RELATIONSHIP BETWEEN GREEN PRODUCT DESIGN, REVERSE LOGISTICS PRODUCT DISPOSITION AND BUSINESS PERFORMANCE AMONG ELECTRICAL AND ELECTRONIC MANUFACTURING FIRMS

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By

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ABSTRACT

This thesis is derived from the concept of reverse supply chain management and focuses on environmental and economic perspectives of reverse logistics product disposition. The current business environment accentuates the need for recoverable products, and manufacturers are encouraged to design products that facilitate multiple recovery capabilities. Returns with higher residual value deserve attention because business benefits from reverse logistics potentially improve firms' performance by extending the useful life of products which had underperformed earlier than expected. The product's structure and composition challenge reverse logistics implementation and these necessitate quantitative research on anteceding factors, particularly green product design and resource commitment, on reverse logistics product disposition. The study also examined the successive influence of reverse logistics product disposition on business performance and investigated whether institutional pressures moderate capability-performance relationships. A mail survey was administered to 177 ISO14001 certified E&E manufacturers in Malaysia and 89 usable responses were empirically tested. The research findings revealed that green product design (design for disassembly and design for environment) and resource commitment were antecedents of reverse logistics product disposition. Consequently, repair, remanufacture and recycling contributed to business performance (profitability and sales growth). By maintaining environmental compliance and shareholder interest, hierarchical regression analyses revealed that institutional pressures exerted significant moderating influence to warrant desirable outcome from reverse logistics activities, that is, repair, recondition, remanufacture, recycle and disposal. If firms have interest on reverse logistics implementation, disassemblability takes precedent over recyclability of products. When risk of penalties from regulatory violation is present, firms are motivated to generate benefits via extended producer responsibility. This study provided insights into antecedents and outcome of reverse logistics and acknowledged the moderating influence of institutional pressure, particularly, coercive and ownership pressure. Instead of analysing green product design and reverse logistics as components of green supply chain management, the relationship between both components was investigated. Limitations and suggestions for future research are discussed.

Keyword: Green product design, Reverse logistics, Business performance, Green supply chain management, Electrical and electronic equipment

ABSTRAK

Konsep pengurusan rangkaian bekalan berbalik merupakan fokus dalam kajian tesis ini. Di samping itu, tesis ini menumpukan kepada produk diposisi logistik berbalik daripada perspektif persekitaran dan ekonomi. Persekitaran perniagaan semasa amat menitikberatkan perolehan semula produk. Pengeluar digalakkan untuk mereka bentuk produk yang dapat memberikan kemudahan dalam pelbagai bentuk kaedah pemulihan. Produk dengan nilai baki yang tinggi patut diberi perhatian. Ini kerana produk ini dapat memberi manfaat logistik berbalik yang seterusnya mampu mempertingkatkan prestasi firma melalui pelanjutan jangka hayat sesuatu produk yang sebelum ini mempunyai mutu yang rendah. Struktur serta komposisi produk memberi kelebihan kepada pelaksanaan logistik berbalik. Faktor-faktor ini mendorong kepada keperluan untuk melaksanakan kajian kuantitatif terhadap pengaruh anteseden seperti rekaan produk hijau dan komitmen sumber terhadap produk disposisi logistik berbalik. Oleh itu, kajian ini menganalisis pengaruh turutan produk disposisi logistik berbalik terhadap prestasi perniagaan. Di samping itu, kajian ini menyelidik sama ada wujudnya tekanan institusi berpengaruh secara moderator terhadap perhubungan kapabiliti-prestasi. Kaji selidik melibatkan 177 buah syarikat pembuatan E&E yang beroperasi di Malaysia serta memiliki pengesahan sijil ISO 14001. Sebanyak 89 maklum balas yang diguna pakai serta diuji secara empirikal. Dapatan kajian menunjukkan rekaan produk hijau (rekaan untuk penyahpasangan dan rekaan untuk alam sekitar) dan komitmen sumber merupakan anteseden-anteseden kepada produk disposisi logistik berbalik. Seterusnya, pembaikan, pembuatan semula dan kitar semula menyumbang kepada prestasi perniagaan dalam aspek keuntungan dan peningkatan jualan. Berdasarkan analisis regresi hierarki, peraturan persekitaran yang dipatuhi dan mengekalkan kepentingan pemilik pula menunjukkan tekanan institusi memberi pengaruh moderator yang signifikan dalam menjamin kesan yang memuaskan daripada aktiviti logistik berbalik. Ini seperti pembaikan, pemulihan, pembuatan semula, kitar semula dan pelupusan. Sekiranya firma berminat terhadap implimentasi logistik berbalik, kebolehupayaan penyahpasangan produk didahulukan berbanding kebolehupayan kitaran semula. Kewujudan risiko penalti akibat peraturan yang tidak dipatuhi, akan mendorong firma untuk menjana manfaat melalui tanggungjawab lanjutan pengeluar. Kajian ini mendapati anteseden-anteseden serta kesan logistik berbalik dan memperakui tekanan institusi sebagai pengaruh moderator. Ini terutamanya melibatkan tekanan perundangan dan pemilikan. Selain menganalisis rekaan produk hijau dan logistik berbalik sebagai komponen pengurusan rantaian bekalan hijau, hubung kait kedua-dua komponen telah dikenal pasti. Selain itu, had-had dan saranan untuk kajian masa hadapan turut dibincangkan.

Kata kunci: Reka bentuk hijau, Logistik berbalik, Prestasi perniagaan, Pengurusan rantaian bekalan hijau, Produk elektrik dan elektronik

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LIST OF ABBREVIATIONS

Abbreviation	Description of Abbreviation
CLSC	Closed Loop Supply Chain
DfD	Design for Disassembly
DfE	Design for Environment
DfR	Design for Recycling
DOE	Department of Environment
EEE	Electric and Electronic Equipments
EMS	Environmental Management System
EPR	Extended Producer Responsibility
FMM	Federation of Malaysian Manufacturers
FSC	Forward Supply Chain
GSCM	Green Supply Chain Management
GPD	Green Product Design
HRA	Hierarchical Regression Analysis
ISO 14001	International Standard for Environmental Management System
KMO	Kaiser-Meyer-Olkin
LCA	Life Cycle Assessment
MCAR	Missing Completely at Random
MRA	Multiple Regression Analysis
MSA	Measure of Sampling Adequacy
OEM	Original Equipment Manufacturer
PLC	Product Life Cycle
PRM	Product Recovery Management
R&D	Research and Development

RBV	Resource Based View
RC	Resource Commitment
RL	Reverse Logistics
RLPD	Reverse Logistics Product Disposition
RSC	Reverse Supply Chain
SIRIM	Standards and Industrial Research Institute of Malaysia
WEEE	Waste of Electrical and Electronic Equipment

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

In the midst of growing concern towards environmental issues, product return deserved greater attention since government regulations and international trade standards have introduced stricter requirements on the management of electrical and electronic waste (e-waste). Reverse logistics developed from the concept of extended producer responsibility and this business activity focused on the challenging task of recovering value from end-of-use or end-of-life products. The presence of hazardous substances in e-waste threats environmental and human health and this circumstance steered the trend of after use product handling. Due to shrinking industry clockspeed, rate of equipment obsoletion is higher as new and improved technologies consistently replace products at current marketplace Fernández and Kekäle (2005) and this have led to the rapid saturation of landfill (Ayres, Ferrer, & Van Leynseele, 1997).

As the environmental and financial impact of waste burgeons, members of European Union, Japan, South Korea and other countries have introduced legislations related to producers' responsibilities to elevate pollution prevention activities. Therefore, manufacturers have begun to invest in sustainable product to take advantage of new market opportunity and benefit from reduced consumption of resources (Mollenkopf & Closs, 2005; Rock & Angel, 2007). Manufacturers ought to improve sustainability of export products beyond mere compliance (Eltayeb & Zailani, 2010) because e-waste legislative at foreign counterparts are shifting the global business environment and Malaysia is not excluded from this scenario (Theng, 2008). In fact, take back laws among developed countries facilitated transition of end-of-life product responsibility from local government to private sector where producers are accountable for collecting and recycling used products (Lee & Na, 2010; Toffel, Stein, & Lee, 2008).

As of October 1993, Malaysia has signed the Basel Convention treaty to control the transboundary movements of hazardous waste. Parallel to this international treaty, Section 34B of Environmental Quality Act 1974 was amended in 1996 to restrict placement, disposition and movement of scheduled waste whereas Solid Waste and Public Cleansing Management Bill 2007 laid out some provisions in regards to reduction and recovery of controlled solid waste by means of product take back. Furthermore, the Ministry of Energy, Green Technology and Water (KeTTHA) has planned to introduce the National Renewable Energy Policy and Action Plan (REAP), an organised approach to fuel a holistic effort towards sustainable development (Agamuthu & Victor, 2011; Chin, 2010) and gradually shift away from end-of-pipeline waste management to pollution prevention approach. Furthermore, Greenpeace International is an independent party who measures and ranks sustainability of electronic equipments periodically and utilises media influence to project product’s brand image (Greenpeace, 2010). Therefore, minimisation of environmental liabilities by committing resources to finance reverse logistics operations built good reputation for current and prospective investors.

Rapid diffusion of green concept among developed countries accentuated the trend of green practicing among Asian countries. WEEE and RoHS Directives were applied by developed countries to convey environmental requirements in regards to use of hazardous substances and rate of recyclability in products (Goosey, 2004). Even though studies on reverse supply chain have begun for over two decades, progression of reverse logistics activities, particularly in Malaysia was relatively modest. Several multinational companies such as Motorola, Nokia, Dell, HP and Apple have begun to accept recyclable equipments through liberal return policy (Agamuthu & Victor, 2011) as these companies had reinvented their backward supply chain to generate valuables from waste (Andel, 1997; Ayres et al., 1997). According to Stock and Mulki (2009), choosing to ill-treat reverse logistics activities caused companies to lose substantial opportunity because reclaimable subassemblies and components were recoverable cost of goods sold. Products with high residual value are time-sensitive and must be recovered effectively whereas product with low residual value should be processed in a cost-efficient manner (Gobbi, 2011). Recovered products are liquidated at marked down value through sales at secondary market (Rogers, Rogers, & Lembke, 2010) and some automotive as well as photocopier manufacturers took advantage of end-of-lease take back strategy to extend the functional use of good condition products (De Brito & Dekker, 2003). In other words, manufacturers ought to embrace the complexity of developing reusable products beyond packaging recycling (Eltayeb & Zailani, 2010). The acceptance of return is an after sales service that induces customer satisfaction and marketing strategy such as trade-in programs potentially improves sales growth in primary and secondary market (Heese, Cattani, Ferrer, Gilland, & Roth, 2005).

Together with growing support for eco-design products from Department of Environment and KeTTHA, more studies should be conducted to incorporate green design principles into new product development. The “eco” syllable in ecodesign referred to economy- and ecology-oriented design (Karlsson & Luttropp, 2006). Product designing phase controlled the environmental consequences of input material throughout the entire product lifecycle (Baumann, Boons, & Bragd, 2002; Dangelico & Pontrandolfo, 2010) and predetermined the yield of high value recoverables while minimising amount of disposable residues. Knemeyer, Ponzurik and Logar (2002) highlighted the need to study the influence of green design on reverse logistics activities. The inclusion of design aspects that facilitate reverse logistics created a challenging feat to designers (Bogue, 2007). Often, product designers were unaware of the challenges dealt by asset recovery division (Gehin, Zwolinski, & Brissaud, 2008) and they may not be well-versed with recyclability of materials. Knemeyer et al. (2002) indicated that producers are not willing to use recycled or recyclable materials if the materials posed substantial risk to product's aesthetic value and perceived reliability unless the renewable materials were of the same price and quality.

Development of green products for reverse logistics product disposition is a feasible subject of study because this issue is not short of operational complexities. Some of the challenges that reside in reverse logistics were as follow: forward-focused supply chain has created barriers for cost-effective recovery because minimal emphasis is invested on various mode of product recovery (Talbot, Lefebvre, & Lefebvre, 2007); void in environmentally friendly design due issues on availability and recyclability of materials (Bogue, 2007); re-designing complex structure to support efficient disassembly such as application of standard structure, joints and demarcations (Desai & Mital, 2003; Kriwet, Zussman, & Seliger, 1995; Sroufe, 2003). Green products ought to assist recoverability via reverse logistics as lack of producer's responsibility affects product's brand image (Gottberg, Morris, Pollard, Mark-Herbert, & Cook, 2006; Rogers & Tibben-Lembke, 1999). Between environmental impact and profitability derivable from reverse logistics, the latter received more attention than positive environmental effects and this posed incumbent challenge to designers.

1.2 Problem Statement

An array of environmental standards that governed product take-backs for recovery and proper disposal can be seen across developed and developing countries. The trend of transferring physical and financial responsibility associated with end-of-pipeline waste management from government to producer have taken place but this gave rise to substandard recycling facilities that threat environmental and human health, e.g., leaked heavy metal generates groundwater pollution. In general, firms are not willing to implement reverse logistics activities to recover value and/or material as they are perceived to improve firms' environmental performance at the expense of economic performance. In the case of Malaysia, local manufacturing environment is susceptible to extended producer responsibility mandated to handle backward flowing returns. Solid Waste and Public Cleansing Management Bill 2007 and Environmental Quality (Scheduled Waste) Regulation 2007 cater a series of provisions for product recovery but they were largely legislative concepts without framework for enforcement.

Growth of e-waste rose at exponential rate where an estimate of 1.12 million tonnes, equivalent to 81.5 million unit of e-waste discarded from households and business institutions will surface in Malaysia by year 2020 (2005). For every tonne of post-consumer waste, tonnes of wastes are disseminated during manufacturing process and resource extraction. As used products were rich source of reclaimable material and energy, reverse logistics played an important role in facilitating efficient consumption of resources through cradle-to-cradle product reincarnation. Eltayeb and Zailani (2010) pointed out that green initiatives specifically eco-design and reverse logistics in Malaysia were fairly passive where most companies shun away from environmental-related return. In addition, local producers lacked design knowledge that minimises complexities that arise from multiple recovery loops and this barrier was accentuated further as firms prioritised on forward supply chain activities. Landfill expenditures and complexity (i.e. cost) for extracting constituents of end-of-use products were unfavourable. Green and reverse supply chain literatures have proposed to integrate design considerations that assist recovery of products with varying residual value. Some empirical studies focused on generic ecodesign aspects and most studies presented normative suggestion with minimal practical relevance. As interdependence of green practices was a viable issue, this study presented empirical evidence on the influence of green design and resource commitment towards product disposition.

Economic viability was a major motivating factor to reverse logistics and product improvement related to disassemblability and recyclability potentially elevate yield of recoverable value, particularly for product remanufacture and recondition activities. King et al. (2006) pointed out that ratio of benefit-to-cost differed across various closed-loop options due to discrepancy of work required for transforming products' physical state. Limited studies focused on reverse logistics product disposition and Skinner et al. (2008) showed that only recycling and disposal strategy improved economic performance under the presence of resource commitment. Although the presence of valuable recoverable is without a doubt, the desired business benefits derivable from reverse logistics were inconsistent and hardly generalisable. Unlike developed countries, legislations (e.g. WEEE, RoHS or EPR) led the implementation of cradle-to-cradle product reincarnation strategy and it is only a matter of time for local regulatory pressure to enforce pollution prevention initiatives. Risks of fines or penalties due to non-compliance are environmental liabilities that challenged firms who strive to attract and/or maintain owner's interest. Since advancement of reverse logistics in Malaysia was comparatively underdeveloped, the moderating influence of institutional pressure on business performance of reverse logistics deserved attention.

1.3 Research Questions

For reverse supply chain, the reverse logistics network and process formalisation have been explored (Fleischmann, Krikke, Dekker, & Flapper, 2000; Genchev, 2007). As product returns processing was a critical aspect for recovering values in returned product, literature reviews have guided this research to investigate the antecedents and outcome of reverse logistics product disposition. The research questions are as follow;

1. Do green product designs and resource commitment exert influence on reverse logistics product disposition?
2. Does reverse logistics product disposition contribute to firm's business performance?
3. Does institutional pressure exert moderating effect if there is a relationship between reverse logistics product disposition and business performance? If yes, what type of moderators can be hypothesised?

1.4 Research Objectives

Reverse logistics product disposition as the focus of this study have led the development of the following research objectives;

1. To investigate the relationship between green product design and reverse logistics product disposition.
2. To investigate the relationship between resource commitment and reverse logistics product disposition.
3. To investigate the relationship between reverse logistics product disposition and business performance.

4. To examine the moderating effect of regulatory pressure and ownership pressure on the relationship between reverse logistics product disposition and business performance.

1.5 Significance of the Study

From the theoretical perspectives, this study utilised resource-based view to define resources and capabilities that were internalised to develop strategic performance. The central focus of this study is reverse logistics product disposition, where business gains were prospective outcome of environmentally viable disposition and design decisions during the stage of product development and resource commitment were antecedent factors. Furthermore, electric and electronic (E&E) industry subsector is a significant contributor to Malaysian economy where exports of E&E products account for RM 236.5 billion in value, equivalent to 46.91 percent of total exports whereas the value of manufactured products account for RM 178.3 billion of total gross domestic product in 2011 ("Economic Report 2012/2013," 2013). The value of conservable resources within high volume of returns improved the economic viability of multiple recovery loops and this was facilitated by development of knowledge and experience that constituted green design aspects.

Previous studies analysed eco-design as a component of green practices but the measurements was not defined for specific purposes as they were largely associated with the generic management of hazardous waste. Other studies (Dangelico & Pontrandolfo, 2010; Hauschild, Jeswiet, & Alting, 2005; Kriwet et al., 1995; Kuo, Huang, & Zhang, 2001; Zhu, Sarkis, & Lai, 2007) utilised various combinations of dimensions to define green product design or design for the environment (DfE) products. For instance, Hauschild et al. (2005) defined design for disassembly (DfD) and design for recycling (DfR) as approaches of DfE whereas Cerdan et al. (2009) observed that DfD and DfR were two least documented eco-design studies. As both concepts were value seeking aspects that facilitate the effectiveness of reverse supply chain, DfD and DfR were applied for measuring green product design.

This study analysed one of the key processes of reverse supply chain which was the 'inspection and disposition' process. This process is affiliated with the reverse logistics component in green supply chain management concept but Zhu et al. (2007) examined this component as investment recovery, where the inclusion of sales of excess inventory as one of the measurements was misleading even though significant amount of cost are recovered. Based on Directive 2002/96/EC on waste electrical and electronic equipment (WEEE), producers are required to augment product recovery rate (reuse and recycle) for various categories of WEEE within the range of 50 to 80 percent of average weight per appliance. Evidently, Malaysia must recognise the impact of international regulations to remain competitive because recoverability of products may become trade barriers. In a study on Malaysian manufacturing industry, Eltayeb and Zailani (2010) defined reverse logistics only within the parameters of products and packaging collection. This conceptualisation did not serve the objectives of reverse logistics that is recovery of materials and energy invested within products, modules or components by extending their useful life. Therefore, this study focused on differentiating reverse logistics product disposition as each option is associated with different level of complexity that required commitment of resources to yield diverse outcome.

Despite the existent of valuable recoverable inside products, reverse logistic activities in developing countries were not as active as those of developed countries. This phenomenon does not reflect that Malaysian industries are unaware of reverse logistics, but in reality, most companies have chosen to overlook the daunting issue associated with waste disposal to avoid additional investment required for managing goods that are perceived as ‘junk’. Lack of institutional pressure such as regulatory and ownership pressures have allowed this situation to persist. In summary, the benefits are as follow;

Government; as regulations for governing producers’ responsibility have yet to develop, this study provided evidence on the significant role of regulatory policy to exert coercive pressure for encouraging firms to develop reverse logistics capabilities in recovering values from returns.

Manufacturing firms; this study provided empirical evidence for manufacturing industries to incorporate fundamental green design factors that facilitate reclamation of values and at the same time operate in accordance with the concept of sustainable development. Rather than financing the cost of landfill or incineration activities, practitioners are encouraged to invest in design changes that enable firms to recover higher residual value. Moreover, the evolvement of stricter regulatory requirements is forthcoming and firms must put more emphasis developing reverse logistics product disposition capabilities to attain better firm performance.

1.6 Scope of the Research

The research examined business performance of reverse logistics in manufacturing industry particularly in electrical and electronic (E&E) industry subsector. Organisation as the unit of analysis is E&E companies which have ISO 14001 accreditation on their environmental management standards and registered with Federation of Malaysian Manufacturers (FMM) or Malaysia External Trade Development Corporation (MATRADE). Firstly, this study presumed that certified companies established environmental management practises based on systematic guidelines outlined by ISO14000 family of standards. Secondly, reverse logistics activities differed across subsectors of the manufacturing industry due to disparate product characteristics. If other industry subsectors were taken into consideration, validity and reliability of the data may be disrupted and this could affect generalisability of empirical findings. Additionally, the issues related to waste of electrical and electronic equipment (WEEE) was the driving factor for this study to analyse the business benefits of product recovery. Thirdly, this study presumed that companies execute generic manufacturing or assembly processes including engaging the services of third party service providers (3PSP). Fourthly, the categories of product returns are not limited to end-of-use and end-of-life products but they included purchase-related, production-related and distribution-related returns.

1.7 Definitions of Terms

Definition and key terms used in the study are presented as follow;

a) *Reverse logistics product disposition*

The term is self-explanatory, also known as disposition options which are industry and product-specific, where decision-making highly depends on conservable value in used products. Products are reincarnated for efficient consumption and disposal of resources by recovering materials and energy invested within products, modules or components to reuse in forward supply chain to gain environmental and business benefits.

b) *Green product design*

Corporate proactive approach for integrating product design and environmental considerations without compromising product's function and quality, including innovations for recovering product value throughout its life cycle prior to disposal.

c) *Design for disassembly*

Designing the product to reduce the complexity and cost for separating functional modules, components or materials in the effort of conserving resources for future use through reuse, recycling and remanufacturing.

d) *Design for recycling*

Designing the product that enable material reuse from used products or components by developing recyclability and durability in products, including the intention to reduce the consumption of natural resources.

e) *Repair*

Work of fixing and replacing malfunctioning components or modules in order to restore the existing used product to working order.

f) *Recondition*

Involve some level of product disassembly in order to restore the existing used product to specific working condition by testing and repairing or replacing some critical components or modules which have failed or about to fail.

g) *Remanufacture*

The process of restoring used product to at least original equipment manufacturer (OEM) performance specification which involve complete product disassembly before proceeding with extensive testing, restoration and replacement of worn-out or outdated components or modules.

h) *Recycling*

A series of process for extracting recyclable material from used products or components including collecting, dismantling, shredding, sorting and processing material for reuse in new products when original product or component loss their identity and functionality.

i) *Environmental Outcome*

Firm's environmental responsibilities in reducing waste generation through proactive and reactive environmental management practices.

j) *Profitability*

Prospective revenue derivable from reclaimable assets within work-in-progress inventories, manufacturing returns, distribution returns and customer returns where reusables are reprocessed to reenter forward supply chain.

k) *Sales Growth*

Business marketing strategies of environmentally proactive companies where both new and used, products or technologies synergize to achieve sales objective within primary and secondary market.

1.8 Organisation of the Thesis

This structure of this thesis is organised in five chapters. **Chapter 1** consists of a discussion on the background of study which composed of introduction, problem statement, research questions and objectives, significance of the study, identifying the scope of research and defining key terms understudy. **Chapter 2** presents overview of supply chain management before narrowing down to reverse logistic activities. This chapter describes underpinning theory in brief and explains the relationships among green product design, resource commitment, reverse logistics product disposition, business performance of reverse logistics and institutional pressures. In concluding this chapter, research framework and underlying research hypotheses are presented. The research methodologies are elaborated in **Chapter 3** where the population of study, unit of analysis, instrument development, method of data collection and method of statistical analysis are discussed. **Chapter 4** focuses in hypotheses testing and presents the findings of the quantitative research including profile of respondents, goodness of measure, descriptive statistics, and multivariate regression analyses. **Chapter 5** discusses the research findings followed by conceptual and practical implications, limitations and suggestions for future studies, and conclusion.

CHAPTER 2

LITERATURE REVIEW

2.1 Supply Chain Management

The competitiveness of business in the presence of technological progression has influenced organisations to improve the flow of products and information across a stream of processes. A comprehensive understanding on the concept of supply chain management (SCM) is best-described by Udin (2004) as,

> *"all activities, processes, entities, material, financial and information flows in the integrated network which consists of providers (suppliers), transformers (original equipment manufacturers) and receivers (customers) with the objectives to improve customer satisfaction, delivery and quality of products, and to reduce costs in the cooperative and collaborative environment."*

This definition of SCM was extended to integrate all physical, information and financial flow among key supply chain partners to balance between supply and demand of inventories while keeping up with the goals of competitive advantage. The SCM concept is an integration of various business functions including sourcing and procurement, production operations, distribution strategy, logistics management, and others. The concept of supply chain management has undergone at least a decade of redefinitions. Due to rising concerns in regards to pollution contributed by electronic waste (e-waste) mismanagement, the upstream product flow attributed to extended producer responsibility has facilitated the emergence of closed-loop supply chain management. Closed-loop supply chain (CLSC) is an integration of forward and reverse supply chain (FSC and RSC) that addresses product movement in the downstream and upstream directions where various categories of returns are gathered from collection points and centralised at returns processing plant, evaluated and undergo appropriate disposition options, re-enter secondary market and the process repeats itself for the next reincarnation cycle until no significant value can be recovered from the product (Stock, Speh, & Shear, 2006).

Supply chain management that embrace recoverable manufacturing systems is slightly different from fundamental aspects of conventional operation management (Guide Jr, Jayaraman, Srivastava, & Benton, 2000). Most of the authors have described reverse supply chain (RSC) as a continuation of forward supply chain (FSC), where assimilation of both closes the supply can loop and fulfils the objective of pollution prevention (French & LaForge, 2006; Rogers & Tibben-Lembke, 1999; Talbot et al., 2007). Environmentally-conscious corporations can integrate sustainability across supply chain by dealing with three major issues in regards to returns management and they are supply, processing and distributions of recovered goods (Flapper, 2003). These factors are the source of variations that complicates CLSC and Tibben-Lembke and Rogers (2002) enlisted some of the differences between both type of supply chain at Table 2.1.

Table 2.1
Differences between Forward and Reverse Logistics

Forward Logistics	Reverse Logistics
Forecasting relatively straightforward	Forecasting more difficult
One-to-many distribution points	Many-to-one distribution point
Product quality uniform	Product quality not uniform
Product packaging uniform	Product packaging often damaged
Destination/routing clear	Destination/routing unclear
Disposition options clear	Disposition options unclear
Pricing relatively uniform	Pricing dependent on many factors
Inventory management consistent	Inventory management not consistent
Product lifecycle manageable	Product lifecycle issues more complex
Negotiation between parties straightforward	Negotiations complicated by additional considerations

(Source: Tibben-Lembke & Rogers, 2002)

Despite their differences, the cost of investing in RSC is significantly relieved through shared resources such as transport equipments and warehouse spaces owned by FSC partners (Fleischmann, Beullens, Bloemhof-Ruwaard, & Van Wassenhove, 2001). In fact, the strategic and operational decisions undertaken during FSC activities complicate returns processing, as the blueprint of a sustainable product have been fixated. Guide, Harrison, and Van Wassenhove (2003) claimed that RSC is dependent on business functions outside of the reverse-focused supply chain particularly product design and marketing. These differences are challenges to closed-loop supply chain (CLSC) and the integration of FSC and RSC activities are especially important to enhance the effectiveness of asset recovery operations. Guide Jr., Souza, Van Wassenhove, and Blackburn (2006) and Guide and Van Wassenhove (2003) have described CLSC as;

> *"The design, control and operation of a system to maximize value creation over the entire life-cycle of a product with dynamic recovery of value from different types and volumes of returns over time".*

2.2 Reverse Supply Chain

Reverse supply chain is a major constituent of closed-loop supply chain. In earlier literatures, reverse supply chain is also known as product recovery management (PRM). PRM relates to the management of products that moves in upstream direction and Thierry et al. (1995) described the objectives of PRM as;

> "T*o recover as much of the economic (and ecological) value as reasonably as possible, thereby reducing the quantities of waste*".

Thierry et al. were among the pioneer authors who highlighted the need to minimise the amount of waste generated by used products and proposed five different product recovery alternatives for reprocessing products and materials. Fernández and Kekäle (2005) described reverse logistics (RL) as the operational support to manage physical product and information for the purpose of recovering added-value constituents and French and LaForge (2006) suggested that both RL and CLSC are interchangeable terms as they were synonymous. Grant and Banomyong (2009) supported that RL is a key component of CLSC and both activities have garnered reputation in sustainable development. A number of previous research have applied reverse logistics as a term that described managerial approach towards asset recovery (Daugherty, Autry, & Ellinger, 2001; Hanafi, Kara, & Kaebernick, 2008; Hazen, Hall, & Hanna, 2012; Lau & Wang, 2009; Skinner et al., 2008). This study was driven by previous studies that presented mixed evidence on viability of reverse logistics business activity in different settings such as country location, type of industry and others (Skinner et al., 2008; Zhu and Sarkis, 2007; Eltayeb et al., 2010; Guide and van Wassenhove, 2003; Mollenkopf and Closs, 2005). Furthermore, the definitions of reverse logistics were broadly interpreted and may include management of returns, reprocessing works and sale of unused assets or scrap materials.

Based on the CLSC model proposed by Talbot et al. (2007), FSC and RSC activities is a continuous loop because RSC behave as a source of material or energy that re-enters FSC. RSC can be applied across subsectors of the manufacturing industry and focuses on opposite movement of products from end user towards point of origin whereas FSC utilises functional parts or products to redistribute at secondary market. Prahinski and Kocabasoglu (2006) formally defined RSC management as;

> "*the effective and efficient management of the series of activities required to retrieve a product from a customer and either dispose of it or recover value".*

According to Prahinski and Kocabasoglu, there are five sequential processes in RSC and the objective associated with each processes is described as follow; (1) 'product acquisition' is the gatekeeping activity to receive and collect used products from downstream customers, (2) 'reverse logistics' is the mechanism for recapturing product value including transportation and centralised returns centre, (3) 'inspection and disposition' is the assessment of returned products and selecting the most appropriate disposition option, (4) 'remanufacturing' (or reconditioning) is the actual work for recovering material and energy to reclaim reusable parts or restore whole product, and (5) 'distribution and sales' creates demand for recovered products in current or secondary market (Blackburn, Guide, Souza, & Wassenhove, 2004; Guide Jr et al., 2000; Prahinski & Kocabasoglu, 2006). There are substantial challenges in managing reverse supply chain as these activities are often an afterthought issue during product development and quite often operates independently from forward flow functions.

According to Li et al. (2008), case study research on third-party logistics providers revealed that most of their clients seek RL services to focus on core business while providing liberal return policy to maintain customer's satisfaction. However, these service providers function according to the tasks assigned by parent company (Fernández & Kekäle, 2005) and the recoverability of product may be impeded to a pre-determined yield target, thus diminishing the effort of maximising value in returns. If the residual value of products is high, firms should expedite the recovery process to capture value from time-sensitive products by being responsive at the expense of cost (Atasu, Guide Jr, & Van Wassenhove, 2008; Gobbi, 2011).

Figure 2.1 illustrates the relationship between total cost, total revenue and total profit against the speed of product's re-entry to secondary market. As the length of time to remarketing increases, revenue from sales of recovered product and investment cost in managing reverse logistics approaches nil value when returns are managed based on cost efficiency. Therefore, speed is critical for securing profit from product recovery activities. It is important to note that recoverable values in products differ across industry and technology clockspeed where products with long lifecycle retain their value and functionability better than products with short lifecycle.

