bahawa faktor kebolehcapaian dan ketersediaan boleh mempengaruhi isi rumah untuk mengitar semula e-sisa? Bagaimana?</i>	
	viii. Convenience	
8.	Which e-waste recycling system did you find most convenient? Either the facilities or the services offered? What should be change?	

	<i>Sistem kitar semula e-waste manakah yang anda rasa paling mudah? Sama ada kemudahan atau perkhidmatan yang ditawarkan? Apa yang patut diubah?</i>	
9.	What would your organization if the e-waste recycling systems offered (either facilities or services) were not convenient? Why? <i>Apakah yang akan dilakukan oleh organisasi anda jika sistem kitar semula e-waste yang ditawarkan (sama ada kemudahan atau perkhidmatan) tidak sesuai? kenapa?</i>	
10.	Do you think that convenience can influences households to recycle e-waste? Why? <i>Adakah anda berpendapat bahawa kemudahan boleh mempengaruhi isi rumah untuk mengitar semula e-waste? kenapa?</i>	
ix. Engagement		
11.	Stakeholders' engagement was proven to motivate households to recycle their e-waste. What are your comments on the stakeholders? <i>Penglibatan pihak berkepentingan terbukti mendorong isi rumah untuk mengitar semula e-sisa mereka. Apakah komen anda tentang pihak berkepentingan?</i>	
12.	NGO are found to be more engaged in e-waste issues. What are your comments on this? <i>NGO didapati lebih terlibat dalam isu e-waste. Apa komen anda tentang ini?</i>	
13.	What are the activities related to e-waste recycling made by the stakeholders (government or NGO)? Do the programs handled really influence household to recycle your e-waste? <i>Apakah aktiviti yang berkaitan dengan kitar semula e-waste yang dibuat oleh pihak berkepentingan (kerajaan atau NGO)? Adakah program yang dikendalikan benar-benar mempengaruhi isi rumah untuk mengitar semula e-sisa anda?</i>	
15.	Do you think that the strategic plan in handling e-waste need to be more holistic and standardized for all states in Malaysia? What is the best way? <i>Adakah anda berpendapat bahawa pelan strategik dalam pengendalian e-waste perlu lebih holistik and standard untuk semua negeri di Malaysia? Apakah cara terbaik?</i>	
x. Advertising		
16.	Do you think that advertising about any related information on e-waste recycling can influences households to recycle e-waste? How? Is the current information provided enough in reaching the public? <i>Adakah anda fikir pengiklanan tentang sebarang maklumat berkaitan kitar semula e-waste boleh mempengaruhi isi rumah untuk mengitar semula e-waste? Bagaimana? Adakah maklumat semasa yang diberikan cukup untuk sampai kepada orang ramai?</i>	
xi. Education		
17.	How to educate household in e-waste recycling from the sources? Where can/should we start? <i>Bagaimana untuk mendidik isi rumah dalam kitar semula e-waste daripada sumber? Di mana boleh/harus kita mulakan?</i>	
18.	Do you think it is relevant if the government introduce specific programs on handling e-waste to educate the youngster or perhaps at school or university? Why? <i>Adakah anda fikir adalah relevan jika kerajaan memperkenalkan program khusus pengendalian e-waste untuk mendidik anak muda atau mungkin di sekolah atau universiti? kenapa?</i>	
xii. Policy and Regulations		
19.	Do you think having a good policy and enforcement on e-waste recycling law is important to influence household e-waste recycling behaviour? Why? <i>Adakah anda fikir mempunyai dasar dan penguatkuasaan yang baik terhadap undang-undang kitar semula e-waste adalah penting untuk mempengaruhi tingkah laku kitar semula e-waste isi rumah? kenapa?</i>	
20.	Waste separation act exist a few years ago but we are still struggling to achieve a higher separation rate. How important is it in relation with e-waste? <i>Akta pengasingan sisa wujud beberapa tahun lalu tetapi kami masih bergelut untuk mencapai kadar pengasingan yang lebih tinggi. Sejauh manakah ianya penting berhubung dengan e-waste?</i>	
21.	Will government provide a recycling subsidy rate to the e-waste collection center? How? <i>Adakah kerajaan akan memberikan kadar subsidi kitar semula kepada pusat pengumpulan e-waste? Bagaimana?</i>	
22.	What do you think about current regulation relevant to e-waste? <i>Apakah pendapat anda tentang peraturan semasa yang berkaitan dengan e-waste?</i>	
C Personal Factors (Household Behaviour)		
RQ2. How does the personal factors influence households to participate in e-waste recycling in Malaysia?		
vi. Attitude		
23.	Do you believe exhibiting environmentally friendly behaviour can encourage household to recycle? Why? <i>Adakah anda percaya mempamerkan tingkah laku mesra alam boleh menggalakkan isi rumah untuk mengitar semula? kenapa?</i>	
24.	Managing e-waste from the source were found to be more necessity rather than voluntary. What is your comment on this? <i>Menguruskan e-waste daripada sumber didapati lebih merupakan keperluan dan bukannya sukarela. Apa komen anda tentang ini?</i>	
vii. Social Norms		
25.	What are the different between rural and urban residence in regard to this small e-waste? <i>Apakah perbezaan antara kediaman luar bandar dan bandar berkaitan dengan e-sisa kecil ini?</i>	
26.	How can we influence behaviour to contribute in e-waste management? <i>Bagaimanakah kita boleh mempengaruhi tingkah laku untuk menyumbang dalam pengurusan e-sisa?</i>	
viii. Knowledge and Experience		
27.	Do you think knowledge in handling e-waste is gained through family norms / close relationship?	