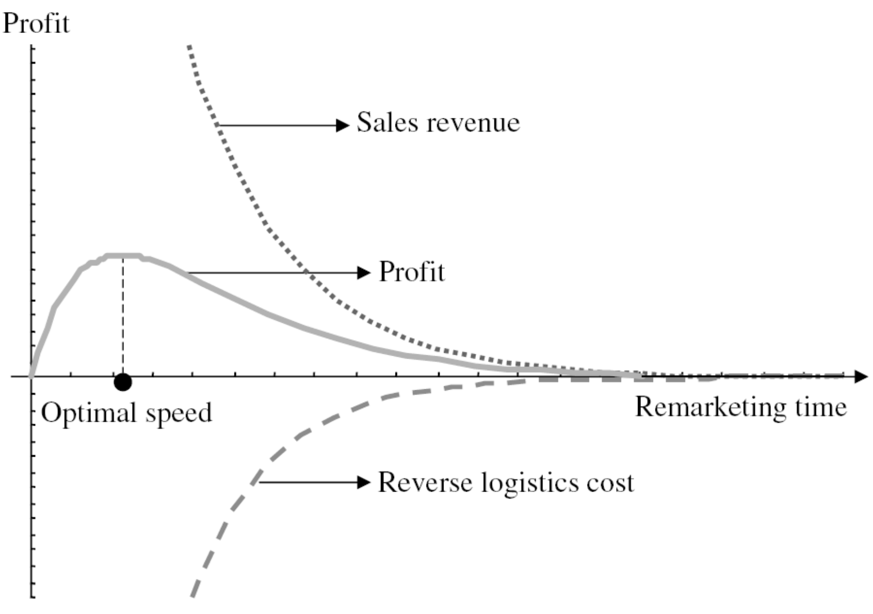


Figure 2.1
Time versus Value in Remarketing Returned Products (Guide Jr. et al., 2006)

In order to serve this afterthought but unique market, design attributes that posed challenges to product reclamation are addressed and marketing plans for sales of new and used products are carefully managed to secure higher market share. One of the business strategies of CLSC is the 'planned obsolescence' strategy where trade-in programs are introduced to customers who return their products for repair due to deterioration of critical parts. However, the collaboration between business functions of FSC and RSC is a relatively recent conception which has not been well received. According to Prahinski and Kocabasoglu (2006), one of the popular issues in product disposition is the complexity for identifying and separating components and materials in assembled products. Furthermore, with growing pressure from competitors in developing green values in products, companies had no choice but to address the product design issues during FSC for RSC (Blackburn et al., 2004). Talbot (2005) and Talbot et al. (2007) were among the advocators of design amendments during product development stage so as to improve the effectiveness of recovering value-added properties embedded in products thus minimising the amount of waste disposed to landfill or incinerator.

From a system-wide standpoint, Guide et al. (2000) credited the complexity of managing, planning and controlling supply chain functions of the recoverable manufacturing system to seven attributes and they comprised of: (1) *the uncertainty in timing and quantity of return,* such as anticipation of returns to manage supply and demand of used products; (2) *the need to balance demands with returns,* associated with product life cycle (PLC) and rate of technological clockspeed; (3) *the need to disassemble returned products,* repair and remanufacturing require different methods and degree of disassembly; (4) *the uncertainty in material recovered,* products disassembly may yield diverse sets of reusable and non-reusable parts; (5) *the need* *for a reverse logistics network,* the number of facilities and location of collection points for product recovery, information system and transportation mode to assist the flow of returns processing; (6) *the complication of material matching restrictions*, some instances complicate inventory planning and scheduling such as products with strict product specifications where parts are serial numbered and some customers do not favour used product replacement, (7) *the problems of stochastic routings for repair and remanufacturing operations and highly variant processing time,* product returns consist of an array of damage or quality level and skilled-labour is required to diagnose products. Among all the seven attributes described by Guide et al. (2000), at least four attributes that complicates product recovery are influenced by product architecture in which two of them can be resolved by choice of materials and fasteners. Due to the choices during product designing, asset recovery bears the consequences of complex product disassembly especially in quality and value of disassembled product (Ayres et al., 1997). In the context of environmental proactivity, Sroufe (2003) revealed that environmental design practices is more influential than environmental recycling or rebuilding practices in improving the performance of environmental management. As such, characteristics of recoverable and sustainable product design to ease accessibility of reusable supplies is researchable.

2.2.1 Categories of Products Return in Reverse Supply Chain

Products return travels from downstream supply chain players towards point of origin. In Malaysia, product take back is governed by Clause 102 of Solid Waste and Public Cleansing Management Bill 2007, where it is optional for Minister of Housing and Local Government to practise his or her authority in requiring producer, assembler, importer or dealer uptake responsibility in product take back. Since Malaysia have not institutionalise product take back, also known as extended producer responsibility (EPR) in California and Canada, the trend in Malaysia is towards voluntary initiative. At present, no data was available to estimate the value of returns absorbed by various parties. However, it is common to discover manufacturers who purportedly avoid acceptance of used products as most believed that cost outweighed the benefits of asset recovery. Elsewhere in the United States, Stock, and Mulki (2009) estimated that the rate of product returns is within the range of 15 percent for mass merchandisers and may swell up to 35 percent for electronic commerce retailers.

Based on a survey conducted by Rogers *et al.*(1999) , the types or reasons of returns differ across end-user, retailers, distributors and manufacturer. Other than environmental legislations which constraint the act of landfilling products, liberalised return policies were introduced to compete for customer satisfaction (Autry, 2005; Flapper, 2003; Rogers & Tibben-Lembke, 1999). With shorter industry clockspeed for electrical and electronic equipments (EEE), the manufacturing industry is experiencing shorter cycle time in product development. Due to this scenario, returns are an abundant source of material and energy because most of the subassemblies and components used in products are compatible particular those from similar generation. Additionally, the growing expectation on quality of customer service is another motivating factor for firms to manage returns in the interest of environmental and economic benefits. There are three categories of product returns and they are lifecycle related returns (introduction, growth, maturity, saturation and decline) such as;

(1) Manufacturing-related returns including raw materials surplus, quality test returns for rework, by-products or production scraps and forced use of used materials (Flapper, 2003; Talbot et al., 2007);

(2) Distribution-related returns including product recalls, wrong deliveries, inventory adjustments, redistribution of goods due to stock balancing, expired inventories, marketing returns, first-quality overstock, overrun, close-outs, buy-outs, job-outs and distribution items (Flapper, 2003; Rogers & Tibben-Lembke, 1999; Rogers & Tibben-Lembke, 2003)

(3) Customer-related returns including warranty returns, leased or rented goods, service returns, end-of use returns, legally endorsed returns and take-back forced by customers attributed to non-defective defectives (Flapper, 2003; Van Nunen & Zuidwijk, 2004).

Between all three categories of product returns, the value of recoverables in EEE from the first category is highest because the costs of marketing and forward logistics have yet to incur. French and LaForge (2006) differentiated internal and external sources of product returns and Table 2.2 displayed the categories of returns based on descending frequency. According to Gregori (2009), some returns require minor product upgrade so that they enter secondary market to serve customers who are not as technologically sensitive.

Table 2.2

List of Internal and External Source of Product Return

No.	Internal Source/Reason	External Source/Reason
1.	Partial containers such as batch shortages and overruns	Product damaged due to shipment
2.	Rework – product that does not meet standard requirements	Substandard products
3.	Obsolete inventory (products)	Unsold products
4.	Expired inventory (products)	Performance of product not as promised
5.	By products	Contaminated
6.	Obsolete inventory (raw material)	Product returned in returnable containers
7.	Expired inventory (raw material)	Expired inventory
8		Sample material
9.		Obsolete product
10.		Demonstration unit (sales)

(Source: French & LaForge, 2005)

EEE products and their packaging materials are reusable or recyclable. In optimising recoverable volume, product designers ought to address recoverability issues dealt by asset recovery division (Ayres et al., 1997). Most of these issues are affiliated with design decisions that significantly affect the cost and complexity of product disposition options. However, recovery of distribution-related returns results in higher gross because they consist of new and first quality products including ‘close-outs’ where retailer no longer line up a particular product, ‘job-outs’ such as off-season products and surplus products that did not sell as anticipated over the counter (Rogers & Tibben-Lembke, 1999). In redistributing returns, some required secondary market whereas others require minor upgrades because product depreciation is directly proportionate to various factors including rate of innovation and position of product life cycle (Tibben-Lembke, 2002).

2.2.2 Reverse Logistics and National Legislations

Reverse logistics is a contemporary manufacturing approach for maximising recoverable value in returned products and Section 2.2 have discussed about the overlapping definition shared by RL and CLSC. Other than CLSC, the integration of environmental management into supply chain management has developed the concept of green supply chain management (GSCM). GSCM is composed of green purchasing, green manufacturing, green distribution and reverse logistics (Hervani, Helms, & Sarkis, 2005). The goals of reverse logistics from the perspectives of CLSC and GSCM are similar, that is to reduce or eliminate waste emissions by reducing, reusing, remanufacturing and recycling ‘waste’ into new material and/or products.

According to Stock and Mulki (2009), the estimated value of backward flowing products is $100 billion per year equivalent to 6 percent of total sales and based on International Association of Electronics Recyclers of the United States, it is estimated that forty million units of computing equipments account for some 1.5 billion pounds of electronic equipments are being sent for recycling in the year of 2010 (Kumar & Putnam, 2008). In the case of Malaysia, Theng (2008) disclosed that consumers can deliver used equipments to original manufacturer provided that the company supports recycling programs and employ policies dedicated to product take back. Based on Malaysian Communications and Multimedia Commission, there are 31.4 million mobile phone subscribers in the country ("Facts and Figures: Statistics and Records," 2010). Within an estimate of one to eight years, at least thirty million mobile phones will lose its functional value and become disposable e-waste that are valuable due to rising price of precious metals such as gold, silver, copper, steel and aluminium. There are two strategic approaches for recovering end-of-use products;

- *Curative action*

  This strategy focuses on improving the efficiency and effectiveness of product recovery by promoting technological development in treating and disposing emissions and effluents (Hart & Ahuja, 1996). These pollution control equipments are known as Post-shredder Separation Technology that shreds products or modules to recover fractions of pure material and X-ray equipment expose product's material composition to identify materials that are worthy of disassembly (Zuidwijk & Krikke, 2008).

- *Preventive action*

  Proactive strategies where product innovation will reduce and prevent pollution through Design for 'X', where the symbol represents any design objectives including Recycling (Kriwet et al., 1995; Ljunberg, 2007), Environment (Argument, Lettice, & Bhamra, 1998; Kuo et al., 2001) and Disassembly (Desai & Mital, 2003). These design objectives introduce minor modifications during product development phase for the interest of various disposition alternatives.

Manufacturing environment of firms from foreign countries are comparatively more developed than Malaysia and most companies have been managing returns to oblige with mandated environmental regulations that necessitate retrieval for repair and/or recycling (Aizawa, Yoshida, & Sakai, 2008; Gottberg et al., 2006; Lee & Na, 2010). For example, Japan introduced the 'Home Appliance Recycling Law' to institute producer's responsibility in collecting and recycling a selection of domestic electrical appliances (Gehin et al., 2008). 'Extended Producer Responsibility Law' outlines recycling target in quantity for manufacturers in South Korea, 'Recycling Fund Management Board' requires Taiwanese producers to take financial responsibility on cost of disposals whereas 'Law on Recycling and Treatment of Waste Household Electrical and Electronic Appliances' is under review in China (Lee & Na, 2010).

The state members of European Union (EU) are required to develop national legislation on principles of producer responsibility (EPR) based on EU's Directive 2002/96/EC, Waste Electrical and Electronic Equipment (WEEE) (Zuidwijk & Krikke, 2008). EPR aims to inculcate environmental responsibility among producers by amending design and production aspects that facilitates product dismantling and recovery to facilitate reusability of parts, components and/or materials. Through EPR or equivalent legislations, original equipment manufacturers and their business partners are accountable for environmentally proactive initiatives. They include but not limited to development of ecologically friendly product design (ecodesign) to accommodate use of recyclable material and utilise renewable resources for improving recyclability of products (Cerdan et al., 2009). Malaysian government is providing environmental tax incentive for setting up proper facilities to store, treat and dispose hazardous waste. As of October 2012, Department of Environment (DOE) have issued licensed to 155 off-site partial and full recovery facilities to recover, recycle and treat e-waste. Additionally, Malaysian manufacturers view trade restrictions as one of the drivers for becoming environmentally compliant towards EU regulations (Eltayeb & Zailani, 2010). WEEE Directive 2002/96/EC encourages several types of recovery options such as repair, upgrade, reuse, disassembly and recycling. Generally, this Directive endorsed two targets for electrical and electronic equipment (EEE) recovery, they are: (1) minimum rate of recovery per appliance is 70 percent of average weight; and (2) minimum rate of reuse and recycling for component, material and substance per appliance is 50 percent of average weight.

Currently, Solid Waste and Public Cleansing Management Bill 2007 outlines provisions for producer's responsibility where Clause 101 seeks to provide for reduction, reuse and recycling of solid waste whereas Clause 102 requires manufacturer, assembler, importer or dealer to introduce take back system and deposit refund system. Additionally, Environmental Quality (Scheduled Wastes) Regulations 2005 controls generation, storage, treatment, disposal and transportation of hazardous waste and Section 34B (Prohibition against placing, deposit, etc. of scheduled wastes) requires that person or institution obtain legal permit for handling scheduled waste at prescribed premises. The provision of both regulations showed that end-of-use and end-of-life EEE are resources that must be recovered with specific manner but Agamuthu and Dennis (2011) argued that provisions outlined in both regulations are generic in nature and product recovery programs among Malaysian manufacturers are limited to voluntary participation. Furthermore, incentives for green technology concept was introduced by Ministry of Energy, Green Technology and Water (KeTTHA) in April 2009 and 'Renewable Energy Policy and Action Plan' was effective since June 2010 but this national program focused on promoting renewable energy instead of recoverable physical products. The second edition of 'Guideline for the Classification of Used Electrical and Electronic Equipment in Malaysia' was published in 2010 to deter transboundary movement and disposal of hazardous waste by distinguishing used EEE exported for direct use from used EEE exported for disposal but disguised as second hand goods. During January 2008, Department of Environment (DOE) of Malaysia announced that draft regulation for controlling and managing e-waste, 'Environmental Quality (Recycling and Disposal of End-of Life Electrical and Electronic Equipment) Regulations' is in-progress (Tengku-Hamzah, 2011). The enactment regulates e-waste take back for the purpose of recycling and safe disposal by compelling manufacturers or importers to reduce or substitute use of hazardous materials and facilitate recyclability by means of product design alterations. Even though Eltayeb and Zailani (2011) argued that reverse logistics in Malaysia are driven by expected business benefits, Kumar and Putnam (2008) advocated the importance of regulations as drivers for preventing pollution diseminated by e-waste and as promoters of economic reuse in multiple recovery loop.

For this study, the type of product returns in E&E industry can be divided into four sub-sectors and they comprised of electronic components, consumer electronics, industrial electronics and electrical products where the examples of products for each sub-sector is described in Table 2.3.

Table 2.3
Categories of Electrical and Electronic Products

Sectors	**Sub-sectors**	**Examples of Products**
Electronics	Components	Semiconductors, passive components, printed circuit boards, metal stamped parts and precision plastic parts
	Consumer	Audio visual products such as television receivers, portable multimedia players (PMP), speakers, cameras and electronic games
	Industrial	Multimedia and information technology products such as computers and computer peripherals, telecommunications equipment and office equipment
Electrical	Electrical	Distribution boards, control panels, switching apparatus and industrial lightings, transformers, cables and wires, primary cells and batteries, solar cells and modules, air conditioners, vacuum cleaners, microwave ovens, washing machines and water heaters

(Source: *Malaysia Investment Report*, 2011)

2.2.3 Reverse Logistics and International Organisation of Standardization

The ISO 14001 series was introduced in 1996 when the International Organization of Standardization addresses external pressures by developing a guideline of environmental management requirements to develop environmental policy that addresses firm’s environmental concerns. The ISO 14000 standard outlines five environmental aspects including labels and declarations, environmental performance evaluation, lifecycle assessment, communication and audit ("ISO 14000 - Environmental Management," 2011). Objectives of ISO 14001:2004 related to product recovery are identified as internal objectives, where firm’s objectives in environment management system (EMS) are made known throughout organisation, and external objectives, where assurance are communicated to external stakeholders such as shareholders, customers, suppliers, regulatory bodies and others.

On the other hand, the European Commission issued the Eco Management and Audit Scheme (EMAS) regulation in 1993. Unlike ISO 14001 which function as a management tool, Ljunberg (2007) described EMAS regulation as documents that disclose sustainable manufacturing practices within European Union. Between ISO 14001 environmental management standard and EMAS regulation, Ljunberg affirmed that both presented environmental management requirements to develop environmental management systems (EMS). Nevertheless, ISO 14001 is an international standard for firms to establish EMS and simultaneously publicise firm’s green initiatives. According to Sarkis (1998), EMS certified firms declare their environmental commitment in the form of ‘a statement by the organisation of its intention and principles in relation to its overall environmental performance’ so that stakeholders are informed about their standard.

In the effort to improve environmental and economic performance simultaneously, the commitment exerted by management at corporate level determines the outcome of EMS but this condition depended on the amount of resources that top management are willing to invest in (Goh, Zailani, & Abd Wahid, 2006). Goh et al. pointed out that ISO 14001 certified environmental management system have mediocre impact on firm's performance because these systemised obligations exert positive influence to perceived customer satisfaction, perceived market position and perceived economic or environmental impact. According to Sroufe (2003), the researcher affirmed that involvement in environmental design and waste practices is positively related to firm's performance especially among ISO 14001 certified organisations. A manual published by Asian Productivity Organization also acknowledged the influence of external standards for driving companies to address environmental issues including CERES (Coalition for Environmentally Responsible Economies), RoHS (Restriction of the Use of Certain Hazardous Substances), WEEE and ISO 14001 (*Green Productivity and Green Supply Chain Manual*, 2008). Cradle-to-cradle management concept is a pollution prevention strategy that recovers end-of-use or end-of-life products to reinstate the condition of used goods for redistribution as second hand products. In minimising environmental impact associated with landfill waste from processes and/or products, firms that have obtained environmental management certification are more inclined to invest in reverse logistics product disposition.

2.2.4 Reverse Logistics Product Disposition

There are five sequential processes in reverse supply chain and they are identified as product acquisition, reverse logistics, inspection and disposition, recondition, and remarketing (Guide Jr et al., 2003; Prahinski & Kocabasoglu, 2006). Based on CLSC or RSC literatures, RL is the management of products movement from point of use to point(s) of disposition such as transportation, inventory management, warehousing and distribution. Moreover, the appropriate product recovery strategy is determined during product 'inspection and disposition' whereas the actual work of reprocessing is performed during 'reconditioning'. Talbot *et al.* (2007) categorised five sets of activities to reflect RSC activities and they encompassed disposition activities such as; (1) recovery, test or dismantling, (2) reuse, repair or upgrade, (3) remanufacture or component extraction, (4) material recycling and, (5) incineration or landfill. In GSCM literatures (Eltayeb, Zailani, & Ramayah, 2010; Hervani et al., 2005), reverse logistics is a term that encompassed collecting product and packaging from downstream customers as well as reprocessing activities such as reduce, reuse, remanufacturing and/or recycling of materials into new materials or products with secondary value at current marketplace. Skinner et al. (2008) argued that return strategy is a customer service offering related to liberal return policies and from an organisational standpoint, disposition strategy is a major expenditure that must be dealt carefully as the cost structure and revenue from recovery varies across different disposition options. To steer away from confusion, this study will identify with 'reverse logistics product disposition' (RLPD), which will be used interchangeably with RL, to represent product disposition and product recovery activities in GSCM, RSC and CLSC literatures.

Reincarnation of resources is comparable to industrial ecology, where resources are reused in multiple lifecycles. According to Bras (1997), industrial ecology is the systematic use and transformation of energy, material and capital to intelligently reuse waste in new and functional products. Other researcher such as Veerakamolmal (1999) portrays industrial ecology as "cradle-for-reincarnation" or "cradle-to-cradle" where landfilling is inappropriate. As such, product reincarnation maximises resources and this can be achieved through implementation of RL. Rogers and Tibben-Lembke (1999) provided a wholesome definition on RL, where RL is;

> *"The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal."*

On the other hand, Stock (1998) presented a comprehensive definition of RL by emphasising on product disposition options and management approaches that best fit the objectives of reverse supply chain. RL is defined as follow;

> *". . .from a business logistics perspective, the term refers to the role of logistics in product returns, source reduction, recycling, materials substitution, reuse of materials, waste disposal, and refurbishing, repair, and remanufacturing; from an engineering logistics perspective, it is referred to as reverse logistics management (RLM) and is a systematic business model that applies best logistics engineering and management methodologies across the enterprise in order to profitably close the loop on the supply chain."*

Both definitions pointed out the viability of recovering valuable resources. From industrial perspectives, Knemeyer *et al.* (2002) affirmed that companies are not willing to uptake RL for the sole benefits of environment. However, firms who are willing to accommodate end-of-use or end-of-life product returns develops competitive advantage (Heese et al., 2005) because reverse logistics allows firms to re-capture value-added materials or components to rebuild second hand products. When products are at the point of disposal, the general perception regards them as trash and their end-of-life value depends on industry actors. For example, independent repairers or remanufacturers are among the stakeholders who find these products usable thus valuable. Therefore, end-of-life and end-of-use are interchangeable terms for describing used products. Figure 2.2 provides a clear illustration of how valuable subassemblies, modules, parts, component, or materials of a product can be recovered for use in subsequent lifecycles. If components of a retired product have insignificant value, either damaged or costly to recover, all that remains are recyclable materials and remaining residues will be disposed (Dowie, 1994).

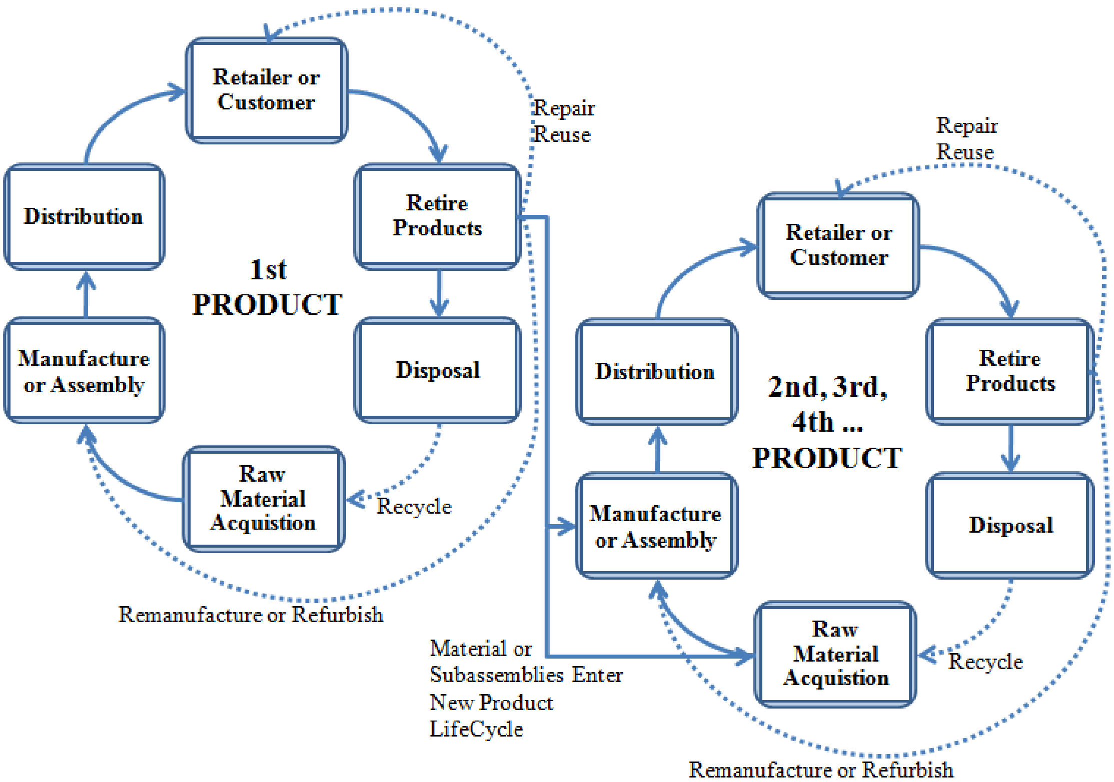


Figure 2.2
Product Downcycling – Components or Parts in Three Lifecycles

Reviews on RL literatures revealed that this process is an additional cost centre (Trebilcock, 2001) that demands meticulous monitoring to contain the expenses in processing returns and maximise revenue generation. Gobbi (2011) argued that when products contain substantial residual value and can be remarketed, the trade-off between cost and speed of recovery is a point to consider because equipments are susceptible to threat of obsolescence such as technology clockspeed. According to Stock and Mulki (2009), a number of well-established corporations have invested resources for implementing efficient and effective reprocessing initiatives which enabled them to recover the product cost within the range of 65 and 80 percent rate. A good example of product reincarnation is Kodak's "Funsaver" disposable camera, where products can be snapped apart to allow 77 to 90 percent of recoupable parts that can be reused in new cameras (Bogue, 2007).

Previous studies have analysed reverse logistics product disposition in explaining the firm's organisational performance (Skinner et al., 2008; Sroufe, 2003; Talbot et al., 2007). According to Skinner et al. (2008), returned products are susceptible to reverse logistics disposition strategies such as destroying, recycling, refurbishing, remanufacturing and repackaging of returned products. The complexities of used products require different level of skills and technical knowledge to diagnose and disassemble products to serve different disposition options (Fernández, Puente, García, & Gómez, 2008), which depend highly on amount of value-added remains in products (Guide Jr et al., 2000). Table 2.4 described RL activities conducted by manufacturers, wholesalers, retailers and service firms. Some activities are excluded from this research because; (1) return to supplier is transport-related activity to send back parts with quality issues, (2) resell and sell via outlet are distribution-related activities, and

(3) reclamation of materials and recycle are similar as they are different only in quality and value of materials.

Table 2.4
Types of Reverse Logistics Activities

Material	Reverse Logistics Activities
Products	Return to Supplier Resell Sell via Outlet Salvage Recondition Refurbish Remanufacture Reclaim Materials Recycle Landfill
Packaging	Reuse Refurbish Reclaim Materials Recycle Salvage

(Source: Rogers & Tibben-Lembke, 1999)

According to Rogers and Tibben-Lembke (1999), asset recovery is the;

> *"classification and disposition of returned goods, surplus, obsolete, scrap, waste and excess material products, and other assets, in a way that maximizes returns to the owner, while minimizing costs and liabilities associated with dispositions".*

In general, asset recovery can be divided into product or part recovery. Product recovery involves minimal disassembly where non-functioning parts are replaced to reinstate products functionality including upgradation works. On the other hand, part recovery requires more disassembly to recover usable parts or components as inventory. Additionally, Ferrer (2001) proposed that wear condition of product and its constituents should be predictable to assist identification of disposition options most suitable for recovering worthy parts and subassemblies. Product inspection is an important aspect because returns with high market value will fetch higher resale price in secondary market (Tibben-Lembke, 2002).

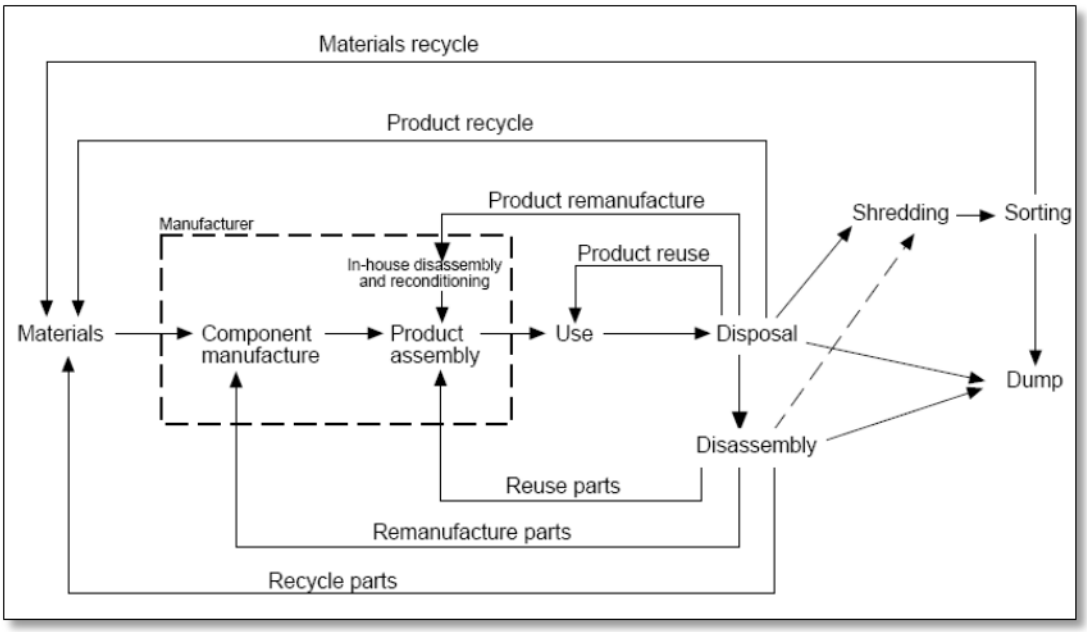


Figure 2.3
The 3Rs Distinguishing Products and Parts (Dowie, 1994)

Figure 2.3 is a representation of parts and products flow where routes for numerous disposition options are symbolised by arrows moving upstream. For every right-to-left arrow, resources can be recovered to reuse parts or products. Despite the complexities in each RLPD options, driving down the cost of product recovery through reuse is a resource that contributes to redistribution of goods. These resources are composed of used subassemblies where a series of verification, cleaning, testing and reprocessing to distinguish non-conforming parts are executed to re-enter the FSC (Genchev, 2007) and the same process is repeated for subassemblies that are further disassembled to part and component level. Ayres et al. (1997) revealed that good quality reconditioned inventories are used in new products assembly by OEM or third party remanufacturer. For the local environment, Tengku-Hamzah (2011) pointed out that there are demands for these parts particularly from independent repair shops. Generally, consumers send malfunctioned EEEs for repair services or sell as end-of-use discards. For the purpose of higher recoverable value, higher resale value and lesser holding cost, Fleischmann et al. (2001) proposed the application of ‘pull’ business strategy such as introduction of trade-in programs to facilitate efficient reprocessing and remarketing at secondary market. However, major issue related to supply and demand of used product in the Malaysian context is almost negligible when compared to producer’s reluctance towards extended responsibility.

The values of reusable modules, parts or components are time-sensitive and their technical and functional qualities may be on par or lesser than the performance standards of new components. Veerakamolmal (1999) argued that used and functional reusable are economically justified because they are reliable and have successfully survived “burn-in” period. Rose and Ishii (1999) proposed that design team analyse product’s wear-out life and technology cycle to anticipate preference in used products disposition. To take advantage of the value in remanufactured products, Sundin (2004) suggested three types of product characteristics that are favourable for profitable asset recovery particularly remanufacturing. They are; first, the core which is the foremost valuable part in the product have not been totally consumed and still functional; secondly, the product can be reinstated to its original condition and quality using the current state of technology and thirdly; low or moderate industry clockspeed introduced minor innovation in product’s technology thus supporting the relevance of recovery. On the other hand, Fernández et al. (2008) briefly outlined the operational activities related to each disposition options but presents determinants for evaluating products to determine type of product disposition based on four criteria that is product value, recovery value, useful life and level of sophistication in the product.

Canning (2006) supported that firms' scope of business should be expanded to include reconditioning and reselling of used but functional products at secondary market. Furthermore, accepting returns for recycling or disposal is a social responsibility that potentially elevates corporate brand image and this practise had created service-based business model. Produce-service business, also known as product-service system, requires customers pay for utilising products including periodical maintenance and thereafter, steer the development of brand loyalty (Roy, 2000). This concept was also known as leasing where OEMs build brand loyalty and collect first-hand information on product's durability. In this scenario, leaser gains advantage for improving product design based on breakdown statistics and manages spare inventories effectively through anticipation of returns. Ayres et al. (1997) studied Xerox's asset recovery operation and revealed that age and wear condition were determinants to the quality of used equipments. Their case study on Xerox revealed that excellent and good quality product will be reused directly whereas lesser quality products are useful for recovery of usable subassemblies and valuable materials. As a result, Xerox's savings on raw materials through active remanufacturing processes reported $69.4 million during the fiscal year of 1995.

Table 2.5 presents the tabulation of all the literatures which have mentioned and/or elaborated about product disposition options from the perspective of RSC, GSCM and environmental management. The frequencies of occurrences for product repair, reuse, recondition, remanufacture, recycle and dispose are significantly higher. As reuse is generally straightforward and commonly known as 'resold as is' or 'repack and sell as new', this disposition option does not require rework if no defectives are found. For example, some popular re-use options such as 'blend-off into the same or similar products' and 'find a customer or market to resell' are redistributions activities that involve considerably minimal resources in reprocessing returns to retail condition (De Brito & Dekker, 2003; French & LaForge, 2006). Therefore, this study excluded the reuse option because the implications of reuse overlap with other disposition options.

Table 2.5
Reverse Logistic Product Disposition Options Identified in Reverse Supply Chain Literatures

No.	Representative Reference	Reverse Logistics Product Disposition Options							
		Repair	Repack	Reuse	Recondition *	Remanufacture	Cannibalise	Recycle	Dispose
1.	Talbot et al. (2007)	/		/		/		/	/
2.	Dowie(1994)			/	/	/		/	/
3.	Skinner et al. (2008)		/		/	/		/	/
4.	Fernández et al. (2008)	/			/	/	/	/	/
5.	González and Adenso-Díaz (2005)	/		/		/		/	/
6.	Ayres et al. (1997)	/		/	/	/		/	/
7.	Aizawa et al. (2008)			/				/	/
8.	Ferrer (2001)			/		/	/	/	/
9.	Gregory and Kirchain (2008)							/	
10.	Kumar and Putnam (2008)	/		/	/	/		/	/
11.	Mathieux et al. (2008)							/	/
12.	Lenox et al. (2000)			/		/		/	/
13.	Tien et al. (2002)	/		/		/		/	/
14.	Zuidwijk and Krikke (2008)			/		/		/	/
15.	Veerakamolmal (1999)			/		/		/	/
16.	French and LaForge (2006)		/	/	/				/
17.	Rose et al. (1999)			/		/		/	/
18.	Zhu et al. (2008b)			/				/	
19.	Bras (Bras, 1997)	/		/	/	/		/	/
20.	Ijomah et al. (2007)	/			/	/			
21.	Thierry et al. (1995)	/		/	/	/	/	/	/
22.	Ljungberg (2007)	/		/	/			/	/
23.	King et al. (2006)	/			/	/		/	
24.	Srivastava and Srivastava (2006)	/			/	/		/	/
25.	Gottberg et al. (2006)	/		/				/	/
26.	Roy (2000)			/		/		/	/
27.	Balakrishnan et al. (2007)	/		/				/	/

Table 2.5 *(Continued)*

28.	Guide et al. (2000)	/				/		/	/
29.	Gobbi (2011)	/			/	/	/	/	/
30.	Hazen et al. (2012)	/		/	/	/		/	/
31.	Stock (1998)	/		/	/	/		/	/
32.	Eltayeb et al. (2010)			/				/	
33.	Hervani et al. (2005)			/		/		/	/
34.	Genchev et al.(2011)	/		/	/				/
35.	Abdullah et al. (2011)	/	/		/	/	/	/	/
36.	Álvarez-Gil et al. (2007)	/		/				/	/
37.	Rogers et al. (2010)	/	/	/	/	/	/	/	/
38.	de Brito and Dekker (2003)	/		/	/	/		/	/
39.	Hanafi (2008)	/		/		/		/	/
40.	Lau and Wang (2009)			/	/	/		/	
N		40	40	40	40	40	40	40	40
Number of occurrences		24	4	30	20	29	6	37	34
Overall percentages (%)		60	10	75	50	73	15	93	85

Note: * Product refurbishment is included in this category.

Warranty is an after-sales service for customers to bring in underperforming products to address product's dysfunctional properties According to Ijomah et al. (2007), repair is 'simply the correction of specified faults in a product'. As product recondition and refurbishment executes rework at module level by upgrading critical components and/or parts, the use of both terms are interchangeable. Fernández and Kekäle (2005) defined refurbishing as the effort 'to bring used product up to specified quality and, eventually, technologically upgrading them, by replacing outdated modules'. This clarification shared similarities with an earlier definition by Thierry (1995), who described that refurbishment activities involve technical upgradation where outdated modules or parts are replaced with technologically superior units to extend the functional value of products. Conversely, Ijomah et al. (2007) differentiates recovery activities based on quality of products. For example, product recondition is 'the process of returning a used product to a satisfactory working condition that may be inferior to the original specification'. Unlike repair, warranty period for refurbished products are lesser than new equipments and only applicable to major wearing parts.

For remanufacturing, Rose and Ishii (1999) anticipated that product suited for remanufacturing are the ones with long wear-out life and short technology cycle. In other words, technology advancement in original products was short-lived due to incremental product innovation but products are able to serve their required functions for a long period of time. As such, Rose and Ishii recommended that designers accentuate remanufacturability of products through design adjustments that facilitate extraction of value-added sub-assemblies to reuse in new or second hand products. Figure 2.4 is a clear depiction of the remanufacturing process where recovered parts can be used to build remanufactured product, new product with remanufactured parts or inventoried as spare parts. These practices are economically and environmentally more attractive than mere disposal.

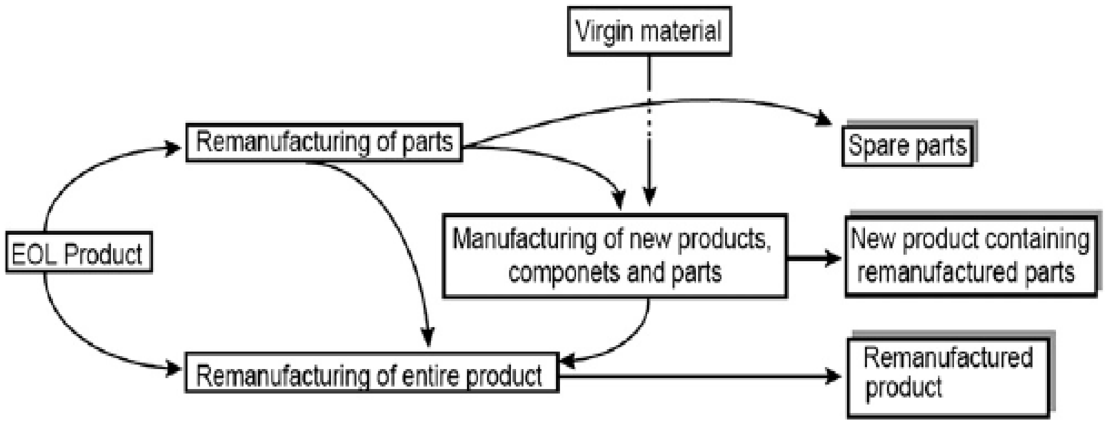


Figure 2.4
Remanufacturing Cycle for Recovering Parts and Products (Gehin et al., 2008)

Due to varying degree of disassembly, Fernández and Kekäle (2005) ranked remanufacturing as third after repairing and refurbishing and defined it as activities 'to bring used products up to quality standards that are as rigorous as those for new products'. Elsewhere, Ijomah et al. (2007) described remanufacturing practice as, 'the process of returning a used product to at least OEM (original equipment manufacturer) original performance specification from the customer's perspective and giving the resultant product a warranty that is equal to that of a newly manufactured equivalent'. Even though the quality of remanufactured and new products are equivalent, remanufacturing incur higher labour cost due to use of skilled labour for complex reprocessing. As the cost of recovery is compensated by conservation of energy and added-value parts or components, the profit margin from remanufacturing products became economically viable. Figure 2.5 displayed the cost structure for new and as-new engine manufacturing. Despite significant reduction in material and overhead costs, labour cost incurred 35 percent of the total costs. Refer to pp. 53, pp. 79, pp. 84 and pp. 88-89 for more discussion on cost related to various disposition options.

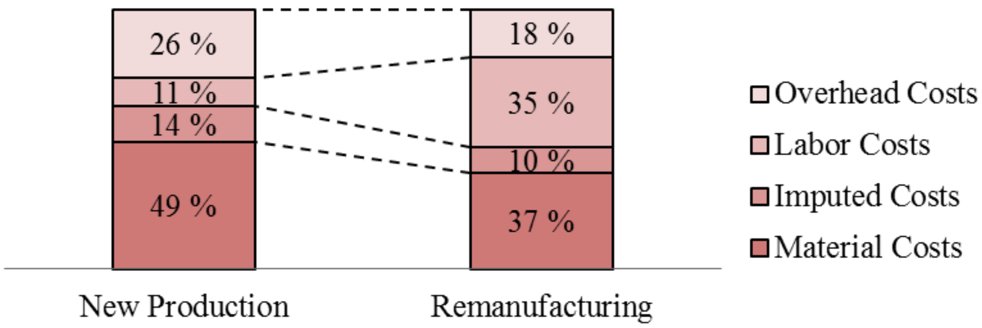


Figure 2.5
Cost Structure Comparison for New Engine and Remanufactured Engine (Johannes, 1995, as cited in Seitz & Wells, 2006)

To improve remanufacturability of products, designers are encouraged to induce some level of compatibility across products innovation from similar technology generations to improve the preservation of economic and environmental values (Sundin, 2004). These values largely depended on age, quality and wear conditions of used product. In general, remanufacturing assembles "as-new product" based on a combination of used and/or new subassemblies, where product quality is close to original but differed in warranty terms. Concurrently, any identification of product's OEM will be removed prior to redistributing remanufactured products at secondary market (Tibben-Lembke, 2002) to deter market cannibalisation, i.e., interruption to sales of new products.

In line with efficient use of resources and utilisation of recyclable resources, Japan enacted Home Appliances Recycling Law in April 2001 to declare a national commitment towards recycling. Under the provision of this law, Japanese manufacturers are required to ensure that recycling yield within the range of fifty to sixty percent depending on the type of appliances (Aizawa et al., 2008). Such regulation existed in Malaysia but due to the shortfall in enforcement, compliance to international trade barriers such as export requirements related to sustainable development became imperative. Gehin et al. (2008) suggested that recycling is a disposition option that requires least amount of investment where the process consists of dismantling, shredding, grinding, sorting to recover material and disposing residual waste by means of landfilling and/or incineration. Guide et al. (2000) argued that recycling is the most viable option only when no value-added components remained in products. If whole product is recycled, recycling reduces the value of used product to solitarily raw materials.

In developing recycling technology that makes recovery of recyclable material cost effective, this initiative is challenged by unpredictable quality of salvageable materials. Their physical and chemical properties are different from virgin material due to the presence of impurities. Typically, materials recycling involve a series or melting in different combination of temperature and pressure to recover material (Ljunberg, 2007). These regimes for treating materials are useful to reclaim virgin materials as properties of precious metal at liquid state are known. Some of the issues that discouraged designers in using recyclable materials are attributed to availability of virgin materials and inconsistencies of price and/or supplies of recyclable materials (Bogue, 2007; Zwolinski, Lopez-Ontiveros, & Brissaud, 2006).

Table 2.6
Composition of Recyclable Items in Municipal Waste in Malaysia

Items	Food Waste	Paper	Plastics	Glass	Ferrous Metals	Aluminium
Composition of Waste (%)	49.3 %	17.1 %	9.7 %	3.7 %	1.6 %	0.4%
Estimated Rate of Recycling = 4.5 %						

(Source: Saeki, 2006)

Table 2.6 breakdowns the mass of recyclable waste by percentage. Even though organic waste dominates municipal waste, WEEE emits the most toxic to environment. The catastrophe of WEEE mismanagement is immeasurable given that D-Link (2007) estimated that WEEE contributes almost 70 percent of heavy metal found in landfill waste. When electronic wastes were disposed without prior treatment, heavy metals reacted with rainwater to create leachate and cause grim soil or groundwater pollution to surrounding area. Thus, take back programs under extended producer responsibility not only provide cheaper resources, but practise of reusing resources protects the environment and enables firms to behave in the interest of sustainable development.

Most literatures mentioned about product recovery management and reverse logistics but limited studies discussed on reverse logistics product disposition. Among them were Gehin et al. (2008), Skinner et al. (2008), Hazen et al. (2012), Gobbi (2011) and King et al. (2006). According to Gobbi, he suggested that returned products should be categorised into low and high residual value to serve recycling and reconditioning activities respectively. Hazen et al. (2012) equate the latter category to product upgrade but did not outline specific characteristics related to each disposition options. At present, a number of empirical studies present generic descriptions on reverse logistics (Chan & Fang, 2007; Eltayeb et al., 2010; Zhu et al., 2007) and it is vital to delineate rework activities to formalise the standard work associated with each disposition option. Guide et al. (2000) identified ‘material recovery uncertainty’ as a major characteristic that complicates recoverable manufacturing system and proposed five differentiating factors that assist the decision-making for repair, remanufacture and recycle. As all three recovery options require varying amount of effort, skills and technology, the factors and their unit of measurement are listed in Table 2.7. This study incorporated first four factors in breaking down the complexities embedded in RLPD options.

Table 2.7
Deterministic Factors for Evaluating the Different Effort of Product Recovery Options

Factors	**Reverse Logistics Recoverable Options**		
	Repair	Remanufacture	Recycle
Product Identity	Unit	Unit, component or part	None
Degree of disassembly	Diagnostic	Complete	Material
Extent of transformation	None	Limited	Complete
Material value-added	Replace or repair defective parts	Replace unrecoverable parts, technical upgrades	None added
Labour value-added	Limited	Extensive	Limited

(Source: Guide et al., 2000)

At hindsight, decisions related to product disposition options are somewhat influenced by designers’ expertise and knowledge. By integrating design attributes that abate harmful environmental impacts, dispositions routes for products are indirectly chartered where returns enter multiple recovery loop to adopt repair, recondition, remanufacture, recycle or mere disposal.

2.3 Product Design

Functional organisation primarily performs work related to their business function whereas project-based team composed of members across firm's business functions. Figure 2.6 describes the difference between both types of organisation structure. The latter structure is a creative approach for facilitating resource integration (knowledge and skills) among members from multiple disciplinary. Such business unit is useful for conceptualising recoverable products from the phase of design, manufacture, assembly to retirement and back again as reusable inventories (Sundin, 2004).

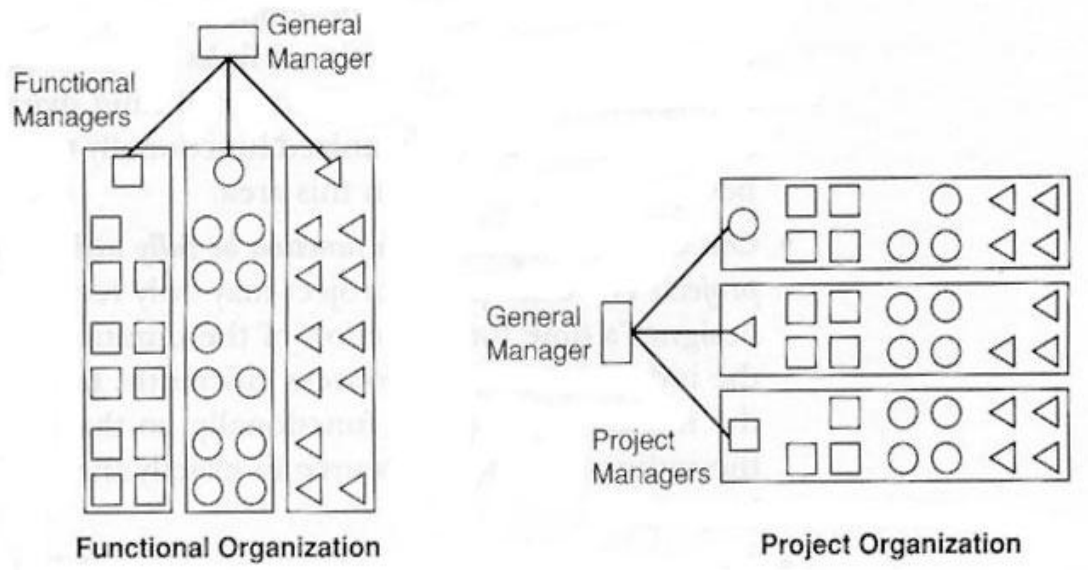


Figure 2.6
The Composition of Members for Different Types of Organisation Structure (Ulrich & Eppinger, 2000)

For several decades, conventional product development prioritises on product's functionality, mass production and cost efficiency. In due course, proactive firms have to invest in the development of recoverable products to anticipate threat from the introduction of extended producer responsibility. The challenges weathered by asset recovery operations are often afterthought issues during product development. Zussman et al. (1994), Kriwet et al. (1995) and Ayres et al. (1997) were among pioneer authors who drew attention to product redesigning to counter environmental impacts related to end-of-life products. Veerakamolmal (1999) associates green product design with concurrent design, where environmentally friendly design is an integrated effort across multiple business functions. Strategic product designing secures higher volume of reusable materials and shorter disassembly time to reprocess time-sensitive products, particularly retrieval of high quality spare parts. This study addressed the role of product design as design changes influence the effectiveness of reverse supply chain management in attaining desired outcome from asset recovery.

Sustainable design is the foundation of green product development which focuses on suppressing environmental issues by modifying design of existing and future products. Based on a generic perspective, Van Weenen et al. (1991, as cited in Baumann et al., 2002) defined green product development as;

> *"resource-, context-, and future-oriented product development aimed at providing elementary needs, a better quality of life, equity and environmental harmony".*

Green designing and RL product disposition share a common environmental objective that is prevention of pollution attributed to waste disposal. The introduction of EPR, a legislative trend among developed countries aims to share the cost of disposal with producers, were deemed appropriate because producers have the utmost authority to amend manufacturing practices that align with the objectives of recoverable products. EPR encourages producers to develop capability in controlling the impact of end-of-life issues. The integration of product reincarnation capability during product designing phase potentially improves the profitability of used product recovery. According to Seitz and Wells (2006), the proportion of material cost from the cost structure of remanufactured products reduced from approximately forty to thirty percent because reusable added-value parts from other products are raw materials to assemble as-new products. These design objectives behave as predecessor to RLPD so that reusable assets are recovered whereas waste or hazardous substances are disposed appropriately. Based on this approach, firms take advantage of physical and financial resources embedded in returns because recovery is an opportunity for OEMs or third party service providers (i.e. second hand repair shop) to extract valuable constituents from EEEs and this practise is analogous to recovery of cost of goods sold.

Conventional manufacturing practices have advocated mass production of EEE that were designed for cost-efficient manufacturing or assembly processes and most firms have conducted business operations at the expense of the environment. According to Menon (2009), the amount of waste in Malaysia is burgeoning especially at urban areas. Even though firm chooses to avoid investment in redesigning products to accommodate recoverability, in time, legislative requirements and cost of disposal will become expensive to the overall operation cost. Ayres et al. (1997) observed that cost of disposal exerts high impact to manufacturing firms operating in Germany, the Netherlands and Scandinavia, where disposal cost for printers and refrigerators averaged two to thirteen percent of direct production cost.

Product disassembly is the pre-requisite for recovering product (*Green Productivity and Green Supply Chain Manual*, 2008). Driving down cost of disposal by improving disassemblability is a promising prospect for sustainable development initiatives, i.e., development of recovery friendly products. Ferrer (2001) analysed recovery decisions by comparing product's reusability, disassemblability and recyclability. Ferrer concluded that disassemblability and recoverable value in products is more influential than relative inspection cost regardless of products' predictable and unpredictable wear. Even though the need to explore product design from the perspective disassemblability and recyclability were advocated by Bogue (2007) and Kriwet et al. (1995) respectively, Dowie (1994) pointed out that complete product recycling is not optimum for profitability and suggested that prior to recycling, it is important to salvage reusable resources to minimise product size or weight prior to disposal.

With that, literatures in reverse and green supply chain management gave rise to environmentally proactive concept by means of disassemblability and recyclability. Further research was required to analyse environmentally-oriented product attributes that eases disassembly to minimise volume and/or pollution from disposables. Studies that outline attributes of recoverable products that promote multiple use of parts, component and/or material were conducted by Brennan et al. (1994), Bogue (2007), Dangelico & Pontrandolfo (2010), Gottberg et al. (2006), Kuo et al. (2001), Desai and Mital (2003), van Hoek (1999) and Cerdan et al. (2009). Gehin et al. (2008) discussed at length on the importance of integrating remanufacturing strategies into product designing phase so as to facilitate product recovery. Figure 2.7 clearly illustrates the sequence of operations undertaken by remanufactured products. Disassembly friendly is an attribute that initiates a string of other processes that facilitates product restoration back to its original quality.

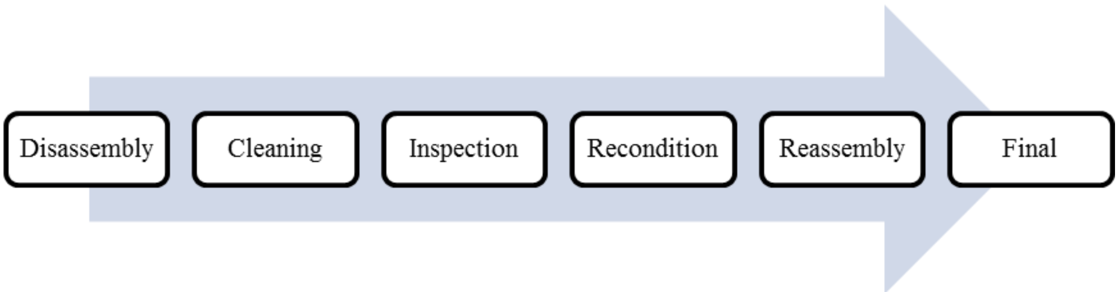


Figure 2.7
A Generic Process Flow for Remanufacturing Process by Steinhilper (1998, as cited in Sundin, 2004)

Mathieux et al. (2008) in his study developed ReSICLED model where multicriteria and multiscenario recoverability indicators were used to evaluate original products and redesign product features that fulfil legislative, economic and environmental goals. Their study described recovery-conscious design (RCD) as fundamental product design strategy to attain higher recoverability and these redesigning initiatives composed of dismantling-conscious design (DCD), dismantling for recovery-conscious design (DRCD), shredding-conscious design (SCD) and recovery system-conscious design (RSCD). On the other hand, Whitmer, Olson, and Sutherland (1995) proposed five product design factors that were equally influential to post-use processes and they are time, cost, materials, energy and modularity. In maximising the recoverable value during product disposition stage of the reverse supply chain, design factors that mitigate complexity of extracting materials such as reusable components, parts and product should be integrated as early as product development stage.

Generally, products that are designed to meet specific objectives are referred to a general term, 'Design for X' or DfX where 'X' represents purpose. Veerakamolmal (1999) presented a list of DfXs strategies and their accompanying objectives such as Design for Assembly (DfA), Compliance (DfC), Disassembly (DfD), Environment (DfE), Logistics (DfL), Manufacturing (DfM), Orderability (DfO), Product Retirement (DfPR), Quality (DfQ), Recycling (DfR^1), Reliability (DfR^2), Safety and Liability Prevention (DfSL), Serviceability (S) and Testability (T). Typically, these DfX strategies are unstandardised and many had overlapping objectives. However, these design elements were practical for designers to address required product characteristics. For the purpose of this study, where recoverability of products is the main emphasis in minimising environmental impact of EEE disposal, Table 2.8 defines some of the DfX strategies related to product recovery.

Table 2.8
Design Practices that Influence Reverse Logistics Product Disposition

The (X) Factor	Objectives
Design for Environment	To design products that address environmental and human health issues arise from the presence of restricted substances during production, consumption and retirement of products.
Design for Disassembly	To design product that reduces the complexity and cost for separating functional modules, components or materials in the effort of conserving resources for future use through reuse, recycling and remanufacturing.
Design for Recycling	To design product that enable material reuse from used products or components by developing recyclability and durability in products, including the intention to reduce the consumption of natural resources.

(Source: Cerdan et al., 2009; Hauschild et al., 2005; Sarkis, 1998)

2.3.1 Organisational Studies on Green Product Design

The concept of environmentally conscious design was coined from the integration of environmental issues into product design (Baumann et al., 2002). Based on Figure 2.8, the environmental impacts of a particular product throughout its life-cycle are fixated right from product design stage and this feat involved collaboration of cross-functional business units. Gehin et al. (2008) also supported the idea that environmental requirements are better assimilated during design phase when the “solution space” is broad. The major focus of ‘green product design’ (GPD) is to foresee and plan retirement strategies for end-of-use or end-of-life products in advance. Figure 2.8 indicated that green aspects in new products are conceptualised by integrating internal and external environmental requirements with idea generation phase during new product development.

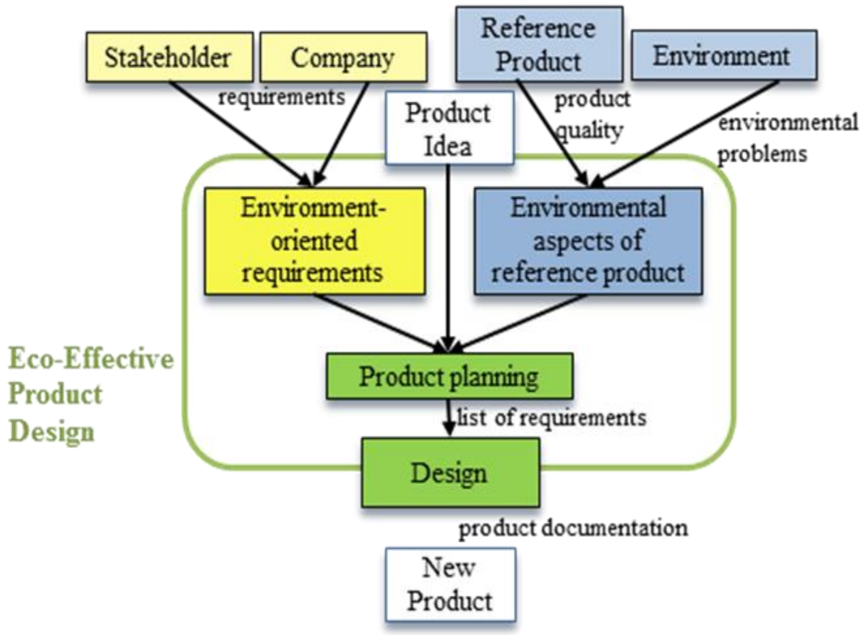


Figure 2.8
The Concept of Eco-Effective Product Design (Frei, 1998)

Despite rapid economic growth and continuous technological upgrades since 1960s, investigation on ASEAN countries revealed that the incorporation of environmental elements into new product is limited given that greening of products is comparatively new, costly and risky (Rock & Angel, 2007). With reference to several literature reviews in relation to green product designs, ‘green design’ was the original terminology and other terms that are gradually introduced include ‘ecological design’, ‘environmentally sound design’, ‘environmentally sensitive design’, ‘environmentally responsible design’, ‘ecodesign’ and ‘design for environment’. These terminologies can be differentiated across different continents where DfE is well-known among American whereas ecodesign identifies with European countries (Baumann et al., 2002). Ecodesign coined from the concept of pollution prevention or source reduction, where pollution are mitigate or reduced at the source in order to conserve the quality of water, air, land and environment. Pollution prevention can be achieved through product or process changes (Zhang, Kuo, Lu, & Huang, 1997). In the effort to facilitate the integration of environmental aspects into product development, Environmental Protection Agency of the United States (1993) has issued a lifecycle design guideline, where resource conservation, pollution prevention, environmental equity, sustainable ecosystem and viable economic systems are environmental objectives that should be observed along with firm's operational goals. As lifecycle design is concerned about environmental impact incurred at every stages of a product's lifecycle, it becomes essential to recognise the type, quantity and quality of pollution generated and address these negative elements during product development.

It is legitimate to proclaim that disassemblability of a product is a source reduction activity that is driven by economic value while behaving in sustainable manner. Other than intangible benefits related to environment friendly brand image, Knemeyer et al. (2002) revealed that the primary drivers for producer's intention to undertake green product design are the prospects for profit and risks aversion such as fines and penalties attributed to regulative violations. Several regulations have been institutionalised to impose responsibilities on producers to dispose products in a compliant manner. If the situation was otherwise, development of innovative green product designs is confined only within the boundaries of idea formulation. On top of it, Sarkis (1998) have proven that design for environment and reverse logistics, a sub-component of GSCM, are interdependent business practices. Subsequent study on this relationship revealed that eco-design resulted in positive and negative economic performance (Zhu & Sarkis, 2007) and this motivated the current research to analyse the effect of green product design on reverse logistics product disposition options and the subsequent effect of the latter capability towards firm's business performance.

In this research, the term “green product design” will be used synonymously with “ecodesign” to represent designs that are environmentally conscious. There are several definitions for green product design that were used to serve specific purposes;

(a) Environmental Protection Agency of the United States has yet to describe green design but the closest term is green engineering and it is defined as follow;

> *“The design, commercialization, and use of processes and products, which are feasible and economical while minimizing 1) generation of pollution at the source and 2) risk to human health and the environment.”*

(b) Research concerning green product design is an expansion from the pollution prevention concept. Navinchandra (1990) discussed environmentally compatible design as green engineering design and defined it as;

> “*The study of and an approach to product and process evaluation and design for environmental compatibility that does not compromise product’s quality or function.”*

(c) Johansson (2002) defined ecodesign as an integration of environmental elements into product without much disruption to original quality of the product;

> *“Actions taken in product development aimed at minimizing a product’s environmental impact during its whole life cycle, without compromising other essential product criteria such as, performance and cost.”*

(d) Sakao (2007) emphasised the importance of environmental consciousness during product designing stage and defined ecodesign as;

> *“Design activity reducing the environmental impacts throughout the life cycle of a product to be designed.”*

(e) In this research, definition of green product design encompasses all the elements highlighted by previous authors and introduced proactivity and business perspective to better serve the interest of industries' operating environment;

> *"Corporate proactive approach for integrating product design and environmental considerations without compromising product's function and quality, including innovations for recovering product value throughout its life cycle prior to disposal".*

From a more functional perspective, Chen (2008) defined 'green innovation' as 'hardware and software innovation that is related to green products or processes, including the innovation in energy-saving, pollution-prevention, waste recycling, green product designs or corporate environmental management'. Chung and Tsai (2007) depicted green design activities as a continuous cross-check between product design and process design to minimise environmental, health and safety risks emitted by numerous stages of product lifecycle.

Designing product for reincarnation in whole or in parts to maximise modules and component reuse is the core focus of repetitive lifecycle (RLC), an approach that fulfils the goals of design for environment (DfE). According to Kuo, Huang, and Zhang (2001), there are three goals of DfE and they are: (1) minimise consumption of non-renewable resources, (2) effective management of renewable resources, and (3) reduce the volume of toxic emission to the atmosphere. Zhu et al. (2007) applied ecodesign in quantitative study and their measurements shared similar meanings with Kuo's DFE goals, they are: (1) design of products for reduced consumption of material or energy, (2) design of products for reuse, recycle, recovery of material, component parts, and (3) design of products to avoid or reduce use of hazardous of products and/or their manufacturing process. Ecodesign and DFE are interchangeable terms that were applied as unidimensional variable by both authors. With reference to a quantitative study conducted among Malaysian manufacturing firms, Eltayeb et al. (2010) developed measurements for ecodesign by adapting from Zhu's study but ecodesign did not address specific design objective that facilitate product recovery particularly technical requirements such as accessibility and separability of parts.

Other studies have described design for disassembly (DfD) and design for recycling (DfR) as approaches of DfE (Hauschild et al., 2005). Furthermore, Argument, Lettice, and Bhamra (1998) are among the few authors who described DfD and DfR as DfX approaches that resided under the aegis of green design. On identifying DfR and DfD as understudied design aspects, Cerdan et al. (2009) developed eleven quantitative ecodesign indicators to assess the degree of eco-efficiency. The proposed indicators are positively associated with the environmental indicators of Life Cycle Assessment (LCA) and DfR- and DfD-oriented indicators potentially minimise length of time and amount of resources required to execute cost-efficient and time-sensitive disposition activities. DFD enables ease of separation whereas DfR improves recyclability in regards to whole-product, components or material recycling (Kurk & Eagen, 2008). Despite a considerable amount of studies in ecodesign, Hauschild et al. (2005) in their state-of-art review revealed that ecodesign and DfD are design techniques which are still at infancy stages and have not been actively adopted in current business practices.

Literatures (Gehin et al., 2008; Rose & Ishii, 1999; Zwolinski et al., 2006) discussed the technical characteristics of the product from the viewpoint of reverse logistics. As soon as organisation plans for cradle-to-cradle product reincarnation, management must set-forth product recovery goals to guide design engineers conceive design improvements that are parallel with the objectives of green product design. Tien, Chung, and Tsai (2002) conducted empirical research to analyse thirty design principles which define environmental designs among Taiwanese manufacturers. The authors outline five categories of design principles and they are use of raw materials, use of energy, design for recyclability, product life cycle assessment and packaging optimisation. Tien et al. disregard the association between 'raw material' and 'design for recyclability'. The authors evaluated environmental-conscious design but did not close the gap on the relationship between ecodesign and product disposition options.