	<i>Adakah anda rasa pengetahuan dalam pengendalian e-waste diperoleh melalui norma kekeluargaan/hubungan rapat?</i>	
28.	Do you think people will continue recycling if they have some experience doing it? Why? <i>Adakah anda fikir orang akan terus mengitar semula jika mereka mempunyai pengalaman melakukannya? kenapa?</i>	
ix. Awareness		
29.	There were several awareness programs for e-waste. Are Malaysian (household) aware of the e-waste disposal? Do you agree that Malaysian had low awareness on e-waste? <i>Terdapat beberapa program kesedaran untuk e-waste. Adakah rakyat Malaysia (isi rumah) sedar tentang pelupusan e-waste? Adakah anda bersetuju bahawa rakyat Malaysia mempunyai kesedaran yang rendah terhadap e-sisa?</i>	
x. Psychological Ownership		
30.	Do you think psychological ownership influence people to recycle their electrical products? Why? <i>Adakah anda fikir pemilikan psikologi mempengaruhi orang ramai untuk mengitar semula produk elektrik mereka? kenapa?</i>	
D Symbiosis Effects RQ3. How does the interactions between situational and personal factors can support the existence of symbiosis effects between HERS and HERB?		
31.	Do you believe that societies and authorities are mutually benefitting each other by living in the same countries? How and why? <i>Adakah anda percaya bahawa masyarakat dan pihak berkuasa saling menguntungkan antara satu sama lain dengan tinggal di negara yang sama? Bagaimana dan mengapa?</i>	
32.	Based on your experience in handling household waste, any difference between 5 years ago and current situation? How engaged were the stakeholders I addressing the issue? <i>Berdasarkan pengalaman anda dalam mengendalikan sisa isi rumah, ada perbezaan antara 5 tahun dahulu dengan situasi semasa? Sejauh manakah pihak berkepentingan yang saya libatkan dalam menangani isu ini?</i>	
33.	Do you think the stakeholders have to provide the e-waste recycling systems first in order to influence households to recycle their e-waste? Why? <i>Adakah anda fikir pihak berkepentingan perlu menyediakan sistem kitar semula e-waste terlebih dahulu untuk mempengaruhi isi rumah untuk mengitar semula e-waste mereka? kenapa?</i>	
34.	Do you think that stakeholders should collaborate with each other to handle this issue? (Government, private sectors, NGO and households) <i>Adakah anda fikir pihak berkepentingan harus bekerjasama antara satu sama lain untuk menangani isu ini? (Kerajaan, 455ector swasta, NGO dan isi rumah)</i>	
E Demographic profiles as moderating variable RQ4. Does the interactions between both factors (situational and personal) and household e-waste recycling participation vary depending on demographic profiles?		
35.	Customize and targeted campaigns to different groups of people based on socioeconomic factors could be effective? Why? <i>Sesuaikan and kempen disasarkan kepada kumpulan orang yang berbeza berdasarkan faktor sosioekonomi boleh berkesan? kenapa?</i>	
36.	Which group—those living in wealthy neighborhoods or in less wealthy neighborhoods—do you think is more likely to recycle effectively? Why? <i>Kumpulan manakah—mereka yang tinggal di kawasan kejiranan kaya atau di kawasan kejiranan kurang kaya—adakah anda fikir lebih berkemungkinan untuk mengitar semula dengan berkesan? kenapa?</i>	
37.	Do you believe that certain demographic profiles (age, gender, income, residential area, nature of living, etc.) influence household e-waste recycling behaviour? Which demographics do you think the most influential and why? <i>Adakah anda percaya bahawa profil demografi tertentu (umur, jantina, pendapatan, kawasan kediaman, alam kediaman, dsb.) mempengaruhi tingkah laku kitar semula e-sisa isi rumah? Demografi manakah yang anda fikir paling berpengaruh dan mengapa?</i>	
F Closing		
Post interview comments and/or observations. Thanking the informants.		