In adopting environmentally conscious practices, designers ought to collaborate with asset recovery division to investigate reprocessing issues that hamper value recovery. Based on a SWOT analysis that evaluates firm's capabilities in meeting WEEE requirements, Kumar and Putnam (2008) pointed out that lack of specialised skills required for dismantling is one of the reasons that drive down the economic profit of reverse logistics activities. The disassembly operation is often challenged by various technical issues and Ayres et al. (1997) suggested that design engineers simplify and accelerate disassembly process by innovating product design. In reusing two welded components or parts, remanufacturer ought to reuse the whole subassembly or risk recovering only the more valuable component or part of the conjoined unit because separating welded assembly normally damage either one or both components or parts. Based on a survey on members of Industrial Designers Society of America, Bogue (2007) revealed that adaptation of GPD is undermined by information unavailability such as comparison of environmental impacts exerted by certain processes or materials, source of sustainable or recycled materials, DfD guidelines, and availability of alternative materials for polyvinylchloride (PVC), flame retardant and lead (solder).

From a general perspective, the initiative for introducing design for disassembly is driven by *'correct identification of the design specifications to minimise the* *complexity of product structure'* (Desai & Mital, 2003). Design for disassembly complements the objectives of design for recycling as the combination of both facilitate products, components and materials reuse (Hauschild et al., 2005). Previous literatures have provided the main objective for recycling as minimising the amount of landfill waste. Ljunberg (2007) analysed the effect of renewable material on products' sustainability by examining the physical properties of various materials during product use and recycling including recyclability, toxicity and durability of materials. For example, synthetic polymers release harmful emission when burnt and composites do not permit ease of material separation. In an earlier study, Sarkis (1998) subdivided the DfE concept into design for reusability, remanufacturing and recyclability but differentiates them based on degree of treatment required during product disposition. Additionally, Talbot (2005) developed 'Product Ecodesign Chain' concept that composed of ten environmental initiatives to focus in product's value chain from point of procurement until point of disposal. These initiatives via guideline are imperative to decision makers because these decisions affect an estimate of 50 to 80 percent of cost incurred during product's life cycle management (Sroufe, 2003). Green product development considered designs that ease multiple future use, ease repair, ease disassembly and ease recycle as elementary factors that address recovery challenges in end-of-use and end-of-life EEEs (Talbot, 2005).

A number of studies have discussed the contribution of green product design towards product disposition options but nevertheless, GPD in Malaysia remains ambiguous because most studies are conceptual in nature. Others focused on tool development for evaluating product's sustainable characteristics and some studies presented normative suggestions to influence managers and policy makers in supporting green product development.

2.3.2 Design for Disassembly

In defining product architecture, Ulrich & Eppinger (2000) described conceptualisation in products as;

> *"define how functional elements of a product are arranged and mapped onto physical components, and what is the specification of interfaces between interacting physical components".*

Decision on product's structural aspects is linked to firm's operational performance. From Hauschild's (2005) perspectives, disassembly is considered as precondition for economically viable product reprocessing which involve both destructive and non-destructive disassembly. Based on Figure 2.9, when the degree of product disassembly increases, more valuable parts are recovered to generate used inventories for remanufacturing or recondition activities. The net value of recoverable scrap reduces with higher degree of disassembly as recyclable precious materials are removed thus leaving behind worthless disposable residues.

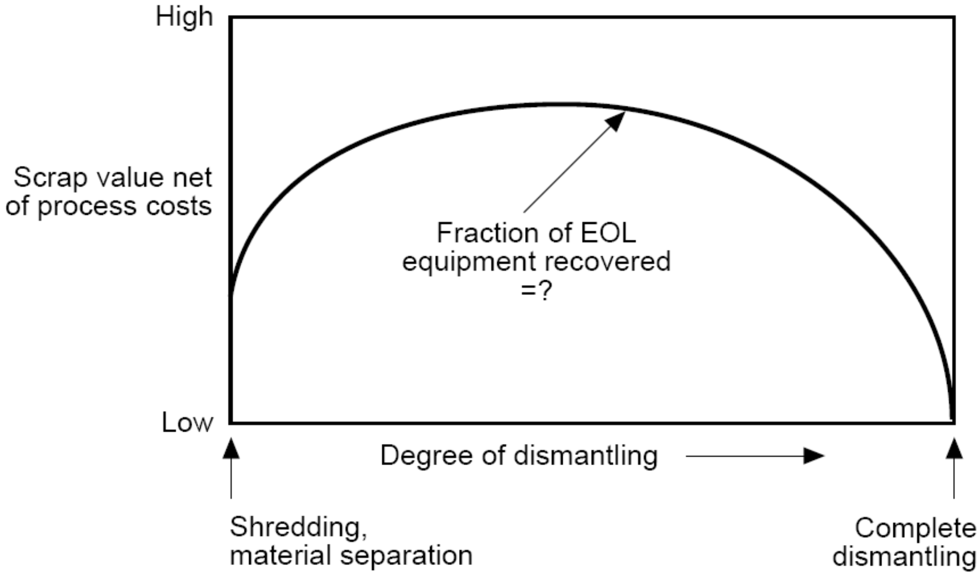


Figure 2.9
Degree of Dismantling against Scrap Value (Dowie, 1994)

Disassemblability of products influences volume of extracted reusable and this work is complex as products were not designed for such purposes. In general, products were designed for cost-effective manufacturing or assembly and joining elements that were not disassembly friendly create joint surface damages between parts and/or components and consequently, the quality of recovered parts may be disrupted. Product disassembly is best described by Brennan, Gupta, & Taleb (1994) as;

> "the process of systematic removal of desirable constituent parts from an assembly while ensuring that there is no impairment of the parts due to the process".

Type of recovery options is differ across product structures because disassemblability, separability and parts recognition are among major issues. Product designers are encouraged to improve disassemblability by developing detachable subassemblies to ease modules or parts diagnosis during inspection as well as maintenance. Sarkis (1998) is one of the pioneer authors who proposed to integrate DfD into product design to ease accessibility and separation of parts for subsequent disposition processes. From the green perspective, incorporating design for disassembly (DfD) into EEE is essential to facilitate reusability and recyclability of products and parts thereof. Without DfD, it is challenging to achieve three objectives that measure recyclability, they are; (1) maximising profit throughout product lifecycle (cost-benefit analysis); (2) maximising quantity of reusable parts, and (3) minimising the weight of waste for disposal (Zussman et al., 1994).

Note that the circumstances of disassemblability for reincarnating products deserved extensive considerations. According to Gungor and Gupta (1999), the product structure that considered DfD concept are relative simpler due to minimisation of parts, use materials that are comparatively common and/or compatible and use joint elements that can be easily separated. Similar to many operation processes, it is possible to drive down the cost of product disassembly by analysing separability factors related to: (1) product structure; (2) materials; (3) fasteners, joints and connections; (4) characteristics of components for disassembly, and (5) disassembly conditions (Bogue, 2007). Additionally, Dowie (1994) recommended several design parameters in regards to choice of fasteners and connection and they are;

- Reduce the quantity of fasteners,
- Reduce the types of fastener,
- Enable accessibility of fastening points,
- Enable easy removability for fasteners,
- Design joints with breakable connection as alternative for removing fasteners,
- Ease identification of access and break points, and
- Reduce the quantity, type and length of interconnecting wires used.

Based on Dowie's recommendations, Mathieux et al. (2008) adopts the first two attributes enlisted above to describe joint characteristics of ReSICLED method. It is important to note that fewer quantities of fasteners and lesser variability of fasteners result in shorter disassembly time and fewer types of tools or methods required to dislodge desired parts. Desai and Mital (2003) suggested that disassembly operations should be executed at minimal force and only require use of common tools. Moreover, Bogue developed separability factors to rate the recyclability of products but these factors have not been empirically tested to ascertain their generalisability. Most of the abovementioned DfD aspects have not been analysed to ascertain the relationship between disassembly friendly design and product disposition options.

In general, brute force and reverse assembly are two basic methods to disassemble parts and they are also identified as destructive and non-destructive joints respectively. Based on the tenth rule of The Ten Golden Rules of EcoDesign, it is recommended that product development apply screws, adhesives, welding, snap fits, and geometric locking as joints between parts and/or components (Luttropp & Lagerstedt, 2006). Some types of fasteners such as screws, glues and welds are time consuming to remove whereas clip, snap-fit or Velcro fastenings require less energy to detach (Veerakamolmal, 1999). Similarly, Ferrer (2001) supported this notion and enlisted bonding, joint-stamping, riveting and welding as examples of fastenings that facilitate effective product assembly but these joints were almost impossible to disengage without damaging (e.g. cosmetic damages) at least one of the conjoined parts and/or components. Furthermore, joined elements are susceptible to wear and this condition might complicate removal. Table 2.9 provides clearer description of how various categories and types of joints affect ease of product disassembly. All types of welding and mechanical joint such as seams, crimps and irreversible snap-fits cannot be conveniently removed. Therefore, the product design ought to steer clear of these joints if alternative joint which serves the same purpose are available. Ayres et al. (1997) argued that the alternatives ought to be renewable, contribute structural strength and can be disassembled without neither complex tools nor exertion of force.

Table 2.9

Joining Processes and the Rating for "Ease of Disassembly"

Joining Processes		"Ease of Disassembly"	
		ϵ [0,1]	Linguistic Expressions
Welding	Liquid State (Oxyfuel Gas, Arc, Resistance)	0.1	Very Low
	Solid State (Forge, Cold, Ultrasonic, Friction, Explosion, Thermit, Electron-Beam, Laser-Beam, Diffusion)	0.1	Very Low
	Liquid-solid State (Brazing, Soldering)	0.1	Very Low
Adhesives	Natural Adhesives	0.7	Medium to High
	Inorganic Adhesives	0.7	Medium to High
	Synthetic Organic Adhesives	0.7	Medium to High
Mechanical	Threaded Fasteners (Bolts, Screws, Nuts)	1.0	Very High
	Rivets	0.6	Medium to High
	Metal Stitching and Stapling	0.6	Medium to High
	Seaming	0.3	Low to Medium
	Crimping	0.4	Low to Medium
	Reversible Snap-in Fasteners	0.9	Very High
	Irreversible Snap-in Fasteners	0.1	Very Low
	Shrink and press fits	0.8	High
	Wrap	1.0	Very High
	Placement	1.0	Very High

(Source: Becerra, 2000)

Most of previous literatures which discussed on recyclability issues were like-minded on the viewpoint that type of fastenings influence disassembly process and product's recyclability (Ayres et al., 1997; Cerdan et al., 2009; Dangelico & Pontrandolfo, 2010; Go, Wahab, Ab. Rahman, & Ramli, 2010; Gottberg et al., 2006; Jorjani, Leu, & Scott, 2004; Veerakamolmal, 1999). By selecting fasteners that mitigate complexities that occur during product recovery, designers enhance the prospects of redistributing recovered EEEs. For remanufacturing, Ijomah et al. (2007) affirmed that certain types of adhesives and welds hinder the recovery process and Veerakamolmal (1999) suggested that "breakable snap fits" and threaded fasteners are preferred because they are comparatively easier and cleaner to remove as compared to non-threaded fasteners and rivets. Without ease of accessibility, the effectiveness of implementing time-sensitive disposition options is significantly disrupted. Therefore, empirical studies are required to measure DfD as one of the dimensions of green product design and their influence towards RLPD options in the Malaysian marketplace.

2.3.3 Design for Recycling

Design for recycling prioritises on salvation of materials, energy and waste emissions from produce in whole or at certain percentage. From the context of eco-design strategies, DfR exists in conjunction with DfD to facilitate a range of product disposition options. One of the motivations that steer material recycling is the availability of recyclable precious materials that can be processed to manufacture new components. Ferrer (2001) explained that recovering product or components are akin to value recovery and material recovery. Material recovery is affiliated to recycling valuable materials when products have lost their entire functions or built-in information. On the other hand, value recovery differs from material recovery because products' added-values are recovered in the form of components and subassemblies.

In the event of rapid dwindling of natural resources and surging price of precious metals, it is imperative for OEMs to collaborate with authorised recyclers and informal recyclers (e.g. scrap dealers, scavengers and second hand EEE dealers) to develop a curative strategy for improving recycling technology and processes. This is important to warrant a constant supply of recycled materials. Ferrer (2001) observed that recycled material are cheaper compared to virgin material although these material undergoes a sequence of costly processes to preserve its original properties. However, recyclable material such as steel requires lesser energy, emits lesser greenhouse gas emission compared to virgin ore processing and can be recycled indefinitely. Despite additional processes required to harvest material at its purest state, Ayres et al. (1997) discussed an instance where demand for recycled copper avoids a series of ecological threats that accompanies copper mining. For every tonne of copper ore, the copper processing industry requires two-fold of copper ore, one tonne of nitrate explosive, half tonne of chemical for flotation and one tonne of hydrocarbon for smelting (Ayres et al., 1997). In response, traces of toxic contaminants such as silver, lead and arsenic are released along with gaseous substances such as three tonnes of carbon dioxide, two tonnes of sulphur dioxide and immeasurable volume of dust and smoke. The following table displayed the range of buying price for recyclable materials and these reimbursements drives recycling activities among consumers in Malaysia.

Table 2.10
Price Comparison for Recyclable Materials across Different Recycling Levels

Recyclable Materials	**Buying Prices (RM)**		
	Primary Collectors	**Recycling Centres**	**Middlemen / Trader**
Aluminium cans	0.35–3.00 /kg	1.70–5.00 /kg	2.50–5.50 /kg
Car batteries	1.00–3.00 /pc	0.60 /kg or 5.00–10.00 /pc	1.75 /kg or 13.00 /pc
Carton boxes (cardboards)	0.07–0.40 /kg	0.10–0.55 /kg	0.07–0.80 /kg
Copper	1.00–3.20 /kg	NA	1.00–9.50 /kg
Glass bottles	0.05 /kg or 0.16 /pc	0.03–0.25 /kg	0.05–3.00 /kg
Other papers	0.10–0.30 /kg	0.15–0.50 /kg	0.20–0.70 /kg
Old newspaper	0.10–0.30 /kg	0.10–0.35 /kg	0.15–0.42 /kg
Paper (computer)	0.20–0.30 /kg	0.20–0.45 /kg	0.20–0.60 /kg
Paper (pure white)	0.20–0.30 /kg	0.20–0.45 /kg	0.50–0.80 /kg
Paper (magazine book)	0.20–0.30 /kg	0.30–0.50 /kg	NA
Waste plastics	0.10–0.70 /kg	0.15–0.90 /kg	0.18–1.10 /kg
Scrap metals	0.15–3.00 /kg	0.20–5.00 /kg	0.25–7.00 /kg

(Source: Theng, 2008)

Product downcycling facilitates multiple recovery loops and encourages use of renewable resources to inherently reduce demand for landfill disposal. Balakrishnan et al. argued that the features and content of products substantially influence the operating standards for disposing products. In fact, most studies have suggested a relationship between eco-design and sustainable development. However, empirical studies on the association between green product design and disposition options are lacking. For the purpose of designing remanufacturable products, Ijomah et al. (2007) conducted a workshop and discovered that it is important to choose durable materials which can withstand the remanufacturing process and survive the wear and tear of equipment use. Careful selection of coatings was important to protect materials against corrosive agents. However, the application of coating layer to protect surface of a product may create negative repercussions when protective material peels and leave behind debris that may affect performance of residue-sensitive components.

From Dowie's (1994) perspective, the guideline of materials that conform with the concept of green product design are outlined as follow;

- Minimise the number of materials
- Avoid contamination by labels, adhesives and others
- Materials of a subassembly should be compatible with each other. If materials are incompatible, enable ease of separation (avoid co-moulding polymers)
- Use recyclable materials
- Hazardous materials should be clearly demarcated and easily removed
- Parts made from precious materials should be easily identified and removed
- Compatible ink should be used for printing plastic parts
- Mark plastic parts for ease of identification

However, Dowie's (1994) design guidelines have not been empirically tested to establish the influence of design as a knowledge-based resource that develops product disposition capabilities. Even though automotive industry is approaching mature stage, Amelia et al. (2009) recommended that local firms should invest in design for reuse to compete with foreign cars and this indicated a lack of exposure towards green designing. Tien et al. (2002) drew attention on material selection and environment-oriented design. They include use of energy-conserving raw material and substitute raw material prohibited by environmental protection regulations with pollution-free materials. At hindsight, integration of design for recycling to improve recyclability of EEE products could be at infancy stage where target rate of recycling among local manufacturers has not been established. Design for recyclability is conceptual in nature and most of the design attributes discussed by authors are elementary aspects of green products. According to Tien et al., design principles related to raw material are as follow and only second and fourth item of Dowie's suggestions were enlisted;

(1) Use of non-scarce materials,

(2) Use of substitutes of scarce materials,

(3) Use of pollution-free raw materials in production,

(4) Use of energy-conserving raw materials in production,

(5) Use of raw materials compliant with environmental protection regulations,

(6) Use of recyclable (renewable) raw materials,

(7) Use of parts easy to recycle with no permanent labels, and

(8) Use of raw materials which disposal will not increase processing cost.

Nevertheless, Tien et al. (2002) did not cross-check the association between designing recyclable products with choice of raw materials through correlation analysis. In other words, these measures on raw materials do not constitute recyclable design. Moreover, a number of empirical studies have analysed green design but rarely address detailed attributes of environmentally friendly materials (Eltayeb et al., 2010; Ninlawan, Seksan, Tossapol, & Pilada, 2010; Shang, Lu, & Li, 2010; Yu, Hills, & Welford, 2008; Zhu et al., 2007). Information unavailability such as detailed comparison of materials' environmental impact is one of the challenges that product designers encounter when justifying use of sustainable material (Bogue, 2007). In a recent study, Ljunberg (2007) assisted designers in making informed decision when selecting types of material in developing recoverable product. Table 2.11 in the following page presents distinctive groups of materials, outline advantages and disadvantages of material, and score sustainable materials based on a value of 1 to 3, where 1 is renewable and 3 is non-renewable.

The sustainability of the materials is judged based on recyclability and reusability of materials that originated from dysfunctional parts and components. Most materials that have poor sustainability score are affected by toxic or radioactive elements, toxic chemical treatments, painting, colouring or impregnations which highly influence the complexity and sustainability of recycling (Ljunberg, 2007). Furthermore, aluminium and thermoplastics (metals and synthetic polymers respectively) are preferred choices as these materials are highly recyclable. As such, Ljunberg's study affirmed the link between material selection and product design in developing sustainable product. Organisations need to develop know-how for exploiting potential benefits of cradle-to-cradle design because lack of knowledge in product recovery warrants weaker revenue when greener future mandates extended producer responsibility.

Table 2.11

Characteristics of Six Groups of Materials for Sustainable Product Development

Material Group	Examples on Materials	Typical Advantages	Typical Disadvantages	Classification of Sustainability*
Metals	• Steel (Fe + C) • Aluminium • Bronze (e.g., Cu + Sn)	• Durable and strong • Often plastic formable • Often cheap	• High cost for machining • Mostly corrosion sensitive	• Easily recyclable (re-meltable) • 2-3
Ceramics	Synthetic materials: • Percelain (clay) • Mineral glass • Al2O3, Si3N4, SiC	• Non toxic • Light • Hard and durable • Corrosion resistant • High temp, resistant	• Brittle • High cost for machining when burnt • Not suitable for load in tension	• Easy to deposit (non toxic) • Possible but expensive to re-melt • 2-3
Synthetic Polymer	• Thermoplastics (e.g., PE, PS, PC, PP) • Two component polymers (e.g., epoxy) • Rubber (e.g., Isopren)	• Non-toxic • Light • Cheap and easy forming • Recyclable by, e.g., burning	• Decomposes easily • Not durable • Toxic when impregnated	• Recyclable by, e.g., burning • Renewable • 2-3
Natural Inorganic Materials	• Stone • Minerals	-refer to ceramics-	• Brittle • High cost for machining • Not suitable for load in tension	-refer to ceramics- • 3
Composites	Mixed materials, e.g.: PS + glassfibres, Cu + W-fÍbres, Rubber + textilfÍbres, asphalt (oil + stone), Wood Polymer Composites (WPC)	• Optimised use of the materials • Often very strong and light	• Often expensive to produce • Very various properties for various composites	• Typically low sustainability due to separation problems for the mixed materials • 1-2

* The sustainability is estimated from the scale of 1 to 3, where 1 indicates the lowest (or weak) sustainability and 3 the highest.

(Source: Ljunberg, 2007)

2.4 Resource Commitment

Other challenges to this noble effort are the investment cost for integrating environmental-oriented approaches in design and other business functions across entire organisation. Knowledge on attributes that define green products is intangible resources (i.e. skilled personnel) whereas capital investments on acquiring technical knowledge (i.e. equipments and machineries) are considered tangible resources. The assimilation of these resources over a period of time accumulates experience and know-how to effectively manage reverse logistics for developing firm's capability in handling returns and this may sustain competitive advantage.

Based on a pioneer study, managerial resource commitment is positively correlated with reverse logistics performance objectives, i.e., recovery of assets, reduction of investment recovery and improved profitability (Daugherty et al., 2001). In addition, financial and managerial resource commitment is associated with environmental regulatory compliance. Arguably, there is a possibility that firm's are not willing to commit financial resources to reverse logistics unless the risk of fines from environmental violations is imminent. In hindsight, development of reverse logistics capabilities was a managerial interest that is integrated to current business operations to improve customer satisfaction. According to Lau and Wang (2009), large corporations may have more resources and capabilities to invest in reverse logistics whereas smaller organisation prefers to minimise total cost particularly when such activities are encouraged but have not been legally mandated. In a later study conducted by Richey et al. (2005a), it is evident that resource commitment directly influence firm's reverse logistics innovations where managerial resources are significant contributor whereas technological and financial resources were dormant influencers. Their study defined RL innovations as system and procedural formalisation, technological acquisition and agility of processes and once again, these factors encompassed system-wide definition of reverse logistics operations. Insignificant findings indicated in their study showed that firms may not have focused on reverse logistics in a wholesome manner even though managers are required to cope with returns. Nevertheless, Grawe (2009) argued that the general influence pertaining financial resources has been established outside logistics-related literatures and this resource was not be excluded from current study.

Several studies has highlighted the importance of resource commitment to manage operational activities related to reverse logistics (Genchev, 2007; Jack, Powers, & Skinner, 2010; Richey, Daugherty, Genchev, & Autry, 2004; Skinner et al., 2008). Resource commitment influenced information system capabilities related to reverse logistics by handling returns efficiently so that cost of product recovery is reduced (Jack et al., 2010). On the other hand, Genchev (2007) proposed that the formalisation of reverse logistics is influenced by knowledge- and property-based resources. Knowledge-based resources are considered as the know-how and skills such as technical knowledge of skilled workers in handling and evaluating disposition strategy suitable for returned products. On the other hand, property-based resources composed of physical facility including automated machineries to facilitate reprocessing. Technological resource commitment is considered as property-based resources as they are physical assets that are acquired for their capability to improve the overall efficiency of reverse logistics such as metals analyser, aluminium shredder, x-ray screening devices and recycling equipments dedicated to shred, sort and process steel, plastic, glass and paper. When resource commitment was analysed as moderator to the strategic performance of reverse logistics product disposition strategies, economic performance of recycling and destroying improved whereas operational responsiveness of refurbishing and remanufacturing improved (Skinner et al., 2008). Among developed countries, recycling and disposal activities are strictly regulated and the expenditures for undertaking environmentally compliant practices minimise risk of fines or penalties from violations. This explained the derivable economic benefits from committing resources in recovering products with low residual value.

Based on Jack et al. and Skinner et al., analysing resource commitment as antecedent of reverse logistics product disposition was viable since previous authors examined resource commitment on different industrial setting (automotive and retail) or different processes of reverse supply chain. These factors rendered the subject matter inconclusive. Reverse logistics as an environmentally proactive pollution prevention practice is regarded as non-imitable capability from the perspective of resource-based view. As reverse logistics fulfils environmental protection initiatives and improve customer satisfaction, firms may consider investment in reverse logistics (Lau & Wang, 2009). Choice of disposition options is few if resources are limited and firms have to weigh their resources to decide on the most feasible cost-to-benefit disposition options. For example, firms that possess inventories of spares and personnel who are well-trained in product assembly should take on remanufacturing activities. On the other hand, firms without such resources should recycle and dispose as both are more economically feasible. Ijomah et al. (2007) and King et al. (2006) pointed out the difference in level of work required to repair, recondition and remanufacture, where warranty, quality and reliability of products improved across disposition options require greater resources. Gobbi (2011) suggested that firms consider the trade-off between time and cost of recovery where products with low residual value undergo cost-efficient disposition such as bulk handling whereas product with high residual value required higher reprocessing cost as they are predominantly time sensitive.

2.5 Business Performance

In countries where supply chain management has been effectively managed to achieve competitive advantage, performance measurements are used as point of reference to monitor and control integrated activities across key players of the supply chain. Gunasekaran, Patel, and McGaughey (2004) defined performance measurement as the parameter for companies to achieve their desired goals. Performance measurement is an important driver for business activities to set objectives, evaluate performance and determine future course of actions. In conventional SCM system, quite a number of empirical studies examined performance measurement for FSC activities particularly plan, source, make or assembly, and delivery. However, performance measurements for RSC were underdeveloped among researchers and practitioners as compared to GSCM. GSCM composed of green purchasing, green manufacturing or materials management, green distribution or marketing and reverse logistics (Hervani et al., 2005). Hervani pointed out that reverse logistics of GSCM is end-of-life product management that comprised of ‘Re(s)’ options and this categorisation is comparable to ‘inspection and disposition’ process of RSC discussed by Prahinski (2006). Hence, the performance measures applied in GSCM literatures are adapted for this study.

On overall, empirical researches on the business performance of RLPD capabilities are particularly few. Talbot et al. (2007) and González-Benito and González-Benito (2005) shared similar perspectives on the influence of product design towards product disposition and their prevailing consequences to environment. In analysing business performance of environmental proactive activities, González-Benito and González-Benito (2005) measured business performance based on marketing performance, mass or lean operational performance and financial performance. Their study revealed that none of the environmentally proactive practices is related to firm’s financial performance and logistics processes (process-related operational practise) are only associated with lean operational performance. As the results were undesirable for managers to invest in recovery conscious products, this study adapted performance measurements in environmental management literatures as proactive environmental practises and reverse logistics shared common interest with pollution prevention.

Talbot et al. (2007) revealed that companies that channel their attention on RSC strategies alongside FSC strategies generate manufacturing capabilities and operational excellence. On overall, CLSC-focused firms attain competitive advantage due to superior market intelligence, manufacturing capabilities, competitiveness, competencies and operational excellence compared to FSC-focused or RSC-focused businesses. Eltayeb and Zailani (2010) pointed out that Malaysian manufacturers are passive towards take back activities even though a number of them are foreign multinational corporations. Although returns management improves brand equity, Li and Olorunniwo (2008) observed that the business benefits of reverse logistics were in contrary with the potential outcome outlined by literatures i.e. reduction of cost of goods sold from parts reclamation, reduction of operating cost due to compliant disposal and revenue generation from sales at secondary market. However, Ayres et al. (1997) analysed economics of remanufacturing and revealed that firms who adopted first-mover strategy in asset recovery programs such as Rank Xerox, Aurora Electronics, BMW and Siemens Nixdorf have generated profit or break-even fifteen years ago. Due to the presence of contrasting outcomes, empirical investigation rationalised the business viability of product disposition.

Economic performance is the trade-off between level of service rendered and cost of service incurred by each disposition options (Skinner et al., 2008). On the other hand, Fraj-Andrés, Martinez-Salinas and Matute-Vallejo (2009) measured economic performance as one of the dimensions for measuring organisational performance of environmental orientation. They defined economic performance from the accounting perspective and partook firm's profitability, sales growth, firm's economic results, profit before tax and market share as underlying measurements. These measurements were unsuitable for evaluating reverse logistics product disposition because green initiatives are emerging operational practise among developing nations. Nevertheless, costing is a major indicator to justify profitability of reverse logistics and when trade-offs between cost and profit of disposition options are agreed upon, green product designing gains momentum in facilitating effective end-of-use product recovery.

A number of literatures have studied the effects of environmental strategies towards organisational performance based on financial, market share and economic measures. Commitment towards environment protection initiatives including compliance and waste reduction develops environmental reputation that directly influence firm's profitability. González-Benito and González-Benito (2005) indicated that measures of performance outcome vary across type of environmental proactive activities. In analysing the relationship of pollution index towards economic performance, Freedman and Jaggi (1992) used financial measures such as return on equity, return on assets (RoA), cash flow to assets, cash flow to equity and debt to equity to measure economic performance. The use of financial indicators to measure firm's performance were applied by several studies (Chan & Fang, 2007; González-Benito & González-Benito, 2005; Menguc & Ozanne, 2005; Rao, 2002; Russo & Fouts, 1997). In analysing natural environmental orientation defined by entrepreneurship, corporate social responsibility and commitment to natural environment, Menguc and Ozanne revealed that the multidimensional variable is positively related to market share and profit after tax but is negatively related to sales growth. On the other hand, González-

Benito and González-Benito indicated that environmental proactive activities such as development of environmental management system, product development, producer responsibility and greener production are not related to RoA in the short run. They suggested that return from initial investment required a longer period although firms experience improved operational and marketing performance. When firms decide to operate in congruence with the concept of supply chain environmental management, Rao (2002) proposed that economic performance should be measured based on new market opportunities, product price increase, sales growth, profit margin and market share. Chan and Fang (2007) applied first three financial measures to define economic benefits of environmental practices and their study showed that ecological design and training (i.e. environmental protection in the production process and education) and product recovery (i.e. ecosystem friendly) activities emanate positive contributions.

Based on the findings of previous authors, it is herewith important to emphasise that environmental benefits are not primary driver for executing product disposition options. Even though economic reasons are more attractive for firms to change their traditional approach (Li & Olorunniwo, 2008) towards higher sustainability, the competition for superior environmental performance do exist (Yang, Hong, & Sachin, 2011). Of late, the perception of green initiative as trade-off between environmental performance and economic performance are changing. Prior to analysing green initiatives and its influence to economic performance, Rao (2002) uptake a neutral perception and indicated that, 'When waste, both hazardous and non-hazardous, is minimised as part of environmental management, it results in better utilisation of resources, improved efficiency, higher productivity and reduced operating cost.'

The costs-to-benefits analyses are used to determine the advantages of pursuing product disposition in RSC (Mathieux et al., 2008; Porter, 2002; Stock et al., 2006;

Veerakamolmal & Gupta, 2000). In terms of cost, most investments are tied up with: (a) a collection of recyclable that are being disposed, and (b) reprocessing activities (Porter, 2002). By examining economic benefits of recovery routes such as manual dismantling, manual extraction, sorting and recycling scenarios, Mathieux et al. (2008) pointed out that several aspects related to reclaimable components, cost of product disassembly and the fees of waste disposal deserved attention. The objective of reverse logistics is efficient consumption of resources through multiple recoveries without undermining firms' profitability. Products that undergo complex disassembly processes were a let-down as profit margin shrank further and cost of proper e-waste disposal would become convenient. Veerakamolmal (1999) estimates net recoverable value of product recovery options by subtracting cost of reprocessing from estimated resale value. Therefore, risks of cost overrun for each disposition options are reduced. Figure 2.10 exhibit the relationship between cost and benefit of pollution abatement.

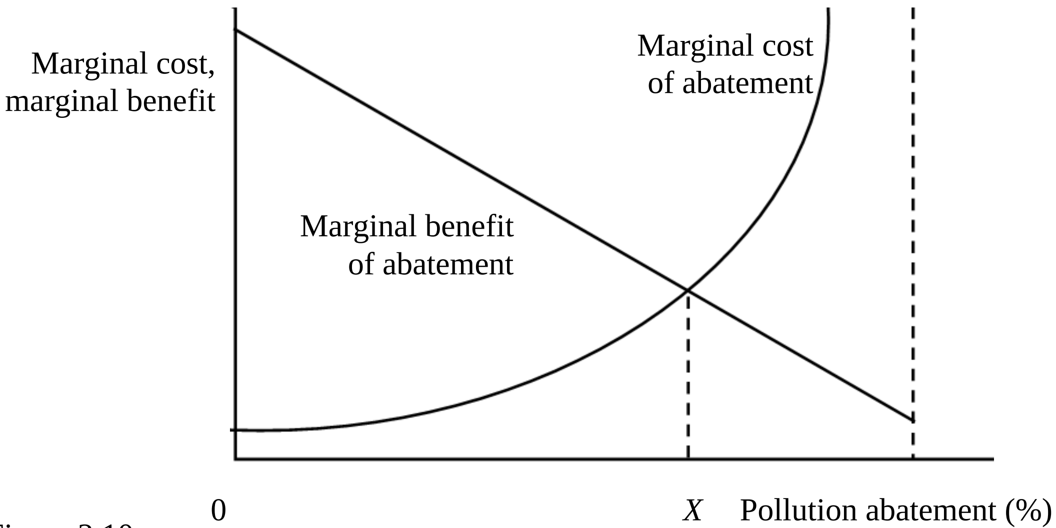


Figure 2.10
The Relationship of Pollution Abatement with Marginal Cost and Marginal Benefit (Porter, 2002)

When a firm decides to undertake pollution abatement activities at higher level, the marginal cost increased exponentially whereas the marginal benefit reduced in the course of negative linear function. For example, "picking low hanging fruits" such as eliminate or substitute the use of hazardous material in components, subassemblies and products were low cost strategies that exert substantial positive influence to pollution prevention. In other words, lower cost and higher benefit for managing end-of-use products should be committed as early as conceptual design stage.

In the face of strategic competition and environmental concerns, Porter (2002) pointed out that cost reduction and product differentiation are product development strategies to attain superior performance. Gradual saturation of landfill and higher demand for incinerating services created larger expenditure in product disposal over the years. This trend influenced manufacturers to look into the prospects of product disposition across product’s lifecycle. For instance, reconditioned and remanufactured products contain high residual value and these products are sought after at secondary market, both local and international (Shinkuma & Huong, 2009). Rogers et al. (2010) pointed out that secondary markets such as online auction site, factory outlets, pawn-shops, dollar stores and charities are among the venues for generating additional revenue from sales of reusable products; thus, recovering expenditures of returns acceptance.

By analysing the adoption of green supply chain management practices, Zhu et al. (2007) revealed that internal environmental management, external GSCM, investment recovery and ecodesign are four green practices that reflect firm’s environmental awareness but their mean scores are within the range of “considering it currently” and “initiating implementation”. However, GSCM performance such as environmental and operational performance fared better than economic performance. In other words, greening of firms’ operational practices incurs additional expenditure that did measure up with improved economic performance. Zhu et al. revealed the pressing need to congregate organisation-wide commitment for improving effectiveness of investment recovery as extended producer responsibility may impede firm’s future performances.

2.6 Reverse Logistics Product Disposition and Business Performance

Environmental management activities can be subdivided into external and internal activities. Green product design, utilisation of environmentally friendly raw materials, waste disposal, and recovery of reusable subassemblies or components were some examples of internal environmental management activities and they were comparable to RSC processes. Despite growing literatures on reverse logistics, product disposition options were understudied but potentially increase product's marketability and reputation of companies that uptake environmental responsibility. During the recent decade, researchers have conducted empirical studies to prove that environmental management coincide with firms' profitability (Chan & Fang, 2007; González-Benito & González-Benito, 2006; Rao, 2002; Zhu et al., 2007). Sroufe (2003) is among the few who emphasised the importance of environmental management particularly environmental design, recycling and waste practices but the latter practise was more significant than environmental recycling practices in predicting firm's operation performance. The performance measurement applied by Sroufe was adopted from Montabon et al. (2000), who analysed the impact of ISO 14000 certified EMS on corporate performance. The performance indicators were a combination of market, operational, financial and environmental goals. Similarly, González-Benito and González-Benito (2005) applied the first three indicators as the business performance of environmentally proactive activities. Given the lack of empirical literatures on product disposition capabilities, environmental management studies are adapted for developing business performance measurements of reverse supply chain management.

Gottberg et al. (2006) argued that product recovery is an initiative that requires active response rather than reactive response, where economic benefits is a major incentive. Some regulations such as California's Waste Recycling Act 2003 have legitimised collection of an advance recycling fee from consumers during point of sale to share financial obligations in recycling and disposing certain electronic products and on the other hand, Japan's Law for the Recycling of Specified Kinds of Home Appliance 2001 practised a recycling system that legitimised collection of recycling fees from consumers during point of disposal whereas manufacturers have physical obligations to recycle 50 to 60 percent of product's content (Aizawa et al., 2008). Lee and Na (2010) indicated that Japanese consumers bear the fee for collection and partial fee for recycling. These fees are also recognised as incentive charging scheme or advance recycling fee (ARF). ARF is collected to fund reverse logistics activities that relate to product disposition. For example, automobile recycling program in Netherlands collect fees to build recycling and dismantling facilities as well as to develop a research and development centre for product recovery technologies (Ayres et al., 1997). In the context of Malaysia, regulations and environmental policy has yet to fully embrace take back regulations let alone introduce charging scheme for recycling. Local manufacturing environment experience minimal incentives in reverse logistics product disposition except for revenue generated from processing bulks of recyclable waste. Even though ARF is a financial incentive collected from customers, these fees may not guarantee the development of efficient recovery because producers may channel cost of recycling to customers. This undesired situation result in high ARF and manufacturers can compete through cheaper ARF when they make design changes that ease recoverability and recyclability of products.

Several literatures have mentioned that the monetary benefits of disposition options are influenced by green product design (Argument et al., 1998; Shang et al., 2010; Srivastava & Srivastava, 2006; Talbot et al., 2007). In a study on third party remanufacturers, Spicer and Johnson (2004) indicated that cost of disassembly is a notable sum because net value of disassemblable products is susceptible to certain degree of uncertainty such as fluctuating cost of skilled labour and price for recycled commodity. Moreover, these manual processes are predetermined during product development stage and they largely influence cost of disassembly which subsequently reduces profit from product recovery. According to Chen, Lai, and Wen (2006), their research revealed that green product innovation and green process innovation were related to firm’s competitive advantage.

Due to the presence of environmental sentiment among consumers, knowledge in green designing is useful for business to gain first-mover advantage. In the context of Chinese manufacturing industry, Zhu and Sarkis (2004, 2007) showed that investment recovery and ecodesign contributed to environmental and economic performance. Positive economic performance was measured by decrease of: (1) cost for material purchasing, (2) cost for energy consumption, (3) fee for waste treatment, (4) fee for waste discharge, and (5) fine for environmental accidents. Additionally, negative economic performance was measured by increase of: (1) investment, (2) operational cost, (3) training cost, and (4) cost for purchasing environmentally friendly material. Zhu and Sarkis (2007) further analysed the relationship between investment recovery and GSCM performance by introducing market, regulatory and competition pressure as moderators and it was found that regulatory pressure generated the opposite of positive economic performance whereas competition pressure generated positive economic performance. For this study, only selected performance measurements were applied as they were more suited to GSCM practises. Nevertheless, Zhu and Sarkis provide mixed evidence in business potential of parts or product reincarnation. In a study on green business activities in Malaysia, Eltayeb and Zailani (2010) revealed that “expected business gains” was a green driver as organisations that commit to green practices anticipate financial and non-financial benefits. This argument was true for ecodesign practise but reverse logistics was not related to neither environmental nor economic outcomes (Eltayeb et al., 2010) Nevertheless, the empirical findings indicated slight positive relationship between reverse logistics and cost reduction.

Even though automotive industry is more experienced in asset recovery than E&E industry, Amelia et al. (2009) revealed some inhibitors of automotive recovery in Malaysia as lack of expertise and lack of R&D programs in designing reusable products. Nonetheless, these factors also exist in E&E sector because designers are overshadowed by limited information such as price, availability and characteristics of recycled material that behave differently under varying pressure, temperature and environment (Bogue, 2007). Generally, products must be designed with downcycling characteristics to support effective and efficient product disposition. Product destined to be reconditioned should be built with ease of accessibility so that defective parts or components can be conveniently replaced to hasten redistribution at secondary market. Compared to recondition, remanufacturing is most complex because used parts of a product undergo rigorous inspection, disassembly, cleaning and testing to determine the quality of recoverable. Even though remanufactured products derive lower revenue and incur higher labour cost, Giuntini and Gaudette (2003) reaffirmed the prospects of profit by pointing out that material cost significantly reduced in 'as-new' products because reusable parts are extracted from cradle-to-cradle conceptualised products. Gobbi (2011) argued that product residual value is vital criteria to determine product disposition options. Even though external factors that determine the quality, condition and value of returned products are out of firm's control, product design is as important as the existence of market for reconditioned and remanufactured goods. The complexities related to removability of reusable components, parts or product are fixated during product development and fabrication (Kumar & Putnam, 2008). Xerox (photocopiers), Kodak (cameras) and Electrolux (refrigerators) are examples of remanufactured equipments that sell at a price cheaper than new EEEs.

Relatively few researchers carried out studies on the relationship between reverse logistics and business performance. Daugherty et al. (2001) studied the contribution of RL program objectives towards RL program effectiveness and found that both environmental regulatory compliance and profitability are most correlated whereas other objectives such as asset recovery, inventory investment, customer relation and cost containment only emanate marginal association with profitability. In another study, Skinner et al. (2008) examined reverse logistics programs of auto parts industry in the United States to verify the effect of disposition strategies towards strategic performance, i.e., economic performance, operational responsiveness and operational service quality. Skinner et al. adopted the RL program objectives defined by Daugherty et al. for measuring economic performance, they are the effectiveness of; (1) handling assets recovery, (2) handling cost containment, (3) maximising profitability, (4) maximising labour productivity, and (5) reducing inventory investment. Under the moderating influence of resource commitment, only destroying and recycling have relationship with economic performance whereas refurbishing and remanufacturing strategy improve firms' operational responsiveness. As this research was conducted in developed countries where automotive manufacturers are subjected to take-back programs, the abovementioned findings do not reflect RL activities for E&E industry in developing countries such as Malaysia. In the local environment, recovery are basically parts replacement in auto parts service industry (Amelia et al., 2009) and packaging recycling is observed in E&E industry (Eltayeb & Zailani, 2010).

In another not quite similar study, Rao and Holt (2005) investigated on green supply chain management among South East Asian countries where GSCM practices is a composite of green inbound, green production and green outbound activities that influence competitiveness, which consequently affect economic performance that are measured by new market opportunities, product price increase, profit margin, sales and market share. Since Eltayeb and Zailani (2010) acknowledged RL as a green initiative and Hervani et al. (2005) described RL as a GSCM practise, it is appropriate to adapt some of the dimensions in economic performance described by Rao and Holt (2005) and Chan and Fang (2007) for defining business performance of reverse logistics. As greening of the supply chain is an emerging concept, most manufacturers engage limited resources on these activities. Therefore, RL performance should not be measured by product price increase and market share. In an environmental management related study by Chan and Fang (2007), both energy saving and ecodesign did not derive significant economic benefits. However, ecosystem friendly, as the fourth and highest level of environmental management, contributed significant economic benefits due to development and promotion of recoverable products.

In defining business performance for product disposition, the above mentioned studies measured environmental proactivity based on economic, organisational or operational performance. Firms must analyse characteristics of product design that behaves as antecedents to product disposition so that this business activity puts forward profitable cost reduction opportunities. It is also important to note that implementation of reverse logistics varies across countries and continents due to significant differences in technology advancement, national legislations and resource commitments. For firms that undertake environmental management practices to react to legislative requirements, product disposition activities are considered as a cost function rather than an investment to recover cost. For environmentally proactive firms, the reverse logistics product disposition is developed to gain competitive advantage over other key players in the E&E business sector by improving marketability of products which inherently contribute to sales growth. Despite the presence of secondary market which may give customers some value for their used products, Heese et al. (2005) suggested that OEMs should focus on repeating sales to secure higher revenue from customer loyalty program, where price discounts are issued to existing customers upon repeat purchases. Ayres et al. (1997) believed that secondary market for remanufactured products is an opportunity for OEMs and Rogers et al. (2010) confirmed this belief by disclosing the secondary channels for expanding firm's customer base and improve inventory turnover. Only then, OEM can generate higher rents and lower cost of goods sold from economic of scales asset recovery (Mollenkopf & Closs, 2005) while at the same time, advocating to the requirements of becoming environmentally responsible towards end-of-use and/or end-of-life products.

2.7 Underpinning Theory

In analysing the antecedents of reverse logistics product disposition options and their influence to business performance, two well-established theories that contribute to the foundation of study are the resource-based view and institutional theory. The relationship of both theories within the context of reverse logistics and environmental proactivity are explained in the following sections.

2.7.1 Resource-Based View

Resource-Based View (RBV) of the firm had been used by several authors to develop reverse logistics programs. As RBV is applied as the underpinning theory, firms' specific resources and their link to enhanced performance are described. Barney (1991) explained firms' resources as,

> *"all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness".*

Several researchers have engaged multifaceted work on resource classification (Barney, 1991; Grant, 1991; Miller & Shamsie, 1996; Mills, Platts, & Bourne, 2003). The identification and classification of firm's resources was important because effective utilisation of resources develops competitive capability. Barney (1991) proposed three classifications of resources known as organisational capital resources, human capital resources and physical capital resources. Mills, Platts, and Bourne (2003) expanded the classification of resources to six categories and they are: (1) tangible resources, (2) knowledge resources, skills and experience, (3) system and procedural resources, (4) cultural resources and values, (5) network resources, and (6) resources with potential dynamic capability. Resources that are utilised to develop distinctive capabilities must be valuable, rare, non-imitable, non-transferable and non-substitutable (Barney, 1991). Firms that acquire and develop resources to cope with dynamic external environment generate value-creating first-mover advantage if attributes of resources and/or capabilities were consistent with Barney's inferences.

Hart (1995) is one of the pioneer study who analysed pollution prevention as a strategic capability to attain competitive business performance under the tenet of resource-based theory. Hart defined pollution prevention as an environmental strategy to minimise and eliminate emissions, effluents or waste by implementing source reduction initiative, also known as environmental proactivity where product and process are redesigned for efficient use of resources throughout stages of product lifecycle. Figure 2.11 is a graphical summary of resource-based view to analyse the relationships between resource, capability and competitive advantage of reverse logistics. The application of different resources creates distinctive competencies that fulfil needs of existing market and subsequently, competitive advantage is developed thus generating a differentiated business performance.

Figure 2.11
Resource-Based View
Note: Adapted from Hart (1995), Genchev (2007) and Skinner et al. (2008)

In developing a conceptual model to assess reverse logistics, Genchev (2007) identified two categories of resources such as property-based resources and knowledge-based resources. Property-based resources are rights controlled resources in specific products or processes where resource imitations are inconvenient due to legal protections (Miller & Shamsie, 1996). On the other hand, knowledge-based resources are best understood through the following descriptions, "…they cannot be imitated by competitors because they are subtle and hard to understand – because they involve talents that are elusive and whose connection with results is difficult to discern" (Lippman and Rumelt, 1982, as cited in Miller & Shamsie, 1996).

In defining the resources required to implement RL activities, they included property-based resources and knowledge-based resources (Genchev, 2007), management resources, financial resources and technological resources (Daugherty et al., 2001; Richey et al., 2004; Skinner et al., 2008). Knowledge-based resources encompassed technological and managerial resources because they are considered as know-how and skills for managing returns (Genchev, 2007). Skills and technological knowledge are assets which generate barriers not through financial or legal virtues, but they are the utilisation of intangible knowledge that creates indefinite imitation barriers and may exude property rights issues. By applying RBV as the underpinning theory, Genchev (2007) proposed to conduct an empirical analysis to quantitatively assess the influence of RL resources towards RL related processes.

Knowledge is not stand-alone resources because Daugherty et al. (2001) have indicated that managerial resources is significantly related to reverse logistics performance objectives. Additionally, Zhu et al. (2008a) indicated that management support and organisational learning systems were significantly related to investment recovery. Consistent with Genchev's model on reverse logistics, knowledge is an intangible resource that can be developed internally to enhance the efficiency of reverse logistics practices through various methods or tools and many studies have discussed on the anteceding role green product development towards reverse logistics processes (Kuo et al., 2001; Talbot, 2005; Talbot et al., 2007; Van Hoek, 1999). Figure 2.12 clearly depicts the role of 'green conceptual design' in facilitating the effectiveness of product disassembly, reuse and recycling so that components, parts and products are recovered from various stages of product lifecycle.

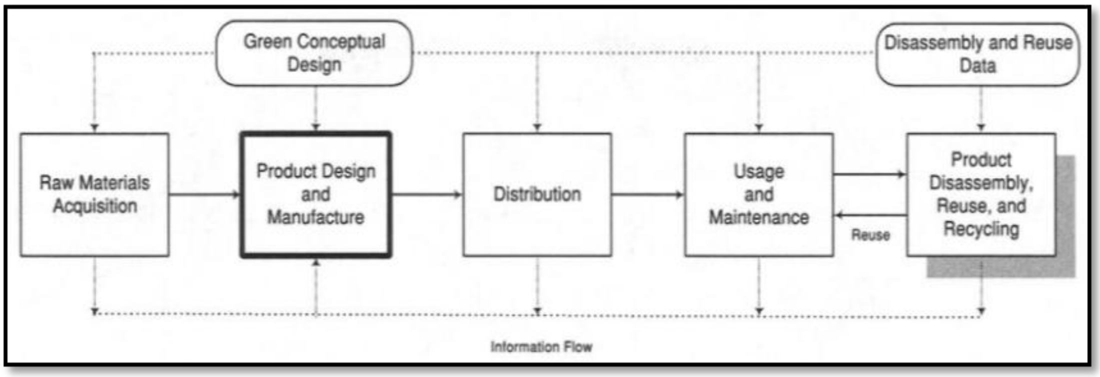


Figure 2.12
Product Life Cycle (Source: Veerakamolmal, 1999)

From RBV perspectives, leveraging capabilities or competencies in new activities enable firms to make good use of the possessed knowledge in becoming competitive (Toffel, 2004). Employing knowledge, skills and resources to develop capabilities (Hart, 1995; Olavarrieta & Ellinger, 1997) in environmental-related operations is a growing initiative because pollution prevention, as an environmental conscious activity, is susceptible to external pressure that arise from the introduction of extended producer responsibility at global environment. Green conceptual design or green product design is the integration of recovery friendly design attributes into products during early development stage. They are considered as tacit knowledge because integrating design attributes to improve capability of asset recovery is a relatively underdeveloped concept for preventing pollution right from the source. Furthermore, knowledge in products exist in the form of managerial resources (Daugherty et al., 2001; Richey et al., 2004; Skinner et al., 2008) because this factor is a critical element that held the authority and decision to invest in the adoption and implementation of activities related to reverse logistics including acquisition of technological resources.

To date, most researchers (Chan & Chan, 2008; Chen, 2008; Eltayeb et al., 2010; Ninlawan et al., 2010; Skinner et al., 2008; Sroufe, 2003; Zhu et al., 2007) focused on investigating the influence of green or environmental practices towards firm's performance. The integration of design knowledge into products is a valuable resource to relieve the complexities related to product disposition. Therefore, this study built on past researches by Talbot et al. (2007), Knemeyer et al. (2002), Navinchandra (1990) and Dangelico and Pontrandolfo (2010) to examine the relationship between green product design and reverse logistics. Consequently, reverse logistics as firm's capability contributed to greater business performance.

2.7.2 Institutional Theory

Institutional theory is suitable for explaining the behaviour of organisations and they can be examined through the lens of regulatory, cultural and social pillars as they were significant in affecting organisation's response in making strategic decisions that affect viability of doing business. Other terms that are used interchangeably to the ones mentioned above are coercive, mimetic and normative pressures respectively. Institutional pressure induces firms to response towards external demands and when institution-driven organisations compete within identical environment, they are inclined to adopt uniform practices, also known as structural isomorphism and procedural isomorphism (DiMaggio & Powell, 1983).

The basic tenet of institutional theory is the perspective that under the influence of societal pressure, organisations will adopt business conducts most suitable for satisfying market needs which are also identified as shared norms and professionalisation. For example, Miemczyk (2008) is one of several authors who analysed end-of-life product recovery capabilities based on institutional influences and the study pointed out that legitimacy is the central focus that drives organisations to implement the best approach for dealing with multi-faceted complexity of product recovery. Organisations are bound by legitimacy and pollution prevention initiatives should be undertaken by observing conformance to norms, rules and regulations extended by institutional actors. Henceforth, the examination of the reverse logistic product disposition will utilise institutional theory and its underlying pillars to explain explicit and implicit factors that influence firm's decisions to behave in a sustainable manner. Additionally, Richey et al. (2005b) developed a framework to monitor global reverse logistics by analysing network relations who sets priorities in societal responsibility. On the other hand, Zhu and Sarkis (2007) analysed the relationship between green supply chain practices and performance under the moderating influence of institutional pressure i.e., existing regulations, market and competition.

Coercive isomorphism or regulatory pressure is a guide for organisation to make environmental commitment and may comprise of mandated rules, restrictions, incentives and sanctions. In the effort to encourage business practices that conform with sustainable development, regulatory and legal requirements are promulgated by government agencies or trade industry who are authorised to exercise their power by means of coercive manners such as rule-setting, enforcement, monitoring and penalty issuance (Richey et al., 2005b). Government entities and legislative policies differ across developed and developing countries, where regulations emit varying breadth and depth of legislative coverage in restricting environmentally undesirable activities. Environmental regulations have been introduced by Malaysian government but weak enforcement prevails because the effects of these legislations transpire only at the expense of minister-in-charge. For example, Minister of Housing and Local Government are authorised to enforce Clause 101 and Clause 102 of Solid Waste and Public Cleansing Management Bill 2007, which provide for (1) reduction, reuse and recycling of controlled solid waste, and (2) take back system and deposit refund system, respectively. Regardless of maintaining or attracting foreign investors, it is important to comprehend the regulatory requirements of receiving countries to avoid risks of violations in environment-related requirements. Interventions that occur due to coercive pressure are accredited to frequent environmental infringement and dwindling natural resource (Zhu et al., 2008a). Zhu also indicated that the existence of such regulations is rational because manufacturers release high volume of pollution and consume a significant amount of resources. Therefore, coercive pressures are amended periodically given that risks of fine and penalty is one of the effective means to make producers consider the financial viability of investing in product recovery.

Within the context of Malaysian industry, Eltayeb and Zailani (2010) ascertained that regulatory pressure is one of the drivers of reverse logistics. Reverse logistics prevent pollution and adherence to regulations is a stronger driving factor for greener businesses when compared to voluntary fulfilment of environmental responsibilities. While regulatory pressure is regarded as threat imposed by government, Delmas and Toffel (2004) pointed out that other established bodies such as trade associations, informal networks and firm’s competitors potentially influence government actions such as level of enforcement and this would eventually induce the development of homogenous environmental practices. Zhu and Sarkis (2007) pointed out that regulatory pressure exerts negative (i.e. opposite positive) moderating effect on the positive economic performance of investment recovery. Adverse result could be attributed to use of measurements that focused on recovery of products with low residual value where sales of excess and reusable material derive significantly lesser value when compared to recovery of components, subassemblies and products for reuse in closed-loop supply chain. Therefore, reverse logistics product disposition in this study portrayed a more wholesome activity in regards to asset recovery and reanalysed the moderating influence of regulatory pressure. Several studies have suggested the importance of regulatory pressure towards development of reverse logistics programs among firms (Amelia et al., 2009; Baumann et al., 2002; Hauschild et al., 2005; Henriques & Sadorsky, 1996; Kumar & Putnam, 2008; Lee & Na, 2010; Terazono et al., 2006; Toffel et al., 2008; Zhu & Sarkis, 2007).

Companies invest in developing knowledge in product design to abide to regulatory standard but some environmentally proactive companies have pre-empted stricter future regulations (Darnall, Henriques, & Sardosky, 2008). These companies continuously set higher standard for their organisation-wide practices to become insusceptible to risk of legal violations. However, operating practices in regards to pollution prevention is not widespread among Malaysian manufacturers because public awareness, extended producer responsibility and infrastructures for reverse logistics are considerably underdeveloped. This condition was partly attributed to significantly lower normative and mimetic pressure. Regulations are imminent influencers for standardising the management of waste and recyclables. For instance, Lee and Na (2010) outlined the law enacted in some Asian countries whereby all involving stakeholder assume their roles towards electronic waste recycling such as Japan's Home Appliances Recycling System 2001, Korea's Act for Resource Recycling of E-Waste and Vehicles and Taiwan's Recycling Fund Management Board (1998). Since Malaysian government have not made it mandatory for manufacturers to take responsibility in by-products and end-of-use (or end-of-life) products disposal, current situation has undermined the development of recycling technology and a chain of negative reactive consequences encompasses high cost of recycling, high cost of recyclable material and low demand for recycled resources.

According to Henriques and Sadorsky (1996), firms are encouraged to formulate environmental plans due to pressure from shareholders, government regulation, customers, community, suppliers, cost of environmental controls, employees, environmental organisations, achievement of efficiency gains and other lobby groups. Only the first four pressures were significant influencers to the formulation of environmental plans and these pressures are illustrated in Figure 2.13 (pp.98). The influence of shareholders, also identified as ownership pressure was noteworthy but Zhu and Sarkis (2007) excluded this dimension from measures of institutional pressure although this aspect was capable of inducing firms to partake strategic responses. Darnall et al. (2008) revealed that both regulatory and ownership pressures held substantial influence on organisation’s business performance but the former pressure contributed higher beta coefficient in driving the development of a comprehensive environmental management system. Nevertheless, institutional pressure was not analysed as a moderating variable whereas Zhu et al. (2007) applied institutional pressure in analysing performance of GSCM practices but they did not include ownership pressure as one of the moderators that alter the strength of relationships understudy. Zhu’s result showed that competitive pressure appeared to be a significant moderator as competitive marketplace inherently provides feedback to lawmakers for mandating higher regulative standards. Furthermore, reverse logistics as one of GSCM practises was signified as investment recovery in Zhu’s study and since it was misrepresented as sales of recoverable, current study reanalysed the performance of product disposition activities of the reverse supply chain processes.

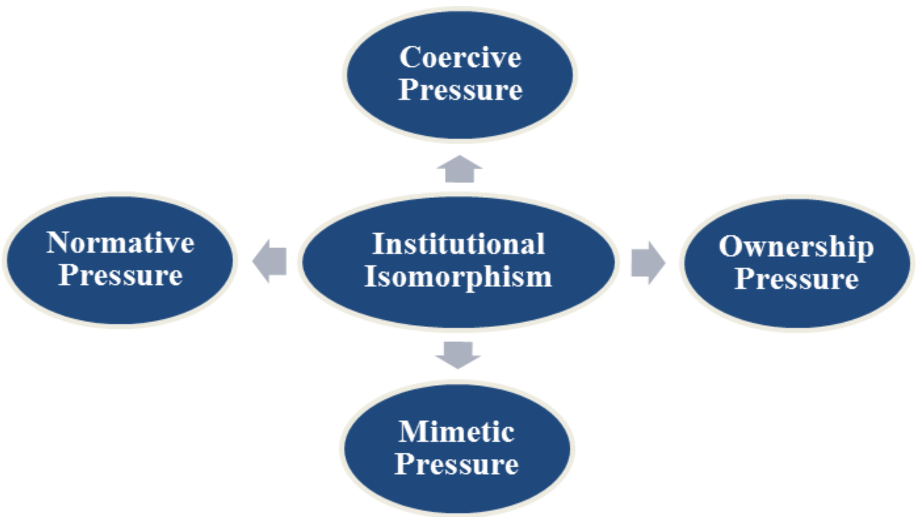


Figure 2.13
Institutional Actors (Darnall et al., 2008; Henriques & Sadorsky, 1996; Hoffman, 2001)

Other than the continuous impact of regulatory pressure, this study took ownership pressure into consideration as owners or shareholders are influential stakeholders who invest financial resources into the company. Darnall et al. pointed out that owners demonstrated interest in firms that engage environmentally responsible activities. Since environmental legislations pose substantial risk such as penalties due to non-compliance, investors are inclined to invest in firms who upkeep their environmental reputation to minimise financial liability and these activities include avoidance of toxic chemical emissions and management of electrical and electronic waste. Shareholders are powerful institutional pressure because they are capital investors whose interests held significant importance to top management's decisions. According to Delmas and Toffel (2004), they revealed that parent company of multinational companies held substantial authority in steering the roles of subsidiary companies operating in countries other than host country because environmental impact exerted by products directly affect brand's reputation. In other words, hosting firm behave as a shareholder pressure as they dictate the business strategies and goals that subsidiary firms should adhere to. To conclude, analysing moderating influence exerted by ownership pressure was suitable for gauging better understanding on the relationship of interest.

In Darnall's (2008) study on institutional pressures, shareholder dimension was analysed by Henriques and Sardosky (1999) as a component of stakeholder theory. Despite slight dissimilarity in theoretical background, both studies were conducted out of interest towards environmental management practices. Henriques and Sardosky revealed that organisations with high environmental commitment generally deal with higher institutional pressure. Shareholder is a sub-component of organisational stakeholders and this aspect can be analysed by reviewing shareholders' concerns voiced during shareholder meetings or monitoring changes in ownership when shareholders sell their stakes due to certain issues or concerns. Several literatures conceptualised shareholders as one of institutional actors (Delmas & Toffel, 2004; Henriques & Sadorsky, 1996; Hoffman, 2001). Yang and Rivers (2009) pointed out that the influence of shareholders in managerial decision-making is particularly important among companies which raised capital through equity issuance. For instance, large shareholders may evaluate companies' internal behaviour towards business activities and external behaviour towards the environment when deciding whether the company is a viable investment whereas small shareholders based their judgement on price stability of firm's equity. Generally, conformance to institutional pressure increases firm's degree of legitimacy and there is arguably adequate evidence to support that these pressures are highly influential in developing environmentally proactive capabilities that generate economic rents, i.e., business performance of reverse logistics product disposition.

2.8 Research Framework and Development of Hypotheses

This section narrowed down from literature review to illustrate the key research area of this study. An outlay of the research framework is presented to visualise the relationships undertaken by this research.

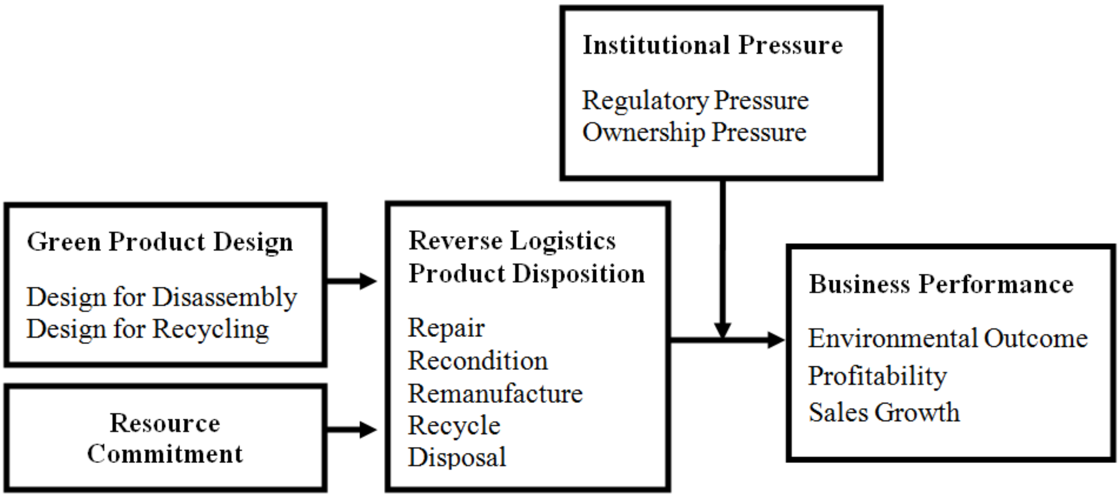


Figure 2.14
The Research Framework

Figure 2.14 illustrated five major variables in the framework of study where green product design and resource commitment are antecedents to reverse logistics product disposition, and institutional pressure moderates the relationship between RLPD and its outcome, also known as business performance. The current model was synthesised from conceptual and empirical studies conducted by Genchev (2007), Skinner et al. (2008), Zhu and Sarkis (2007), Eltayeb and Zailani (2010), Sroufe (2003) and Daugherty et al. (2001). Genchev in their conceptual study proposed a quantitative empirical study to analyse the relationships among RL resources, competencies, capabilities and performances. Green product design is comparable to knowledge-based resources (Barney, 1991; Miller & Shamsie, 1996; Mills et al., 2003) of the resource-based view, where they can be conceived or improved to develop capability in reverse logistics. Past researchers highlighted green product development as ‘resource-, context- and future-oriented product development aimed at providing elementary needs, a better quality of life, equity and environmental harmony’ (Baumann et al., 2002). According to Mills, knowledge is intangible resource that is documented in written form or exists unconsciously. Therefore, tacit knowledge is embedded in skills and abilities of engineers or designers, where the coordination of knowledge with financial and managerial resources develops competencies that may result in competitive advantage. One of the most effective methods for sustainable product consumption is the integration of environmentally friendly design knowledge into physical product to enable reusability of whole product, subassemblies and/or components. Dangelico and Pontrandolfo (2010) revealed that RL is subjected to the anteceding effect of green product design. Therefore, the concept of green product design which emphasised use of renewable resources and reduce toxic waste release to the environment was appropriate.