Appendix B6: The agenda of FGD

FOCUS GROUP DISCUSSION: E-WASTE FROM THE SOURCE AGENDA

TIME	PROGRAMME
0845 - 0900	Discussants' login and registration
0910 - 1110	SESSION 1: E-WASTE MANAGEMENT FROM THE SIDE OF OPERATIONS and MANAGEMENT
	<p>Description: This session addresses the management of e-waste flows from the source through the operation and management teams.</p> <p>The use of and demand for electronics has grown to unprecedented levels, fueled by new technologies and peoples' reliance on connectivity in personal and professional lives. According to the 2020 UN Global E-waste Monitor, e-waste is the world's largest waste stream globally, often contains materials that are conflict-ridden and toxic to human health and the environment. When e-waste is not recycled, these chemicals contaminate landfills, adversely impacting the water supply through leachate, and polluting the land. Communities located near landfills are particularly susceptible to chemical exposures resulting from improper e-waste disposal. Environmental contamination from recycling operations is common, impacting human health in neighboring communities. E-waste presents unique challenges and risks to companies in the tech-enabled world, the key consideration for this session is to get through operation and management teams on how they change the narrative on e-waste. From internal changes in corporate policy, to overall operation management that involved the other stakeholders which provides the potential solutions to combat the e-waste problem. This session also seeks to get a wider view from the e-waste operation companies on how they differentiate themselves in an increasingly competitive e-waste landscape.</p>
1140 - 1340	SESSION 2: E-WASTE MANAGEMENT FROM THE SIDE OF AUTHORITIES
	<p>Description: This session addresses the complexity in managing e-waste flows from the source from the approach of local authorities and councils.</p> <p>E-waste is one of the fastest growing waste streams on the planet. The consumption of Electrical and Electronic Equipment (EEE) is strongly linked to widespread global economic development. Higher levels of disposable incomes, growing urbanization and mobility, and further industrialization in some parts of the world are leading to growing amounts of EEE. After its use, EEE is disposed of, generating a waste stream that contains hazardous and valuable materials. Following the high demand from local industries has raised fear that Malaysia would become a dumping ground for the world's e-waste (Illegal E-waste Importation). In 2019, the world generated a striking 53.6 Mt of e-waste, and is projected to grow to 74.7 Mt by 2030. Most developing countries, including Malaysia, are facing lack of e-waste recycling facilities and low household participation therefore, stronger link between manufacturers, consumers, recyclers and the government are needed to combat e-waste issues for a better e-waste management. The key considerations for this session are to provide deeper understanding from the authorities on the quantities and flows of e-waste provides a basis for monitoring, controlling, and ultimately preventing illegal transportation, dumping, and improper treatment of e-waste.</p>
1330 - 1430	LUNCH BREAK
1440 - 1640	SESSION 3: E-WASTE MANAGEMENT FROM THE SIDE OF AUTHORITIES (MEDIA), RECYCLING SERVICES and NGOs
	<p>Description: This session addresses the level of engagement and different approach of e-waste management from the eye of authorities, recycling facilities / center and NGOs (the engagement) to attract society's involvement in e-waste recycling.</p> <p>The number of new innovations keeps growing and although these devices have many benefits, they are also contributing to a huge problem — the growing pile of e-waste. E-waste has now become the world's fastest-growing waste stream. E-waste is produced every year, but only 20% is recycled through appropriate channels while the remainder is often incinerated or dumped in landfills. This is largely due to poor waste management which stems from people's lack of knowledge and awareness regarding E-waste disposal. While many Malaysians are aware that e-waste can be harmful if mishandled, few of them know where and how to properly dispose of unwanted electrical and electronic items. Social media is found to be an important role in educating the community on the importance of reusing and recycling materials that might pose harm to the environment. The key considerations for this session are to acknowledge different roles and approach provided by recycling authorities and facilities to encourage others to adopt proper recycling habits. Since Malaysia has an inadequate awareness to adopt recycling habits mainly for e-waste, this session will discuss in deeper on different level of strategies made by recycling authorities and facilities to address this issue.</p>