In line with CLSC concept, Talbot et al. (2007) examined ecodesign elements that associate with RSC activities and the dynamic of the resource-capability relationship contributed to firm’s manufacturing capability. Based on the tenet of resource-based view, previous researchers conducted empirical study on the economic performance of RL from the context of automotive industry (Autry, 2005; Daugherty et al., 2001; Richey et al., 2005a; Skinner et al., 2008). Skinner’s results revealed that only disposition strategies namely destroy and recycle improved organisation’s economic performance in spite of the presence of resource commitment as moderating variable. The respondents of this study indicated that ‘lack of awareness and knowledge in reverse logistics’ and ‘importance of reverse logistics relative to other issues’ were major barriers to RL. Therefore, the introduction of resource commitment and green product design as anteceding variables of RL were called for as success cases related to asset recovery have surfaced. Subsequently, careful selection of product disposition options assisted redistribution of product or its constituents through multiple recovery loops. As most studies focused on the performance of GSCM, RSC and environmental management practices, this study addressed the void in pertinence to interdependence of GSCM practices.

Business institutions and consumers were main generators of EEE waste in Malaysia but local government absorbed the majority of cost associated with recycling and disposal of domestic and consumer waste (Gobbi, 2011; Junaidah, 2010). According to Tsen et al. (2006), Malaysian consumers preferred ecologically sound products or packaging and are supportive of firms who embark on pollution mitigation activities. Therefore, firms should invest a good amount of resources in encouraging reusability. Other than minimising ecological impact, GPD focused on generating business benefits from returns by improving reusability of products, such as ease of product disassembly and improve recyclability. In a state-of-the-art review conducted by Baumann et al. (2002), past decade had seen many literatures on product designing for recoverability where most presented normative suggestions or develop tools to assess product's environmental footprint but empirical testing was limited. Gottberg et al. (2006) emphasised on the importance of producer's commitment in reducing volume of end-of-use or end-of-life discards by adopting ecodesign opportunities that extend useful life and improve recyclability of products. Go et al. (2010) suggested that studies should develop technologies that minimise cost of disassembly and reassembly whereas Cerdan et al. (2009) observed that design for disassembly and design for recycling were most understudied aspects of product design strategies. Other study (Cerdan et al., 2009; Desai & Mital, 2003; Veerakamolmal, 1999) developed eco-design indicator, disassemblability scores and design for disassembly index to relatively measure the reusability or recyclability products. Based on the findings of previous studies, some hypotheses of this research are presented as follow;

H1. Green product design has a significant relationship with reverse logistics product disposition.

H2. Resource commitment has a significant relationship with reverse logistics product disposition.

Recent trends in manufacturing industry have seen improvements in sustainable development where leading companies differentiated themselves from competitors by introducing environmentally friendly products as one of the marketing strategy. Even though studies have acclaimed positive environmental impact exerted from product disposition activities, the effect of RLPD on business performance were inconclusive because expected business benefits for recovering product were inconsistent across academic research. Numerous organisations engaged licensed e-waste contractors to recycle and dispose waste in an environmentally compliant manner whereas many organisations were stalling appropriate response to avoid expenditures related to cost of handling end-of-use or end-of-life products. Sarkis and Cordeiro (2001) analysed corporate environmental proactivism from the perspective of pollution prevention (higher proactivism) and end-of-pipe solutions (lower proactivism). In regards to return on sales, their study revealed that both mode of proactivity were negatively related to firm’s financial performance but pollution prevention experienced stronger negative relationship. Additionally, Rogers et al. (2010) indicated that there is range of secondary channel for liquidating used and/or new products with used parts.

In this study, utilisation of business performance to evaluate the performance of reverse logistic from the perspective of profitability and sales growth is adapted from several literatures (Fraj-Andrés et al., 2009; Heese et al., 2005; Rao, 2002; Skinner et al., 2008; Sroufe, 2003; Talbot et al., 2007; Yang et al., 2011; Zhu et al., 2007). Consistent with RBV theory, investment of resources develops capability in reverse logistics which successively led to improved business performance. As this study focused in reducing the environmental impact exerted by end-of-use and end-of-life EEE, it was vital to analyse the environmental outcome of RL product disposition. This was justified by a recent study conducted by Yang, Hong, and Modi (2011), who analysed the business performance of environmental management practices by applying environment performance as one of the measures. The only empirical study that analysed product disposition at the centre stage was conducted by Skinner et al. (2008) and other authors who differentiated product disposition options were Thierry et al. (1995), Krikke et al. (1998), Ijomah et al. (2007) and King et al. (2006).

A number of studies have analysed investment recovery as a GSCM practise but this activity put forth mixed performance outcome, where positive economic performance are seen in the automotive industry (Zhu et al., 2007), and positive environmental performance, positive and negative economic performance are seen when the study is conducted among representatives from multiple industry subsectors (Zhu & Sarkis, 2007). From the context of Malaysian manufacturing industry, Eltayeb et al. (2010) pointed out that reverse logistics is not associated with neither environmental outcome nor economic outcome but resulted in cost reduction. In the effort to abate negative environmental impact, narrowing down the analysis to focus on E&E manufacturing firms is viable as waste released by this subsector composed of hazardous substances that can be reused in the form of product, subassemblies, components and materials.

H3. Reverse logistics product disposition has a significant relationship with business performance of reverse logistics.

With reference to institutional theory, institutional actors induce homogenised or legitimated activities based on pressure from internal and external environment. Several authors (Aizawa et al., 2008; Daugherty et al., 2001; Hazen et al., 2012; Lee & Na, 2010; Tengku-Hamzah, 2011; Terazono et al., 2006; Zhu & Sarkis, 2007) have indicated that regulations exert significant coercive influence to force manufacturers and service providers uptake extended producer responsibility by implementing RSC activities via product take back programs. Other moderating variable that affects the relationships understudy were regulative pressure, competitive pressure, market pressure, quality management and just-in-time concept (Zhu & Sarkis, 2004, 2007) but only first two variables exert significant moderating effect. Competitive pressure was not applied to this study since product recovery is a voluntary initiative among developing countries. Market or normative pressure was excluded as well because the general awareness towards recycling and recyclability of products is relatively absent.

Reverse logistics as a valuable capability can be benchmarked by government agencies to serve as reference for future legislations. Despite existence of competitive and market pressure, the risks associated with regulatory pressure are more significant where enforcement of legislative requirements instantly expedite the implementation of reverse logistics especially among manufacturing companies who focused in end-of-pipeline waste management strategy. Regulatory pressure played an important role to the development of environmental management system because environmentally reactive firms are motivated by risk of penalties or environmental protest (Chan & Fang, 2007). However, Chan and Fang indicated that even though ecosystem friendly business is the highest level of environmental proactivity, regulatory pressure does not play an important role. Therefore, the ambiguity of effect exerted by this pressure were amplified when Zhu and Sarkis (2007), who analysed the performance of GSCM practices in China, indicated that ‘regulation may not actually improve environmental performance but in return, hurt economic performance’. Furthermore, Eltayeb and Zailani (2010) only analysed government regulations as one of the drivers for firms to undertake green initiatives and due to this, moderating effect of regulatory pressure on reverse logistics within E&E manufacturing environment in Malaysia is inconclusive.

Only Miemczyk (2008) conducted exploratory study on the influence of institutional pressure on product recovery activities. Various studies on regulatory and ownership pressure were conducted in the context of environmental management (Berrone, Gelabert, Fosfuri, & Gómez-Mejía, 2007; Darnall et al., 2008; Delmas & Toffel, 2004; Henriques & Sadorsky, 1999; Miemczyk, 2008) and the influence of regulations towards organisational performance were inconsistent. Regulatory pressure is significant when higher standard of extended producer responsibility creates fines and penalty threats whereas ownership pressure is significant when shareholders put emphasis on sustainable growth. However, Berrone et al. (2007) pointed out that availability of financial resources to payoff legal sanction neutralises the influence of coercive pressure. Nevertheless, Darnall et al. (2008) showed that regulatory pressure exerts higher influence than ownership pressure in encouraging the adoption of environmental management practices. Environmental liabilities are undesirable to ownership pressure as firms who issue share equity to gather capital investment strive to maintain and/or attract investors. Therefore, this study examined two institutional actors, i.e, regulatory and ownership pressure as moderator variable.

H4. Institutional pressure has significant moderating effect on the relationship between reverse logistics product disposition and business performance.

2.9 Summary

From the literature review, there is a wide selection of designing aspects that influence recoverability of product. Given that the building blocks for green product designs are unique combinations of design objectives including design for disassembly and design for recycling, hence it becomes relevant to identify these design objectives so as to develop reverse logistics capabilities. By analysing the relationship between design objectives and their linkage with product disposition and subsequently, the influence of RLPD towards final dependent variable, business performance; this research seek to assists product designers in making informed decisions that are consistent with the environmental and economic interest of CLSC. Other than competing in products marketability, product designers and engineers face challenges in responding towards environmental requirements and green consumerism thus accentuating the importance of identifying design attributes which warrant subsequent product disposition options in an effective and profitable manner. Limited studies have analysed the influence of institutional pressures in the context of reverse logistics. As such, other than regulatory pressure, the moderating effect of ownership pressure is just as important but previous researches have not analysed both aspects in the context of reverse logistics performance within Malaysian manufacturing environment. In conclusion, this study will analyse green product design and resource commitment as a precondition for the selection reverse logistics product disposition options, which are associated with enhancement of firm’s business performance.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

Given that the literature review have provided the foundation to develop the research framework and research hypotheses, this chapter builds on the previous chapter by defining the research design. Henceforth, the subsections in this chapter will discuss some important issues for conducting this research such as unit of analysis, identification of population, instrument development, scale measurement, strategy for data collection, and method of data analysis including pilot study for validity testing.

3.2 Research Design

Research design is a framework for guiding a researcher in choosing the preferred data collection method for testing hypotheses under study. In quantitative research, Wiersma (1993) discussed some of the characteristics that ensure a good research design and they include the degree of freedom from bias, freedom from confounding, control in extraneous variables, use of statistical precision for testing hypotheses and managing the variances to uphold goodness of research designs. Prior to the development of survey instrument, a comprehensive review on literatures is important to identify the contributions of study. Subsequently, the most appropriate industry and method for administering questionnaires for this research is determined. Consequently, the statistical tool and methods most suitable for analysing collected data is selected.

3.2.1 Purpose of Research

This is an empirical study that analyse the antecedents and outcome of reverse logistics product disposition. Green product design and resource commitment are anteceding variables whereas business performance is analysed as outcome variable. Apart from the abovementioned, this study examined the moderating influence of institutional actors such as coercive and ownership pressures on the business performance of reverse logistics product disposition. By conducting a quantitative analysis, this study unveils considerable information on the current status of green product design and reverse logistics practices within Malaysian manufacturing environment. A descriptive and explanatory study facilitates firms in recognising design practices that are associated with reverse logistics product disposition options, which are bound to generate desirable business benefits. Statistical data analyses were conducted and the results were evidence to the legitimacy of proposed relationships.

3.2.2 Time Dimension

In descriptive research, quantitative studies are differentiated by time factor such as longitudinal or cross-sectional studies. Both studies differs in regards to frequency and timing of data collection where data collection for longitudinal study is taken from the same sample over two or more periods of time whereas the cross-sectional study collects data from the sample understudy for only once at a given point in time (Hair, Money, Samouel, & Page, 2007). Most researches in the area of reverse suuply chain management and green supply chain management used latter type of study to analyse the relationship between variables (Daugherty et al., 2001; Eltayeb et al., 2010; González-Benito & González-Benito, 2005; Skinner et al., 2008; Talbot et al., 2007; Zhu et al., 2007).

3.2.3 Research Design Strategies

This study applied survey or questionnaire as the instrument for gathering data from a large number of respondents. If the instrument is administered carefully to accurately measure the variables understudy, survey is an effective tool for hypotheses testing. Face validity and pilot study were conducted on a small number of respondents which consist of lecturers and industrial representatives to assess items of multidimensional variables and scale measurements that are being applied by the survey instrument. At this stage, unforeseen deficiencies in the instrument are addressed to maximise the quality of information gathered from data collection process. Furthermore, this method for collecting data is relatively inexpensive as larger samples were accessed through distribution of standardised questions. In questionnaire survey, a cover letter and definitions of selected terms were provided at the beginning of the survey booklet to brief and develop a common understanding between researcher and participants such as purpose, objective and confidentiality of the survey. The length of questions and the number of questions for each variable were meticulously tailored to ensure that the questions are precise, simple and understandable. The questionnaires were delivered by conventional and electronic mail and responses were expected to return within a period of one month. Some of the strategies applied to enhance the response rate are described in Section 3.4.

3.2.4 Unit of Analysis

The unit of analysis for this study was organisation and data were collected from representatives of E&E manufacturing companies. They were members of Federation of Malaysian Manufacturers (FMM) or Malaysia External Trade Development Corporation (MATRADE) and were enlisted with the Industry Directory for Electrical and Electronics 2007/2008. This study sought the contribution of representatives from ISO 14001 certified companies who either held executive or managerial level positions in Environmental, Health and Safety Department. If this department was non-existent, the researcher approached environmental management representatives who were appointed to address the requirements related to ISO 14001 environmental management system. These respondents were presumably well-versed in EMS including environmental impact of products and processes and could be involved in strategic decision-making for issues and opportunities related to asset recovery.

3.3 Population and Sampling

According to Green Productivity and Green Supply Chain Manual, "ISO 14000 do not provide environmental performance targets, but instead provide organisations with the tools to assess and control the environmental impact of their activities, products or services". Sekaran (2003) suggested that researchers should meticulously select the subjects under study to collect dependable data. Therefore, the population of this study is electrical and electronic manufacturing companies which are operating in Malaysia and have obtained ISO 14001 accreditation on their environmental management system (EMS). Industry-by-industry analysis was recommended by Sarkis and Cordeiro (2001) because circumstances related to product, parts and materials reuse are unique across diverse subsectors of the manufacturing industry. For instance, recyclability of food and beverages, transport equipment, metal products, furniture and construction waste vary as a result of distinctive product characteristics.

Organisations which have obtained professional certification are deemed to own considerably higher sense of responsibility and commitment towards environmental health. The selection of population with ISO 14001 certification is appropriate as international standards for implementing a comprehensive EMS build on established framework. Sroufe (2003) pointed out the presence of significant relationships between EMS and environmentally-oriented practices such as design, recycling and waste management practices. Therefore, only representatives of E&E manufacturing firms who are well-versed with firm's environmental impact are eligible respondents.

Sampling frame is the list of population elements where sample is drawn (Zikmund, 1991). ISO 14001 certified companies enlisted with SIRIM (Standards and Industrial Research Institute of Malaysia) Directory Services was not referred to because companies from multiple industrial backgrounds are clustered together. The sampling frame composed of 177 ISO 14001 certified E&E manufacturing companies enlisted in FMM-MATRADE Industry Directory for Electrical and Electronics 2007/2008. E&E industry subsector was chosen as they contribute approximately 46.91 percent of manufactured exports, equivalent to RM 236.5 billion in value during fiscal year 2011. This large volume of foreign exports highlighted the urgency to conform to international environmental standards. Based on Krejcie and Morgan (1970), a sample size of 122 is recommended. A simple random sampling procedure was applied where every respondent had equal opportunity of being chosen by drawing their names from a container. Nevertheless, additional population elements were contacted to increase the response rate and improve the generalisability of findings.

3.4 Data Collection

The study distributed structured questionnaire to collect data from geographically dispersed sample because this method is considerably cost effective and reliable but may be relatively weaker in terms of validity and depth of information. Nevertheless, additional effort was required to improve the quantity of returning questionnaires, also known as the response rate. Researchers have suggested several factors for improving response rates including (Fox, Crask, & Kim, 1989; Yammarino, Skinner, & Childers, 1991) length of survey instrument, return postage, sponsors, appearance of survey, respondents' anonymity, deadline, follow-up, pre-notification and others. Prior to mail out, the organisations were contacted to identify targeted respondents and induce respondents' interest on the objectives of study. The survey instrument was available in the form of a booklet and Word document to serve both conventional and electronic mailing. Accompanying the survey instrument was a personalised cover letter to acknowledge particular respondent, describe the subject matter of survey, provide instructions for returning the survey, appreciate respondent's contribution to the study and provide reassurance on confidentially of information shared.

With reference to Hussey and Hussey (1997), they indicated that response rate for conventional mailing is generally ten percent or less. A comparison with previous studies which examined interrelated research area showed that low response rate is anticipated. As respondents have no formal obligations to respond to non-work related surveys, the initial calling was imperative to develop good rapport with identified individual. In order to provide convenience, respondents received both hardcopy and softcopy version of the survey package, which composed of a cover letter, permission letter for collecting data and questionnaire booklet. For conventional mail delivery, a pre-addressed return envelope with postage stamp affixed is attached. Fox, Crask, and

Kim (1989) also indicated that follow-up is useful for administering gentle reminders that emphasise on closing date for receiving responses. This step was useful for replacing misplaced questionnaires. Therefore, the respondents were followed-up twice by email or phone call for two consecutive weeks after a period of two weeks from the initial mail-out and this improved speed and rate of return considerably. Other than emphasising on closing date for responding, communication with respondents helped clarify concerns, gathered qualitative information and assisted smooth returns of answered surveys.

3.5 Development of Survey Instrument

In developing the measurements that defined the variables in research framework, an extensive search on literatures related to reverse supply chain, green supply chain and environmental management studies was conducted. Due to the reason that most studies were suggestive in nature with very few empirical evidence (Baumann et al., 2002), only a small number of reliable and validated measures can be found among literatures. To this date, studies on green product design, reverse logistics for end-of-use product disposition and their potential outcomes are relatively few (Knemeyer et al., 2002). The following subsections elucidated how prior research operationalised the constructs and dimensions that developed the framework of study.

3.5.1 Reverse Logistics Business Performance: Construct and Dimensions

Other than focusing on reusability of products that has reached end-of-use or end-of-life stage, this study also looked into the business prospects of taking responsibility in products' environmental impact. Generally, business performance of reverse logistics is determined by quality of products specifically value of recoverables in products, subassemblies and components that undergo various disposition options while minimising operational cost associated with reprocessing. As such, this section focuses on the performance objectives of RLPD, a mechanism that binds some of the business activities of forward supply chain.

Olavarrieta and Ellinger (1997) analysed the relationship between strategy and performance within the context of supply chain management. For example, Ferrer (2001) developed three economic measures to evaluate economic efficiency of end-of-life product recovery strategies such as recyclability, disassemblability and reusability of products. According to Daugherty et al. (2001), finance- and serviceoriented objectives were two categories of objectives for measuring effectiveness of reverse logistics. Economic performance is finance-oriented and they comprised of recovery of assets, cost containment, improved profitability and reduced inventory investment (Daugherty et al., 2001). On the other hand, Skinner et al. (2008) and Richey et al. (2004) measured economic performance based on these measurements as finance-oriented objectives held significant importance to the relevance of RL implementation. Although the performance measures were extended to include labour productivity, this aspect was excluded as most companies did not dedicate a special team for RL operations. According to González-Benito and González-Benito (2005) and Sroufe (2003), environmental proactivity affects the financial performance of firm's business activities through indefinite manners. Reactive strategy, pollution prevention or environmental leaders are various strategic profiles that emit different level of performances (Buysse & Verbeke, 2003) and Yang et al. (2011) examined business performance of environmental management activities based on profitability and sales growth. Furthermore, the presence of secondary market for used products is affirmed in studies conducted by Tibben-Lembke (2002) and Rogers et al. (2010).

Within the context of green supply chain management among Southeast Asian countries, Rao and Holt (2005) measured economic performance based on new market opportunities, product price increase, profit margin, sales and market share. Since RL was a comparatively understudied aspect of GSCM, identifying benefits from product disposition is vital to the business continuity of green initiatives. As a frequent contributor to green literatures, Zhu et al. (2007) discussed the relationship of green practices such as eco-design and investment recovery with economic performance, from both positive and negative perspectives (refer to pp. 84). As reduction of cost associated with resource recovery and environmentally compliant waste management is the central focus of this study, only some measurements applied by Zhu et al. were adapted. Gregory and Kirchain (2008) recommended the use of cost-benefit analysis to express the economic performance of RL by analysing the complexity associated with used product reprocessing against value of recoverable materials and cost of waste disposal. The prominence of cost as one the significant outcome of green initiative was also highlighted by Eltayeb and Zailani (2010) and Zhu and Sarkis (2007). Even though investment recovery is incomparable with RLPD options, Zhu, Sarkis, and Lai (2008a) suggested that sales of used inventories or assets was essential to recover value. As lower cost is related to higher profit and vice versa, this study analysed profitability as one of the dimensions of business performance.

Closed-loop supply chain influences the profitability of product recovery and planned obsolescence is one of the sales strategies that can be utilised to improve sales at both primary and secondary market (Heese et al., 2005). Other than profitability and sales growth, one dimension that deserves recognition when measuring firms' performance is the environmental outcome since reducing volume of waste and unlawful disposal motivated this study. Apart from Zhu et al. (2007), who analysed environmental performance of GSCM practices, King and Lenox (2001) were among the few who analysed the relationship between environmental and financial performance based on industry's toxic emissions and they revealed that pollution reduction is associated with financial gain. By being environmentally compliant, Klassen and McLaughlin (1996) recognised the likelihood of cost saving due to minimisation of environmental liabilities. Due to some similarity in sampling element, this study adopted some of the measurement applied by Eltayeb et al. (2010) to measure the performance of RLPD. For this study, environmental outcome, profitability and sales growth are dimensions that measured business performance. All of the questions for measuring business performance are enlisted Table 3.1 and respondents are required to indicate the level of significance of each measurement items that reflected firms' business performance.

Table 3.1
Questions for Business Performance

No.	Items	Sources
Environmental Outcome		
1.	Significant reduction of air emission.	Zhu et al. (2007)
2.	Significant reduction of waste water pollution.	Zhu et al. (2007)
3.	Significant reduction of solid waste generation.	Sroufe (2003); Zhu et al. (2007)
4.	Significant reduction of hazardous waste consumption.	Zhu et al. (2007); Eltayeb and Zailani (2010)
5.	Minimal occurrence in environmental accidents i.e. spills.	Klassen and McLaughlin (1996); King and Lenox (2001)
6.	Minimal occurrence in fines or penalties pertaining improper waste disposal.	King and Lenox (2001)
7.	Recognition or reward for superior environmental performance.	King and Lenox (2001)
8.	Significant improvement in commitment towards environmental management standards or practices.	King and Lenox (2001); Daugherty et al. (2001)
Profitability		
1.	Significant improvement in revenue from after sale services.	Amini, Retzlaff-Roberts, and Bienstock (2005)
2.	Significant improvement in reclaiming reusable products.	Daugherty et al. (2001); Skinner et al. (2008)
3.	Significant reduction in inventory investment.	Daugherty et al. (2001); Skinner et al. (2008)
4.	Significant reduction in cost of goods sold for recovered products.	Daugherty et al. (2001); Mollenkopf and Weathersby (2003)
5.	Significant reduction in the cost for purchasing raw materials, components or subassemblies.	Zhu et al. (2007); Eltayeb and Zailani (2010)
6.	Significant reduction in the cost of packaging.	Eltayeb and Zailani (2010)
7.	Significant reduction in cost for waste treatment.	Zhu et al. (2007)
8.	Significant reduction in cost for waste disposal.	Zhu et al. (2007)

Table 3.1 *(Continued)*

Sales Growth		
1.	Significant improvement in sales of used product at primary market.	Tibben-Lembke (2002)
2.	Significant improvement in sales of used product at secondary market.	Tibben-Lembke (2002)
3.	Significant improvement in sales of new products through price discounts.	Heese et al. (2005);
4.	Significant improvement in sales of new technologies by means of trade-in programs.	Talbot et al. (2008)
5.	Significant improvement in market share.	Klassen and McLaughlin (1996); Talbot et al. (2008)
6.	Significant improvement in relationship with customer to encourage repeat buyers.	Daugherty et al. (2001); Heese et al. (2005)
7.	Significant improvement in corporate environmental reputation among environmentally conscious customers.	Zhu et al. (2007); Talbot et al. (2008)
8.	Significant improvement in sales growth.	Rao (2002); Chan and Fang (2007)

3.5.2 Reverse Logistics Product Disposition: Construct and Dimensions

In this study, RLPD is comparable to the inspection and disposition process of reverse supply chain management. This stage involved examination on the quality of returned products in used or unused condition and determining the most appropriate product disposition option to maximise amount of recoverable and minimise volume of disposable waste. Based on the conceptual study by Genchev (2007), he proposed to analyse RL competencies or RL process formalisation, for improving the relationship between knowledge-based resources and RL capabilities which will consequently lead to enhanced economic performance. Genchev pointed out six fundamental activities to develop a responsive RL and they are; (1) return initiation, (2) determine routing, (3) receive returns, (4) select disposition, (4) credit or charge-backs, and (5) analyse and measure returns. Nevertheless, Stock et al. (2006) emphasised that value of returns depend on type of disposition decision employed and this value is greater when product recovery strategies correspond with firms' remarketing strategies. Note that this study is concerned with the business outcome of various RL product disposition options.

In determining the product recovery options of returned products, Guide et al. (2000) defined five types of differentiating factors for evaluating products such as physical identity, degree of disassembly, extent of transformation, material value-added and labour value-added factor. When whole products are directly recovered such as "resell as new" in alternative distribution market or returned to vendor, cost of recovery is minimal because the amount of work required is limited to repack and redistribute. As such, this study excluded product reuse to focus on other product disposition options that required more resources in extending the useful life of products, subassemblies and components. Thierry et al. (1995) is one the pioneer authors who outlined product characteristics related to each product recovery strategies including repair, refurbish, remanufacture, cannibalise and recycle. The complexity and value of recoverable asset differed across products and Gobbi (2011) pointed out that recoverable value in products with high residual value requires time-sensitive recovery whereas products with low residual value (i.e. material recovery) prefer cost-efficient disposition.

In the study conducted by Skinner et al. (2008), they analysed the economic performance of five industry-specific reverse logistics disposition strategies such as repack, remanufacture, refurbish, recycle and destroy. Literatures on reverse supply chain and environmental management revealed a list of frequently mentioned product disposition options and repair, refurbish, remanufacture, recycle and disposal are among the options that top the list (Gobbi, 2011; Hazen et al., 2012; Hervani et al., 2005; Ijomah et al., 2007; King et al., 2006; Krikke et al., 1998; Talbot et al., 2007; Thierry et al., 1995). Many literatures have suggested that product recycling and disposal is the most common product recovery activities. Even though recycling is a product recovery initiative that benefits the environments, recoverable value is least and aversion from negative environmental impact is weakest when compared to other disposition options (Gehin et al., 2008). Both recycling and disposal are not the most optimum disposition options because materials and energy are underutilised as they are excluded from multiple recovery loops. According to Meadows et al. (1992, as cited in King et al., 2006), the rule of thumb for estimating the volume of wastes generated by one tonne of consumer waste is five tonnes of manufacturing waste and twenty tonnes of waste disseminated during resource extraction. As such, the effort for reducing waste through various RLPD options is a pollution prevention initiative that conserves natural resources by extending products' functional value.

Based on interviews with representatives of multinational corporations, Eltayeb and Zailani (2010) revealed that the implementation for reverse logistics activities among Malaysian manufacturers is limited to reprocessing of rejects and warranty returns. Other than that, recycling is restricted to packaging materials and proper management of internal waste including waste water treatment, scheduled waste management and others. In order to internalise the activities associated with reverse logistics product disposition, it is important to identify a series of reprocessing activities associated with each disposition options including extent of product disassembly, level or depth of rework, quality of product, warranty service, supplier involvement and/or others. Only then, environmental design activities can invest more resources in developing recovery friendly products. The source of literatures where measurements were adapted and conceptualised to suit the current study is detailed in Table 3.2. Respondents are required to evaluate the existence of these recovery activities based on 5-point Likert-type scale.

Table 3.2
Questions Used on Repair, Recondition, Remanufacture, Recycle and Disposal

No.	Items	Sources
Repair		
1.	Repair is the correction of faults in a product.	Ijomah et al. (2007)
2.	Repair restore product to working order.	Krikke et al. (1998)
3.	Repair prolongs the product’s lifecycle.	King et al. (2006) Talbot et al. (2007)
4.	Repair replaces broken parts that have failed.	Thierry et al. (1995)
5.	Repair involves disassembly at product level.	Thierry et al. (1995)
6.	Warranty for repaired product is less when compared to remanufactured product.	Ijomah et al. (2007)

Table 3.2 *(Continued)*

Recondition		
1.	This strategy involves collecting used product from customers for reconditioning.	Rogers and Tibben-Lembke (2001)
2.	Recondition is the work for returning used product to a satisfactory working condition.	Ijomah et al. (2007)
3.	Recondition inspects critical modules in the product.	Krikke et al. (1998)
4.	Recondition extends functional use of the product.	King et al. (2006)
5.	Recondition replaces all major components that have failed or that are on the point of failure.	King et al. (2006)
6.	Recondition involves disassembly up to module level.	Thierry et al. (1995)
7.	Recondition involves product upgrade within specified quality level.	Thierry et al. (1995); King et al. (2006)
8.	Warranty for reconditioned product is less when compared to remanufactured product.	Ijomah et al. (2007)
Remanufacture		
1.	This strategy involves collecting used products from customers for remanufacturing.	Rogers and Tibben-Lembke (2001)
2.	Remanufacture is the work for returning product to at least OEM original performance specification.	Ijomah et al. (2007)
3.	Remanufacture inspects all modules and parts in the product.	Krikke et al. (1998)
4.	Remanufacture involves disassembly at part level.	Thierry et al. (1995)
5.	Remanufacture involves product upgrade up to as-new quality level.	Thierry et al. (1995)
6.	Warranty for remanufactured product is highest compared to other disposition options.	Ijomah et al. (2007)
7.	Remanufacture is the work of building a new product on the base of a used product.	Whitmer et al. (1995)
8.	Suppliers are required to collect back remanufacturable product.	Eltayeb et al. (2010)

Table 3.2 *(Continued)*

Recycle		
1.	This strategy involves collecting used products from customers for recycling.	Eltayeb et al. (2010)
2.	This strategy involves collecting used packaging from customers for recycling.	Eltayeb et al. (2010)
3.	Procedures for recycling have been established.	Talbot et al. (2007)
4.	Procedures for handling hazardous materials for end-of-life products have been established.	Talbot et al. (2007)
5.	Recycling reduced the amount of energy required for extracting virgin material.	King et al. (2006)
6.	Material recycling is the re-melt of materials to make new products.	Ljunberg (2007)
7.	Energy recycling is the extraction of heat from burning materials.	Ljunberg (2007)
8.	Recycle involves disassembly at material level.	Thierry et al. (1995)
9.	Recycle involves reusing materials from used products and components.	Thierry et al. (1995)
10.	Suppliers are required to collect back recyclable product.	Eltayeb et al. (2010)
11.	Suppliers are required to collect back recyclable packaging.	Eltayeb et al. (2010)
Disposal		
1.	This strategy involves collecting used products from customers for disposal.	Rogers and Tibben-Lembke (2001)
2.	This strategy involves collecting used packaging from customers for disposal.	Rogers and Tibben-Lembke (2001)
3.	The amount of waste for disposal is minimised.	Talbot et al. (2007)
4.	Disposal involves appropriate storage of waste.	Talbot et al. (2007)
5.	Disposal involves appropriate dumping of waste.	Talbot et al. (2007)
6.	Disposal involves appropriate treatment of waste.	DeMendonça and Baxter (2001); King et al. (2006)

3.5.3 Green Product Design and Resource Commitment: Construct and Dimensions

In describing the characteristics of green products that complement inspection and disposition activities of reverse logistics, de Brito and Dekker (2003) evaluated end-of-use and end-of-life products from the perspectives of product composition, product deterioration and usage pattern. Researchers described green product design as a concept coined from sustainable development, where other terms included ecodesign, design-for-the-environment, environmentally-sensitive design and ecological design (Argument et al., 1998; Baumann et al., 2002; Chen, 2008; Eltayeb & Zailani, 2010; Hauschild et al., 2005; Zhu & Sarkis, 2007).

Empirical researches in this field of study are comparatively few and measurements on green product design or ecodesign have not been well-defined by previous studies. Some studies focused on development of product design tools and a number of studies presented normative suggestions on green product designing but they have not been empirically tested. As end-of-life product management emphasised on cost versus value of product recovery, Dowie (1994) was among the pioneer authors of "green design" who developed recovery friendly design guidelines that highlighted on three aspects of product design, also identified as materials selections, fasteners or connections and product structure. Dowie's perspective of green design is consistent with the concept of DfDRR, also known as design for disassembly, reuse and recycling, proposed by Veerakamolmal (1999). DfDRR is an initiative that focused on modular product structure, design of functional units, materials selection, minimise waste or harmful contaminating materials, and ease of product separation.

Additionally, this study enhanced the comprehensiveness of design attributes that defined green product design by adopting measures from environmental management literatures. Design for the environment (DfE) was described as an environmentally conscious business practise and encompassed design for recyclability, reuse, remanufacturability, disassembly and disposal (Sarkis, 1998). However, sub-components of DfE were not described further. From another perspective, Argument et al. (1998) revealed that green design expands from the concept of environment conscious design which sheltered the concept of design for assembly, disassembly and recycling whereas Gehin et al. (2008) described design for disassembly and design for recycling as DfX practices that are beneficial to reverse supply chain activities. Furthermore, Hauschild et al. (2005) indicated that both designs comes under the aegis of DfE and Cerdan et al. (2009) observed that both ecodesign strategies were understudied design aspects. Therefore, investigating the influence of product design from the basis of recoverability to develop reverse logistics capabilities was viable.

Designing green products is a knowledge-based resource embedded in organisations. Ecodesign is a component of GSCM studies (Eltayeb & Zailani, 2009; González-Benito & González-Benito, 2005; Shang et al., 2010; Zhu et al., 2007). Zhu et al. (2007) measured ecodesign empirically and they are the design of products; (1) for reduced consumption of material or energy, (2) for reuse, recycle, recovery of material, component parts, and (3) to avoid or reduce use of hazardous products and/or their manufacturing process. Reducing consumption and avoiding use of hazardous materials are common characteristics of green products and Zhu’s second measurement emanated substantial void because design elements that accommodate other recovery objectives particularly products with high residual value were not taken into consideration. Other than adopting Zhu’s measurement of ecodesign practices when developing environmental management practise related to product, González-Benito and González-Benito (2005) took into consideration design for disassembly, reusability and recyclability coined from Veerakamolmal's study. For the benefit of products that reached end-of-life stage of the product lifecycle, Talbot (2005) recommended that products should be designed for ease of disassembly and ease of recycling whereas Gottberg et al. (2006) indicated that facilitating product disassembly is an enabler for improving recyclability of products as well as to extend product lifecycle. Zussman (1994) suggested that the product disassembly process is a pre-requisite phase to recycle whole or part of the product.

Disassembly friendly products is required for various disposition options and its importance increased in the sequence of repair, remanufacturing and recycling (Guide Jr et al., 2000). The authors who recommended design aspects associated with disassemblability of products include Bogue (2007), Sarkis, Gonzalez-Torre and Adenso-Díaz (2010a), Cerdan et al. (2009), Desai and Mital (2003), Kriwet et al. (1995) and Dowie (1994). According to Desai and Mital (2003), the design parameters that significantly influence product disassembly are; (1) degree of accessibility of components and fasteners, (2) amount of force (or torque) required for disengaging components (in case of snap fits) or unfastening fasteners, (3) positioning, (4) requirement of tools, and other design factors such as (5) weight, shape and size of components being disassembled. As these design attributes had been numerically analysed, these measures were incorporated into the survey to assess their effects on product disposition because the fundamental objective of disassemblability is accessibility of faulty and/or reusable parts to assist subsequent recovery options. This is supported by Sundin (2004) who proposed five product properties specifically ease of identification, ease of access, ease of handling, ease of separation and wear resistance as design attributes that facilitate accessibility of targeted subassemblies or components for remanufacturing and reconditioning processes.

The other dimension of green product design concerned recyclability of products. The measurement of design for recycling were adapted and modified from Tien et al.(2002), Zhu and Sarkis (2007), Kriwet et al. (1995) , Cerdan et al. (2009), Eltayeb et al. (2010), Sarkis et al. (2010a) and González-Benito and González-Benito (2005). Tien et al. (2002) and Zhu and Sarkis (2007b) discussed about using environmentally compliant materials whereas Kriwet et al. (1995) described recyclability from the viewpoint of materials, components and subassemblies reuse. From the perspective of environmental designs practice of EMS, the measurements composed of substitution, reduction, redesigning, design for disassembly and use of recycled materials (Sroufe, 2003). Applicable measurements were basically choice of materials and ten questions were enlisted after a series of considerations ascertained non-repetitive measures.

Other than green product design, commitment of resources is a significant enabler in developing reverse logistics capabilities. Genchev (2007) proposed to analyse the influence of knowledge-based resource and property-based resource in formalising reverse logistics whereas Daugherty et al. (2001), Skinner et al. (2008), Richey et al. (2005a), Jack et al. (2010) are among the authors who advocated the importance of resource commitment particularly financial, technological and managerial resources. Table 3.3 enlists the questions for measuring design for disassembly, design for recycling and resource commitment. Similar to RLPD, the survey measured the presence of GPD practices in existing industrial practises based on their extent of their existence. Additionally, the level of resource commitment will be evaluated based on substantiveness of investment allocated to reverse logistics.

Table 3.3
Questions on Green Product Design and Resource Commitment

No.	Items	Sources
Design for Disassembly		
1.	Focus on reducing the cost for dismantling products.	Cerdan et al. (2009)
2.	Design products that use modular components.	Sarkis, Gonzalez-Torre, and Adenso-Díaz (2010a); Kriwet et al.(1995)
3.	Design products that use snap fits in lieu of screws.	Sarkis, Gonzalez-Torre, and Adenso-Díaz (2010a)
4.	Design products that avoid use of weld or adhesive.	Becerra (2000)
5.	Design products that minimise the number of fasteners.	Dowie (1994); Bogue (2007)
6.	Design of products that ease accessibility of valuable components/materials.	Kriwet et al. (1995)
7.	Design products that ease accessibility of joining elements.	Kriwet et al. (1995); Dowie (1994)
8.	Design products that avoid use of special tools or destructive disassembly techniques to disassemble joints.	Kriwet et al. (1995); Bogue (2007)
9.	Design products that protect joining elements from corrosions and wear.	Kriwet et al. (1995)
10.	Design products that minimise the amount of force (or torque) required for disengaging parts or components.	Desai and Mital (2003)
11.	Design products that consider the weight, shape and size of structure for disassembly.	Desai and Mital (2003)
12.	Design product with clear identification of parts or components to facilitate disassembly.	Sarkis, Gonzalez-Torre, and Adenso-Díaz (2010a)
Design for Recycling		
1.	Use of pollution-free raw materials in production.	Tien et al. (2002); Eltayeb et al. (2010)
2.	Use of raw materials compliant with environmental protection regulations.	Tien et al. (2002)
3.	Design of products that reduces consumption of material.	Zhu et al. (2007); Eltayeb et al. (2010)

Table 3.3 *(Continued)*

4.	Design of products to avoid or substitute the use of hazardous substances.	Zhu et al. (2007); González-Benito and González-Benito (2005)
5.	Design of products to allow use of recycled materials.	Cerdan et al. (1999); Eltayeb et al. (2010)
6.	Design of products to allow use of recycled subassemblies or components.	Kriwet et al. (1995)
7.	Design of products that cluster materials to utilise their compatibility.	Kriwet et al. (1995)
8.	Design of product for reuse, recycle, recovery of materials, component parts.	Zhu et al. (2007); Chan and Fang (2007)
9.	Design packaging with higher durability to enable multiple reuse.	Tien et al. (2002)
10.	Design packaging that is recyclable.	Tien et al. (2002); Talbot et al. (2008)
Resource Commitment		
1.	Technological resource commitment to reverse logistics.	Daugherty et al. (2001); Skinner et al. (2008); Richey et al. (2005); Jack et al. (2010)
2.	Managerial resource commitment to reverse logistics.	
3.	Financial resource commitment to reverse logistics.	

3.5.4 Institutional Pressure: Construct and Dimensions

Institutional pressure motivates manufacturers to adopt extended producer responsibility on the environmental impact of end-of-use and end-of-life products by conforming to predetermined standards in managing waste of electrical and electronic equipment (WEEE). Many authors analysed the influence of institutional pressures towards environmental management practices and only few studies examined this aspect from the standpoint of reverse logistics. In a pioneer study conducted by Henriques and Sardosky (1996), they identified four out of ten sources of pressure that significantly influence firms to respond to environmental requirements and they consist of government regulatory pressure, neighbourhood or community pressure, shareholder pressure and customer pressure.

Generally, these pressures exert diverse influence towards various industries and they serve as guideline for developing environmental friendly practices that mitigate negative impact on natural environment. Additionally, the extent of influence exerted by institutional pressure towards developing countries is generally weaker compared to those of developed country because substantial investment is required to build ecological infrastructure or create awareness on risk related to scrupulous WEEE management. For this study, institutional theoretic perspectives such as community and market pressure is excluded because their impact towards environmentally conscious products is relatively minimal when compared to regulatory and ownership pressure. Based on a study conducted by Zhu and Sarkis (2007), they pointed out that regulatory pressure encouraged organisations to develop green practises including investment recovery. Even though investment recovery was analysed as sales of used or excess materials and equipment, this activity the first milestone of product recovery as cost of investment are recovered instead of landfilled. Zhu and Sarkis indicated that regulatory pressure exerts negative moderation effect on the relationship between investment recovery and positive economic performance. Therefore, this study redefined investment recovery and renamed product recovery initiative with reverse logistics product disposition to extend depth of study so that the moderating influence of environmental regulations introduced by the local government are clarified. Prior research has examined reverse logistics in the context of Malaysian manufacturing environment but the performance of reverse logistics was not convincing. Even though Eltayeb et al. (2010) revealed that regulations and expected business benefits were significant drivers for adopting green supply chain initiatives, the moderating influence of regulations were inconclusive without hierarchical regression analyses.

Under the presence of coercive pressure, Berrone et al. (2007) pointed out that firms are encouraged to undertake legitimate business activities and capitalise on economic gains derivable from conformance to institutional pressure. The measurements for regulatory pressure was adopted from several studies (Darnall et al., 2008; Eltayeb & Zailani, 2010; Henriques & Sadorsky, 1996; Zhu et al., 2007). Compliance to current, future and corporate environmental regulations is the most effective method to minimise risk of fines or penalties related to violations of environmental standards. Henriques and Sardosky (1996) indicated that regulatory pressure influence firm’s commitment in becoming environmentally proactive and this factor is measured by; (i) regulatory changes that results in unacceptable product impact, (ii) non-compliance penalties (of all kinds), and (iii) the banning or restriction of raw materials. Latter study from Zhu et al. (2008a) also indicated that regulatory pressure exerted by environmental regulations endorsed by receiving countries may be disadvantageous to product’s market value.

The inclusion of ownership pressure as part of institutional theoretic settings was presented by Darnall (2008), who pointed out that firms that incur financial liabilities to investors due to poor environmental responsibility may inhibit potential owners' interest to invest. This disinterest among investors are expressed when shareholders withdraw from committing resources to the company by selling their stakes in the company and this consequently result in lower share price or decrease of capital investment (Darnall et al., 2008). Henriques and Sardosky (1996) measured ownership pressure from the perspective of risks that threats the potential growth or good image of manufacturers such as; (i) discontent with environmental fines which lower profits, (ii) disillusionment with progress towards environmental goals, and (iii) difficulties in raising new capital or attracting new investors. Since financial investment is a form of resource commitment that motivates firms to react in compliance with environmental requirements, they were adapted as items of ownership pressure since non-compliance potentially affects companies' or brands' reputation. Institutional actors influenced firms' decision-making at managerial level and the degree of attention paid to these effects differed across their importance or urgency. For this variable, respondents are required to evaluate the extent of influence exerted by regulatory and ownership pressure based on 5-point Likert-type scale.

Table 3.4
Questions for Regulatory Pressure and Ownership Pressure

No.	Items	Sources
Regulatory Pressure		
1.	By taking back products, my firm tries to reduce or avoid the threat from current environmental regulations.	Zhu et al. (2007); Darnall et al. (2008)
2.	By taking back products, my firm tries to reduce or avoid the threat of future environmental regulations.	Zhu et al. (2007); Darnall et al. (2008)
3.	Environmental regulations in other countries, such as Europe, Japan and US induced my firm to adopt reverse logistic initiative.	Zhu et al. (2007); Eltayeb and Zailani (2010)
4.	My firm's parent company sets strict environmental standards for my firm to comply with.	Eltayeb and Zailani (2010)
5.	There are frequent government inspections or audits on my firm to ensure that the firm is in compliance with environmental laws and regulations.	Eltayeb and Zailani (2010)
6.	Environmental regulations are important influence to the environmental practices of my firm.	Darnall et al. (2008)
7.	Environmental regulations present risk related to unacceptable product impacts.	Henriques and Sardosky (1996)
8.	Environmental regulations present risk related to penalties due to non-compliance.	Henriques and Sardosky (1996)
9.	Environmental regulations present risk related to banning or restriction of raw materials.	Henriques and Sardosky (1996)
Ownership Pressure		
1.	Risk of shareholder discontent with environmental fines which lower profits.	Henriques and Sardosky (1996)
2.	Risk of shareholder concerns when the company does not achieve environmental goals.	Henriques and Sardosky (1996)
3.	Risk of difficulties in raising new capital or attracting new investors.	Henriques and Sardosky (1996)
4.	Risk of lower share price due to shareholders' investment withdrawal.	Darnall et al. (2008)
5.	Financial incentives offered by the Malaysian government, such as grants and tax reductions, are significant motivators for my firm to adopt reverse logistic product disposition.	Eltayeb and Zailani (2010)
6.	Financial incentives offered by international organisations, such as United Nations, are significant motivators for my firm to implement reverse logistic.	Eltayeb and Zailani (2010)

3.6 Measurement Scale

The five-point Likert-type scales are used for most of the questions. Likert scaling presents a simple and straightforward method for respondents to score items. According to Babbie (1990) and Zikmund (1991), this method presumed that the scales are ordinal, where the attitude towards each scale has equal weight, and this scale is generally easy to construct, adaptable to a variety of items in forming an index. For this study, the responses available to these items were very low extent, low extent, moderate extent, high extent and very high extent of a ‘verb’ to suit the concept understudy. Due to the reason that Malaysia is a newly industrialised country with comparatively lenient policy on extended producer responsibility, green product design and reverse logistics product disposition are relatively underdeveloped business practices. The ‘extent of existence’ will be used to measure green product design and reverse logistics product disposition whereas ‘extent of influence’ will be used to measure the moderating effect of regulatory and ownership pressure on the business performance of product disposition practices.

Likert scale enabled researcher to measure the attitude towards an item using a scale that range from very negative to very positive (Zikmund, 1991). Five-point scale applied to this study consists of: not at all, a little bit, to some degree, relatively significant and significant, where scores of 1 to 5 are parentheses to reflect firms’ level of performance in reverse logistics. In this study, ‘to some degree’ was chosen as mid-point option instead of undecided or neutral to ensure that the scale ascend across the scores. Business performance of RLPD is assessed based on significance of business benefits whereas antecedent of RLPD specifically resource commitment is assessed based on substantiveness of investment.

3.7 Validity of the Instrument

Validity relates to whether the results of the subject matter understudy are associated with current business practices. In other words, the measurements are measuring what they set out to assess. Since most of the questions were adapted from previous studies, disparities of business environment are part of the reason that some level of deficiency in regards to face validity exist. According to Zikmund (1991), face validity or content validity entails subjective judgment on accuracy of responses towards predetermined questions by means of logical valuation. The items in the questionnaire ought to acquire the input of experts from academia and industry to warrant content validity (Devellis, 2003). Three academicians who have obtained doctorate degree in the field of environmental engineering, green supply chain and supply chain management contributed constructive suggestions. Two face-to-face discussions with industrial practitioners from the background of lean manufacturing and product design also took place. In addition, three phone interviews were conducted with two managers from Department of Environmental, Health and Safety (EHS) and one manager from Department of Supply Chain Management. All the industrial practitioners, who represented ISO 14001 certified E&E manufacturing firms, had more than five years of working experience at their respective firms. Such feedbacks are valuable as they elevate the relevance and coherence of measures in representing examined concept (Babbie, 1990; Sekaran, 2003). Initial assessments on measurement items minimise discrepancies between the questionnaire and measured concept. The changes made to the questionnaire are summarised in Table 3.6.

3.8 Pilot Study

Based on Zikmund (1991), the method of data collection for pilot study is conducted in a similar manner with actual data collection. Upon identifying the population to be addressed by actual study, the pilot study is accomplished by administering the survey instrument unto several population elements. Pilot study is essential to gather feedbacks and opinions for improving the survey questionnaire (Hair et al., 2007). The questionnaire was pretested twice during a period of 2 months. In the first round, the group consisted of 27 industrial representatives from Environmental, Health and Safety Department. As they were randomly chosen from various subsectors of the manufacturing industry, the nature of manufactured products became a point of concern because food and beverage, textiles and clothing, wood furniture, chemical products and others do not require complex recovery beyond product recycling. Therefore, the second pilot study attempts to minimise potential errors by narrowing down the scope of research to focus in E&E industry subsector.

Table 3.5
Reliability Analysis of Pilot Study (n=27)

Variables and Dimensions	Items	Cronbach's Alpha
Green Product Design		
Resource Commitment	3	0.921
Design for Disassembly	12	0.913
Design for Recycling	10	0.898
Reverse Logistics Product Disposition		
Repair	6	0.794
Recondition	8	0.959
Remanufacture	8	0.958
Recycle	11	0.901
Disposal	6	0.905
Business Performance		
Environmental Outcome	8	0.833
Profitability	8	0.862
Sales Growth	8	0.900
Institutional Pressure		
Regulatory Pressure	9	0.683
Ownership Pressure	6	0.878

Since the results of reliability test on small sample size would not be accurate due to insufficient data, it is more crucial to observe the occurrence of missing data, review feedbacks and address the subtle barriers that would inhibit respondents' interest in completing the questionnaire. These subtle barriers include clarity of instructions, length of questions, ambiguous wordings, double-barrelled measurements, and sequence of questions applied for extracting information. With reference to Babbie (1990) suggestion, the number of questions in the final survey instrument was reduced based on the responses obtained from pilot study. Another modification to the survey was the addition of a multiple choice question to identify the barriers of reverse logistics implementation for products and packaging materials.

All the modifications that were introduced to the questionnaire are summarised in Table 3.6. During the second round of pilot study where the population was redefined and survey instrument was refined, the study was administered to a small group of industrial practitioners. Six representatives of EHS Department from ISO 14001 certified E&E manufacturing firms were contacted and subsequent discussions revealed that no major correction is required.

Table 3.6

Changes Made to Questionnaire during Validity and Pilot Study

<table>
<tr><th></th><th>Face Validity</th><th>Pilot Study 1</th><th>Pilot Study 2</th><th>Nature of Change</th></tr>
<tr><td rowspan="6">Section A: Company Profile</td><td></td><td colspan="2">Nature of Business</td><td>Focus on electrical and electronic manufacturing industry.</td></tr>
<tr><td></td><td colspan="2">Type of Business</td><td>Identify different supply chain players.</td></tr>
<tr><td colspan="2">Reverse Logistics</td><td></td><td>Modify response category to identify RL activities for products and packaging.</td></tr>
<tr><td colspan="2">Export Market</td><td></td><td>Identify destination of products.</td></tr>
<tr><td></td><td colspan="2">RL Barriers</td><td>Identify barriers in RL implementation.</td></tr>
<tr><td></td><td colspan="2">Financial Performance</td><td>Modify response category for financial results.</td></tr>
<tr><td rowspan="2">Section B: Green Product Design</td><td colspan="2">Design for Disassembly</td><td></td><td>Add ‘ease of separation’ as parentheses to understand DfD.</td></tr>
<tr><td colspan="2">Design for Recycling (Q9)</td><td></td><td>Add ‘multiple’ to amplify on reusability of material.</td></tr>
<tr><td rowspan="2">Section C: Reverse Logistics Product Disposition</td><td colspan="2">Repair (Q3)</td><td></td><td>Replace ‘increases’ with ‘prolongs’ to better represent the outcome of repaired products.</td></tr>
<tr><td colspan="2">Disposal (Q6)</td><td></td><td>Add a question to address waste treatment activity.</td></tr>
<tr><td>Section D: Institutional Pressure</td><td colspan="2">Regulatory Pressure (Q1 and Q2)</td><td></td><td>Bold the words ‘current’ and ‘future’ to distinguish the questions.</td></tr>
<tr><td rowspan="2">Section E: Business Performance</td><td></td><td colspan="2">Profitability</td><td>Combine ‘cost’ and ‘profitability’ items as they are inversely related.</td></tr>
<tr><td colspan="2">Sales Growth (Q6)</td><td></td><td>Replace ‘customer loyalty’ with ‘relationship with customers’ for better understanding.</td></tr>
<tr><td rowspan="3">Section F: General Information</td><td colspan="2">Designation</td><td></td><td>Apply ‘Others’ as 10th response category.</td></tr>
<tr><td colspan="2">Department</td><td></td><td>Apply ‘Others’ as 9th response category.</td></tr>
<tr><td colspan="2">Additional Information</td><td></td><td>Make available an open question to allow respondents to describe their company’s practices.</td></tr>
</table>

3.9 Data Analysis

Upon administering the questionnaire survey to sample respondents, the collection of data is analysed using Statistical Package for Social Science (SPSS) version 19.0. Primarily, data cleaning and transformation are conducted to prepare the data for a series of statistical analyses intended for hypotheses testing. These analyses are explained in following sections.

3.9.1 Descriptive Statistics

Descriptive statistics was conducted to compute the value of mean and standard deviation associated with each dimensions of the variables. These values are computed to obtain an overview of respondents' perception towards the variables of interest and subsequently, the distribution of data is estimated.

3.9.2 Factor Analysis and Reliability Analysis

According to Hair, Black, Babin, and Anderson (2010), the fundamental purpose of factor analysis was to identify the underlying structure within variables to examine the interrelationships between variables and/or dimensions. Principal component analysis extraction method and varimax rotation technique was applied to derive factors based on common variance. The primary interest of data reduction is minimisation of measurement items to develop variables and this enabled substantial convenience in analysing the effects of predictors. Factor analysis was applied on the measurement items of green product design, resource commitment, reverse logistics product disposition, business performance and institutional pressure. According to Hair et al., the value of significant factor loading most appropriate for interpretation is influenced by sample size where items that are being tested on smaller sample size requires higher factor loading to ascertain practical significance. Since the final sample size for this study is 89, only items with factor loadings of 0.587 and above is significant.

Subsequently, reliability analyses were conducted to substantiate that these measures yield consistent results on different occasions (McBurney & White, 2010). According to Zikmund (1991), repeatability and internal consistency are two aspects that define the concept of reliability. Cronbach’s alpha is the most widely used measure to assess reliability of the dimensions and the rule of thumb suggests that value of Cronbach’s alpha must exceed 0.70 (Nunnally, 1978). Higher value denotes higher reliability and Hair et al. also recommended that value of item-to-total correlations and inter item correlations should exceed 0.50 and 0.30 respectively (p. 125).

3.9.3 Correlation Analysis

With reference to Hair et al. (2010), value of correlation coefficient (*r*) can take any value from -1.0 to +1.0 and this value denotes strength of association between two metric variables where positive r value indicates direct relationship whereas negative r value indicates inverse relationship. According to Cohen (1988), the strength of correlations is classified into small (r = 0.10 to 0.29), medium (r = 0.30 to 0.49) and large (r = 0.50 to 1.00). For this study, a two-tailed Pearson's product-moment correlation analysis was conducted to analyse the association between reverse logistics product disposition and its antecedents (green product design and resource commitment) as well as outcome (business performance). The correlation between moderator variable (institutional pressure) and business performance is important for identifying the presence of quasi or pure moderators.

3.9.4 Regression Analysis

Linear regression analysis is a statistical technique that determines the predictive ability of multiple independent variables towards single dependent variable (Hair et al., 2007). According to Zikmund (1991), regression analysis predicts the values of continuous dependent variable (interval scale) from specific numerical values in independent variables. Based on the concept of correlation, standard multiple regression and hierarchical regression analyses examine the relationships between variables. Therefore, the linearity between independent and dependent variables is important and can be estimated through residual plots such as normal P-P plot of regression standardised residual, partial regression plot and others. Multiple regression analyses were applied to examine the antecedents and outcome of reverse logistics product disposition whereas hierarchical regression analysis examined the moderating effect exerted by institutional pressure on the relationship between RLPD and business performance of reverse logistics.

3.9.5 Flow of Hypothesis Testing

The hypotheses of this study were tested based on a sequence of statistical analyses described in **Figure 3.1**. During hypotheses testing, the assumptions of linear regression analyses were met to acknowledge the validity of variables that are being analysed as antecedents and outcome of reverse logistics product disposition.

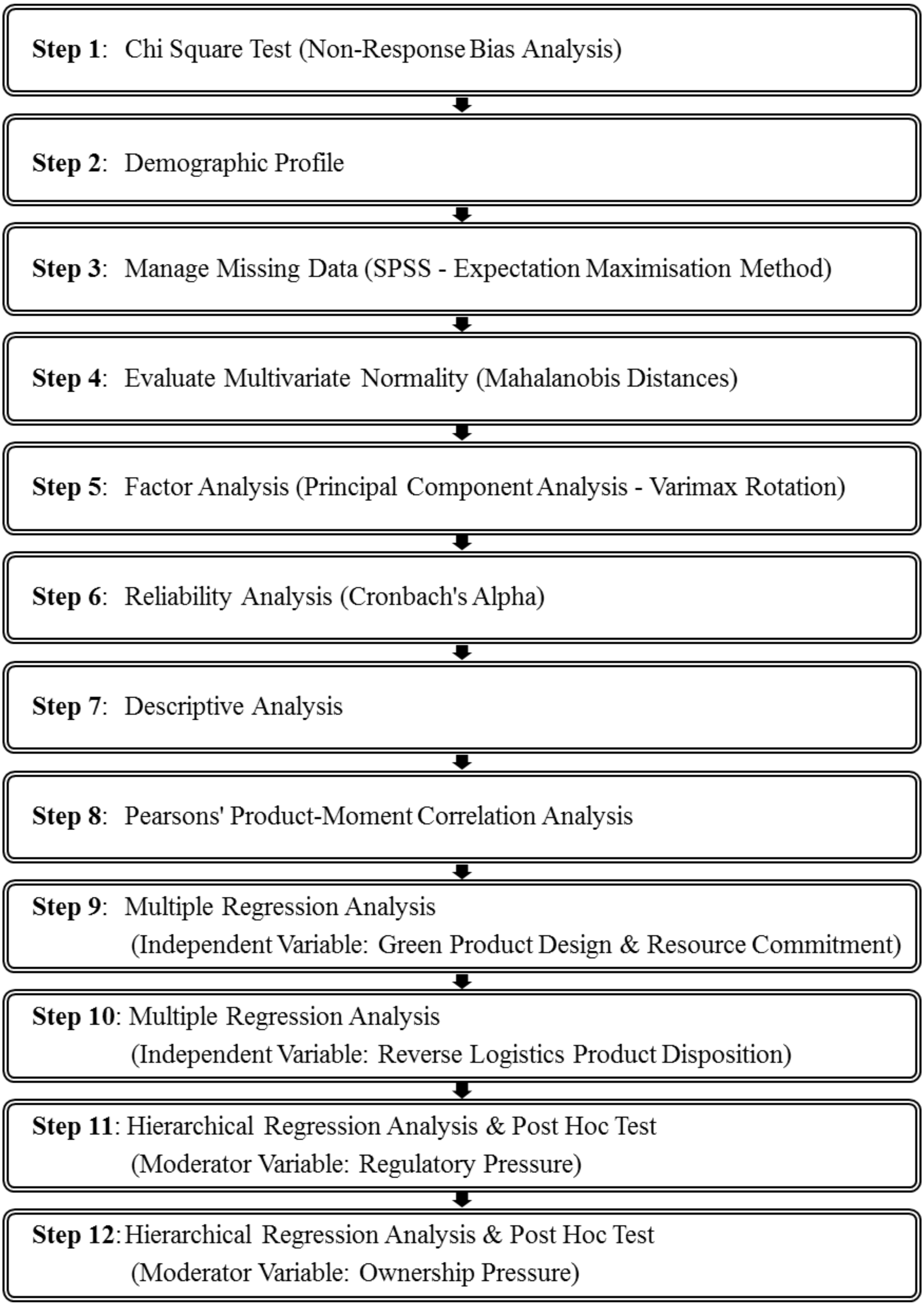


Figure 3.1
Flow Chart for Hypothesis Testing

3.10 Summary

This chapter describes the methodology applied to this study, which comprised of development of survey instrument, sampling design, data collection strategies, measurement scale and methods of data analyses. Pilot study screening on validity of measurement items and reliability of research instrument are also discussed. The results of multivariate regression analyses conducted for this study are presented in the following chapter.

CHAPTER 4

DATA ANALYSIS AND FINDINGS

4.1 Introduction

A series of statistical analyses was applied on the data to gather information from administered questionnaires. This chapter is organised in several sections to present the results; which includes chi square test to determine difference between early and late responses, demographic profile of sample respondents, missing data analysis, goodness of measure of unidimensional and multidimensional constructs, descriptive statistics, modified research framework, restatement of hypotheses, Pearson's product-moment correlation analyses, hypothesis testing through linear regression analyses, and graphs of moderation effects. The chapter ends with a summary of the research findings.

4.2 Response Rates

The response rate is calculated by dividing the number of responses received with net contacted responses, where the latter is a sum that excludes organisations with unreachable contact details, experienced a major change in organisation's nature of business and other reasons alike. According to Babbie (1990), response rate measures researcher's success in persuading respondents to return the questionnaire. About 160 out of 177 organisations were contacted but only 99 companies returned the survey via conventional and electronic mail. Some respondents who were interested in this study returned the survey early whereas other respondents were followed up with a series of friendly reminders. For this study, the reminders were important to garner participations because most of the environmental managers and/or environmental management representatives have indicated their willingness to respond to the survey during the initial call. As such, the overall response rate was 61.88 percent.

Additionally, question no. 6 (refer to Appendix A) was included to distinguish the level of reverse logistics implementation. Nine respondents indicated that their organisation are adopting ‘not considering it’ approach towards reverse logistics activities for both products and packaging based on five ascending response categories. In minimising response bias that may disrupt the interest of this research, this study excluded ten responses, where nine responses were described above and an additional exclusion was a questionnaire which contained more than fifty percent missing data. Therefore, the usable rate of return is 55.63 percent and this value is equivalent to 89 sets of data. Based on Babbie’s (1990) and Zikmund’s (1991) recommendation, this quantity is adequate for multivariate analyses and reporting as they advocated for a minimum of fifty percent response rate.

4.3 Test for Non-Response Bias

The chi square test is applied to test for significant characteristic distribution among early and late respondents. For this study, the questionnaires were mailed out continuously and thirty-five responses which took more than a month to return were considered late responses. Table 4.1 is the results of chi-square test and hypothesis null depicted that there are no difference across respondents' demographic characteristics based on speed of responses. The null hypothesis cannot be rejected because most of the variables were insignificant at $p > 0.05$. Total current asset was the only variable which was close to becoming significant at $p = 0.076$ because sixteen respondents provided missing data for this variable.

Table 4.1
Chi-Square Test for Comparison of Early and Late Responses

Variables	Categories	Responses		Chi Square Value	Sig. (2-sided)
		Early	Late		
Subsector	Electronic Components Consumer Electronics Industrial Electronics Electrical Products	22 10 6 16	12 4 3 16	2.574	0.462
Type of Business	OEM Custom Manufacturer Distributor/Trading/Retail Electronic Manu. Serv. Others	14 12 1 26 1	9 4 0 22 0	3.525	0.474
Ownership Status	Local Government Joint-Venture American Japanese European Others	12 0 5 4 25 4 4	4 0 4 3 17 4 3	1.953	0.856
Length of Business	Less than 5 years 6 to 10 years 11 to 15 years 16 to 20 years More than 20 years	0 2 3 12 37	1 0 5 4 25	6.042	0.196

Table 4.1 *(Continued)*

No. of Employees	Less than 50	3	1	6.206	0.287
	51 – 150	14	4		
	150 – 500	15	9		
	501 – 1000	13	8		
	1001 – 2000	5	7		
	More than 2000	4	6		
Reverse Logistics (Products)	Not considering it	5	6	6.189	0.185
	Planning to consider it	9	5		
	Considering it currently	4	2		
	Initiating implementation	10	1		
	Implementing it currently	25	21		
Reverse Logistics (Packaging)	Not considering it	4	3	1.729	0.785
	Planning to consider it	7	7		
	Considering it currently	3	1		
	Initiating implementation	8	3		
	Implementing it currently	31	21		
Total Current Assets	Less than RM 10 million	9	7	8.479	0.076
	RM 10 to 25 million	6	6		
	RM 25 to 100 million	18	3		
	RM 100 to 500 million	7	3		
	Less than RM 10 million	6	8		
Average Annual Revenue	Less than RM 10 million	12	5	4.621	0.328
	RM 10 to 25 million	8	4		
	RM 25 to 100 million	17	6		
	RM 100 to 500 million	8	7		
	Less than RM 10 million	5	7		
Designation	Vice President or Above	0	0	3.738	0.588
	General Manager	2	1		
	Senior Manager	6	4		
	Department Manager	16	15		
	Executive	23	9		
	Officer	6	4		
	Others	1	2		
Department	President's Office	1	0	4.086	0.849
	Product Design	1	1		
	Environmental, Health and Safety	25	20		
	Engineering	3	1		
	Warehouse / Logistics	2	0		
	Operations	6	4		
	Planning	1	0		
	Quality	12	6		
	Others	3	3		
Length of Service	Less than 2 years	7	6	1.045	0.903
	2 – 5 years	9	5		
	6 – 10 years	12	6		
	11- 20 years	18	14		
	More than 20 years	8	4		

4.4 Demographic Profile of Sample Organisations

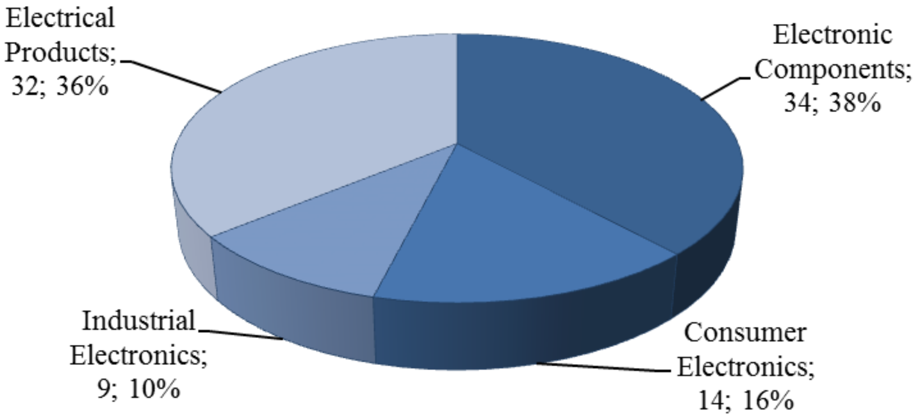


Figure 4.1
Subsector of E&E Industry

As illustrated by Figure 4.1, electrical and electronic manufacturers identified four industry subsectors to categorise E&E products and both electrical products (36%) and electronic components (38%) are more thriving in terms of number of companies when compared to consumer electronics (16%) and industrial electronics (10%). Based on Figure 4.2, most of the companies who participated in this survey are electronic manufacturing service provider (48), followed by original equipment manufacturer (23) and custom manufacturer or sub-contractor (16).

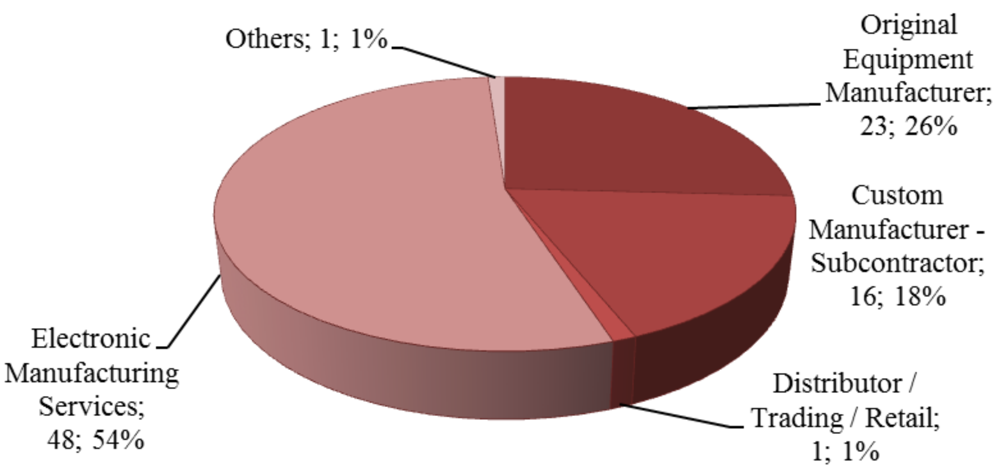


Figure 4.2
Type of Business

In terms of type of ownership, most of the respondents were representing Japanese-owned companies (42) and local companies (16). Other types of ownership were the joint-venture, European-owned and American-owned companies, with 9, 8 and 7 representatives respectively. 'Others' type of ownership is not illustrated in Figure 4.3 and they consisted of Singaporean-owned (3), Taiwanese-owned (3) and Australian-owned companies (1). Within the manufacturing industry, a wide selection of environmental standards is established to monitor and control the ecological impact of firms' operating activities. Although compliance to these standards depends on firms' proactivity, an important driver for organisations that operate at home or foreign country is the environmental trade barriers that restrict trading across nations. Based on Figure 4.4 and Table 4.2, ISO 14001 Environmental Management System and Restriction of Hazardous Substance (RoHS) Directive are dominant influencers to organisations' environmental practices. The European Union introduced Waste of Electrical and Equipment (WEEE) Directive three years earlier than RoHS but only 32 out of 89 firms acknowledged this standard. Further analysis on other sources of influence revealed that 31 firms abide by REACH (Registration, Evaluation, Authorisation and Restriction of Chemical substances) regulation and a couple of firms recognised the influence of green purchasing and customer requirements. Firms who paid attention to WEEE and RoHS regulations indicated that the pressure to reduce and/or eliminate hazardous substances is apparent and they are, in the order of descending frequency, lead (69), mercury (55), cadmium (49), hexavalent chromium (48), polybrominated biphenyls (43), polybrominated diphenyl ethers (41) and others (25). From the returned survey, other substances that are being targeted by firms include, but not limited to, zinc, cyanide, manganese, nickel, paint sludge waste and SVHCs (Substance of Very High Concern) prohibited by REACH.

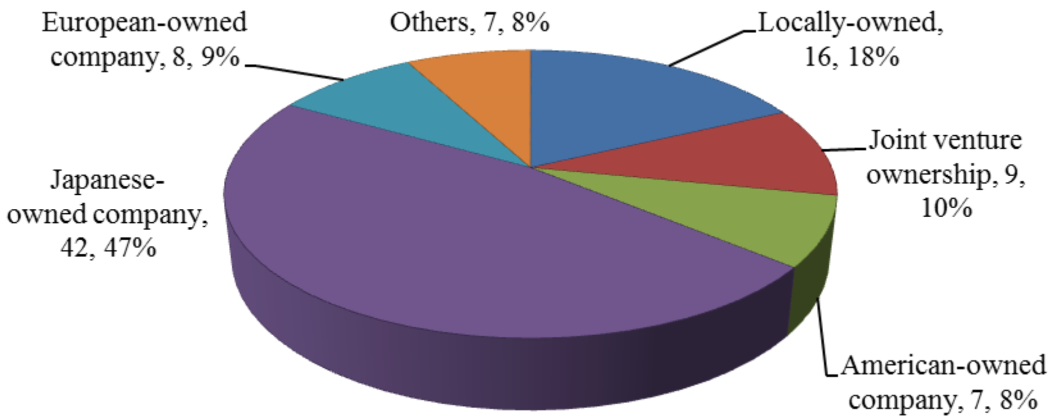
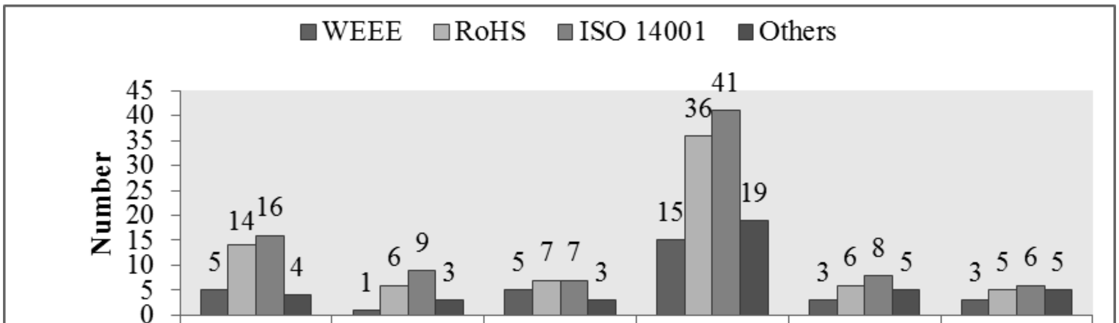


Figure 4.3
Ownership Status



	Local	Joint-venture	American	Japanese	European	Others
WEEE	5	1	5	15	3	3
RoHS	14	6	7	36	6	5
ISO 14001	16	9	7	41	8	6
Others	4	3	3	19	5	5

Figure 4.4
Business' Sources of Influences among Various Types of Ownership

A summary of additional demographic information can be found at Table 4.2. In regards to size of organisations, the frequency distribution of sample organisations were relatively normal as the number of employees less than and more than 500 are 52 percent and 48 percent respectively. For length of business, the data are left-skewed where 62 and 16 firms have been operating for ‘More than 20 years’ and ‘16 to 20 years’ respectively. In terms of financial performance, information on firms’ total current assets and average annual revenue were provided by 73 and 79 firms respectively. It is common to find that respondents are reluctant to provide data on financial performance and the results showed that amount of current asset and annual revenue reported by 29 percent of companies are within the range of RM 25 to 100 million. At least ≈ 33 percent of companies are within ‘RM 100 to 500 million’ and ‘More than RM 500 million’ range for both financial measures. Undoubtedly, these companies could be major contributors to the E&E industry, which dominated the value of manufactured goods exported by Malaysia. The companies are exporting to, in the order of descending frequency, diverse markets such as Asia (74), Europe (50), North America (33), Middle East (21), South America (15), Pacific Ocean (11), Africa (5) and others (1). The destinations of exports may indirectly influence firms in prioritising the reusability, recoverability and/or recyclability of EEE as European, Japanese and Chinese markets have initiated regulations related to extended producer responsibility in managing environmental threats exerted by WEEE.

Table 4.2
Demographic Profile of Organisations

Variables	Measures	Frequency	Percentage (%)
	Single Choice Questions		
No. of Employees	Less than 50	4	5
	51 to 150	18	20
	151 to 500	24	27
	501 to 1000	21	24
	1001 to 2000	12	13
	More than 2000	10	11
Length of Business	Less than 5 years	1	1
	6 to 10 years	2	2
	11 to 15 years	8	9
	16 to 20 years	16	18
	More than 20 years	62	70

Table 4.2 *(Continued)*

Total Current Assets	Less than RM 10 million	16	22
	RM 10 to 25 million	12	16
	RM 25 to 100 million	21	29
	RM 100 to 500 million	10	14
	More than RM 500 million	14	19
Average Annual Revenue	Less than RM 10 million	17	22
	RM 10 to 25 million	12	15
	RM 25 to 100 million	23	29
	RM 100 to 500 million	15	19
	More than RM 500 million	12	15
Reverse Logistics (Products)	Not considering it	11	13
	Planning to consider it	14	16
	Considering it currently	6	7
	Initiating implementation	11	13
	Implementing it currently	46	52
Reverse Logistics (Packaging)	Not considering it	7	8
	Planning to consider it	14	16
	Considering it currently	4	5
	Initiating implementation	11	13
	Implementing it currently	52	59
Multiple Choice Questions			
Export Markets	Asian	74	83
	African	5	6
	Middle East	21	24
	North America	33	37
	South America	15	17
	Pacific Ocean	11	12
	Europe	50	56
	Others	4	4
Source of Influence	WEEE	32	36
	RoHS	74	83
	ISO 14001	87	98
	Others	39	44
Hazardous Substances	Lead	69	78
	Mercury	55	62
	Cadmium	49	55
	Hexavalent chromium	48	54
	Polybrominated biphenyls	43	48
	Polybrominated diphenyl ethers	41	46
	Others	25	28

An effective waste management system is developed by maintaining a good balance between environmental needs and economic benefits. The sustenance of electronic waste management is attainable only through the development of RL infrastructure and this study focuses on the asset recovery options in products, which highly relied on manufacturers' nature of business. Based on this study, the mean of reverse logistics practices on products and packaging is 3.76 and 3.99 respectively, indicating that generally, firms have initiated implementation of product recovery and this include, but not limited to, defining the target of recycling, recovery and disposal to coordinate obligated contributions from stakeholders of the supply chain. Mean of reverse logistics practices were compared across size of organisation (Figure 4.5), industry subsector (Figure 4.6) and type of business (Figure 4.7). Even though the mean difference across the size categories was small, Figure 4.5 demonstrated that extent of RL implementation in products increased across size of organisations.

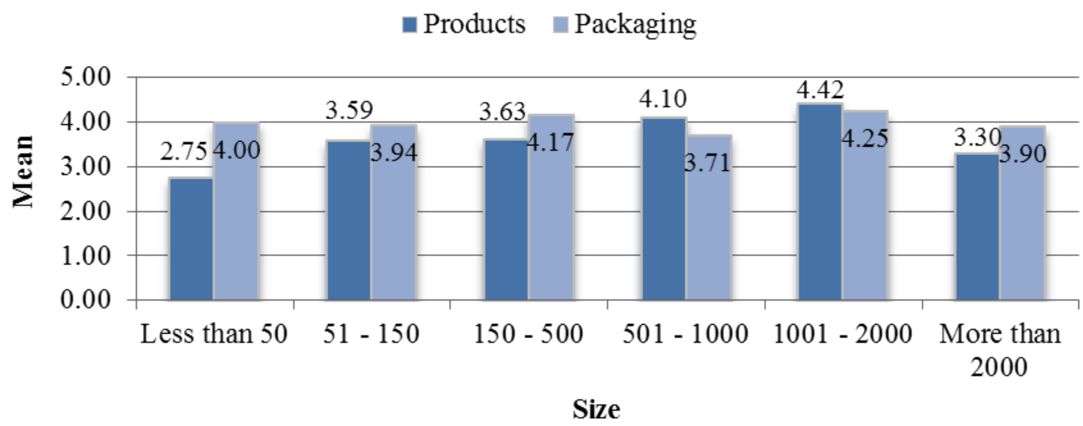


Figure 4.5
Mean of Reverse Logistics Practices based on Size of Organisations

For industry subsector, RL for packaging was more active in electronic components and electrical products subsector whereas the mean score of RL for products were close to $\mu = 4.00$ for all subsectors except for electronic components. This exception is highly attributed to size of components which are complex to recover and contained comparatively lesser recoverable material. When respondents were compared across types of business, it became evident that original equipment manufacturers were major contributors of RL practices for products (μ = 4.26) and packaging (μ = 4.30). Based on Figure 4.7, custom manufacturers (μ = 3.56) and electronic manufacturing service providers (μ = 3.67) reduced the overall mean for RL in products to μ = 3.76.

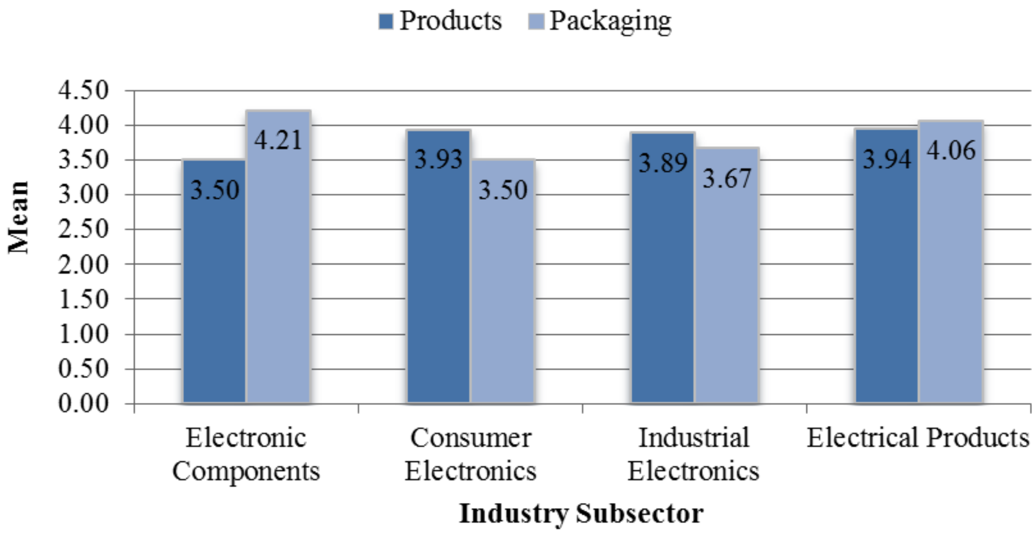


Figure 4.6
Mean of Reverse Logistics Practices based on Industry Subsector

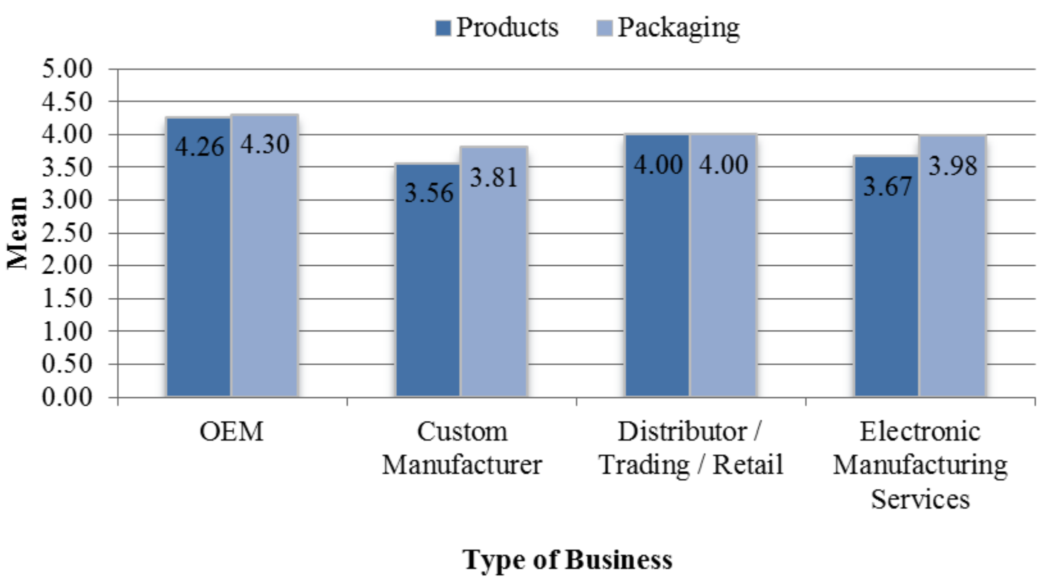


Figure 4.7
Mean of Reverse Logistics Practices based on Type of Business

4.5 Demographic Profile of Respondents

A summary of demographic information related to the representatives of the sample organisation is tabulated in Table 4.3.

Table 4.3
Demographic Profile of Respondents

Variables	Measures	Frequency	Percentage (%)
Designation	General Manager	3	3
	Senior Manager	10	11
	Department Manager	31	35
	Executive	32	36
	Officer	10	11
	Others	3	3
Department	President's Office	1	1
	Product Design	2	2
	Environment, Health & Safety	45	51
	Engineering	4	4
	Warehouse / Logistics	2	2
	Operations	10	11
	Planning	1	1
	Quality	18	20
	Others	6	7
Length of Service	Less than 2 years	13	15
	2 to 5 years	14	16
	6 to 10 years	18	20
	11 to 20 years	32	36
	More than 20 years	12	13

Most of the respondents of this study held managerial positions (49%) and about 36 percent and 11 percent of the respondents are executives and officers respectively. Respondents were pre-identified to ascertain that they are experienced and well-informed about products' and processes' environmental impacts. If the members of Environmental, Health and Safety (EHS) Department cannot be reached, the survey will be redirected to person-in-charge of ISO 14001 certification or environmental management representatives. As such, the majority of respondents were from the EHS department (51%); followed by quality department (20%); operations department (11%); 'others' category (7%) which comprised of human resource, industrial engineer and general affairs; engineering department (4%); product design and warehouse / logistics department (4%); planning department (1%); and president's office (1%). Table 4.3 also revealed that 44 representatives (49%) had more than 11 years of experience in the organisation. The frequency distribution for length of service is skewed slightly to the left, indicating that most respondents are qualified to a certain level.

4.6 Dealing with Missing Data

SPSS Missing Value Analysis module was used to verify the severity of missing data. Based on Figure 4.8, 75.28 percent of cases were available for complete case analysis and 5.94 percent of values for items in the multidimensional constructs were missing.

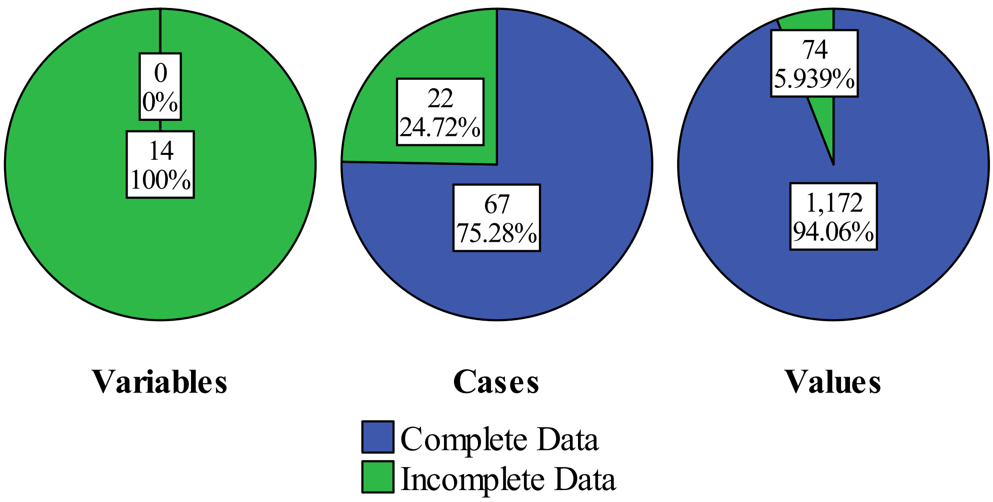


Figure 4.8
Overall Summary of Missing Values

There are various approaches for handling missing data and Table 4.4 provides a summary of means and standard deviations for data that are handled by means of listwise deletion, utilise all values and single imputation based on expectation maximisation (EM). In the event of listwise deletion, 22 cases equivalent to 24.72 percent of data must be excluded from analysis and this may reduce the statistical power of regression analysis significantly. Compared to other approaches, the mean for some dimensions in listwise deletion is relatively smaller but the standard errors were relatively higher. SPSS provides single imputation through maximum likelihood approach where the advantage of single imputation is that no missing values are present for multivariate data analysis. This approach should be avoided due to risks of underestimating standard errors and overestimating the statistical power associated with uncertainties of 'made up' data (Johnson & Young, 2011).

Table 4.4

Summary of Means and Standard Deviations for Listwise, All Values and Expected Maximisation Statistics

Variables	Listwise		All Values		EM*	
	μ	σ	M	σ	μ	Σ
Green Product Design[1]	3.35	0.84	3.46	1.00	3.49	1.00
Design for Disassembly	3.04	1.01	3.12	1.01	3.17	1.01
Design for Environment	3.96	0.87	4.04	0.82	4.05	0.82
Design for Recycling	3.06	1.20	3.21	1.18	3.25	1.18
Resource Commitment[2]	3.29	0.94	3.41	0.95	3.41	0.95
Reverse Logistics						
Product Disposition[1]	2.99	1.10	3.05	1.09	3.06	1.08
Repair	3.34	1.06	3.46	1.05	3.45	1.04
Recondition	2.75	1.15	2.77	1.19	2.82	1.18
Remanufacture	2.40	1.16	2.42	1.17	2.45	1.14
Recycle	2.67	1.07	2.71	1.04	2.71	1.04
Disposal	3.79	1.05	3.87	1.01	3.86	1.01
Business Performance[3]	3.38	0.90	3.33	0.94	3.34	0.94
Environmental Outcome	3.91	0.75	3.88	0.80	3.89	0.80
Profitability	3.10	0.94	3.10	0.94	3.11	0.94
Sales Growth	3.13	1.01	3.01	1.07	3.03	1.07
Institutional Pressure[4]	3.45	0.84	3.40	0.86	3.41	0.86
Regulatory Pressure	3.82	0.74	3.80	0.77	3.80	0.77
Ownership Pressure	3.07	0.93	3.00	0.95	3.01	0.95

*Little's MCAR test: Chi-Square = 220.570, DF = 198, Sig. = .130

Note: Items are measured based on following scale;

1. 1=Very low extent of existent; 5=Very high extent of existence
2. 1=No investment; 5 =Substantial investment
3. 1=No significant business benefits; 5=Significant business benefits
4. 1=Very low extent of influence; 5=Very high extent of influence

The EM estimated data are tried on Little's MCAR test, where the null hypothesis denoted that data is missing completely at random (MCAR). Based on Table 4.4, the significant value of Little's test is 0.130 ($p > 0.05$) and this denoted that the null hypothesis cannot be rejected and this confirmed that data is MCAR. According to Acock (2005), listwise deletion approach is recommended for MCAR data as it minimises the effect of biased parameter estimates and standard errors. However, reducing the sample size to 67 by omitting 22 cases would incur substantial loss of data and this potentially disrupts the results of linear regression analyses. As such, pairwise deletion is an optimum strategy that utilise all available data to estimate the covariance between two pairs of dimensions and/or variables.

The mean and standard deviation statistics for "All Values" in Table 4.4 were in fact, descriptive statistics for the variables used in this study. As all values were utilised, multivariate normality was assessed by estimating the Mahalanobis measure (D^2). D^2 observes the distances of each observation from the mean value for all observations of a set of variables (Hair et al., 2010). For the first model where reverse logistics product disposition was the dependent variable, the maximum value of Mahalanobis distance is 13.302 and this was lower than the critical value, 20.515, a value obtained from chi-square distribution table where alpha is 0.001. For the second model, where business performance was the dependent variable, Mahalanobis distance is 16.418 and this was slightly higher that the critical value of 16.266. Based on Warner's (2008) suggestions, multivariate outliers were not a major concern because Figure 4.9 and Figure 4.10 showed that the histograms of standardised residuals z scores (i.e. bell-shaped distribution) looked relatively normal and predicted *y*-scores were within the acceptable range of -3 and +3.

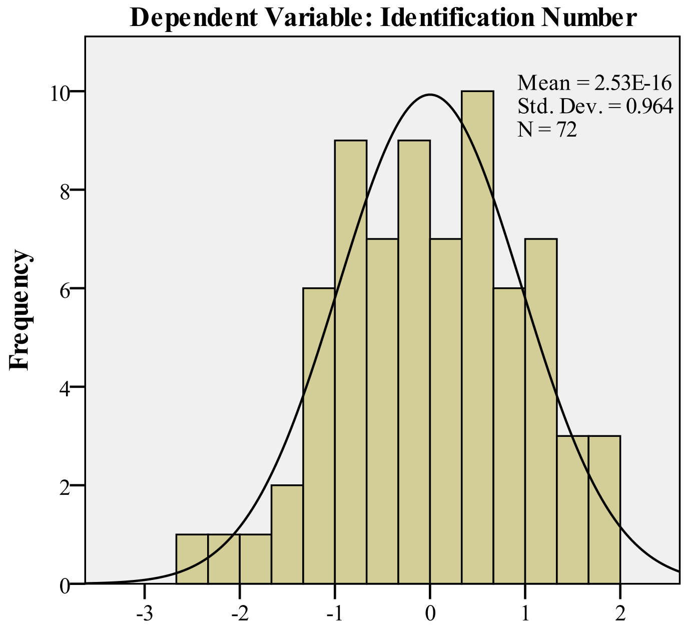


Figure 4.9
Histogram of Standardised Residual (DV: Reverse Logistics)

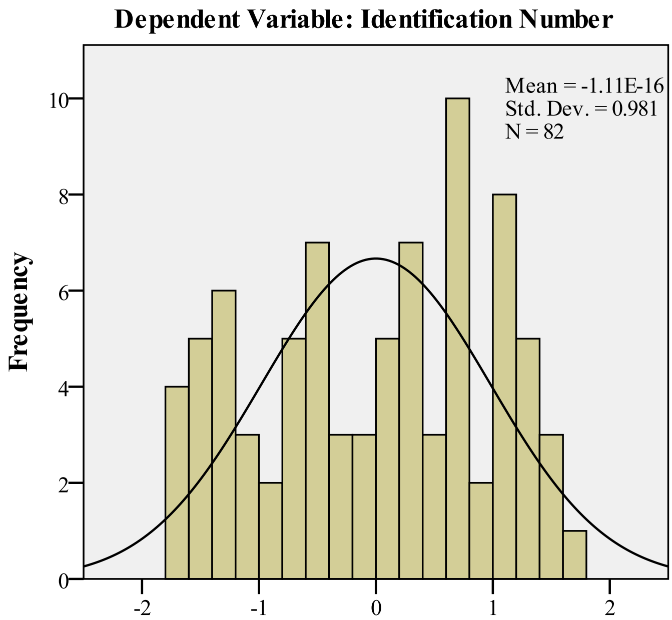


Figure 4.10
Histogram of Standardised Residual (DV: Business Performance)

4.7 Goodness of Measure

Prior to subsequent multivariate analyses, the goodness of measures of this study is analysed through factor analysis and reliability test. The results of both tests are discussed in the following sections.

4.7.1 Factor Analysis

The main purpose for conducting factor analysis is to identify underlying dimensions within the variables under study. The principal component analysis method is used to extract data and the Varimax rotation technique is applied to interpret the factor matrix. Factor analysis detects pattern of variations and develops factors (dimensions) where scale items that loads on each factors is highly intercorrelated with one another (Babbie, 1990; Coakes & Steed, 2007; Pallant, 2007). This process of generating multidimensional constructs is also identified as data reduction approach, which simplifies the items of a variable and eliminates items that disrupt the accuracy of predicted attributes. Note that the generation of items to the factors are based on empirical association and each factor is presumably independent of one another.

Although the general rule of thumb to determine sample size for factor analysis is ten observations for each variable, Hair et al. (2010) recommended that obtaining higher cases-per-variable ratio optimises the generalisability of data. Studies have proven that the role of sample size is not as imminent when higher communalities among items are observed. According to MacCallum, Widaman, Zhang, and Hong (1999), they pointed out that the effect of sample size is further minimised with smaller number of factors. These trade-offs motivated Hair et al. (2010, p. 117) to recommend the value of significant factor loading across size of samples for interpreting the underlying structure of a variable. Although the respondents-to-variable ratio for this study is 17.8:1, some items appeared to have low communality and/or cross-loads on several factors. Therefore, the value of significant factor loading is determined to assist the interpretation of common themes in variables. Note that items that are clustered through procedures based the judgements of themes but do not warrant interpretability or validity of themes (Hammersley, 2008). Upon consideration on effect of sample size, items with loading less than 0.587 are ruled out as insignificant. Prior to interpreting the rotated component matrix, the results of factor analysis must satisfy Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity. The minimum acceptable value for KMO statistics is 0.5 and the higher the value is, the greater the confidence there is for adequacy of sample size (Field, 2009). The results of Bartlett's test should also be significant ($p < 0.001$) to ascertain that correlation matrix is not an identity matrix. When above mentioned statistics are met, factors with eigenvalue greater than 1 are construed. The acronyms for the derived factors are enlisted at Table 4.5.

Table 4.5
Acronyms for Variable and Dimensions

Variable	**Variable Acronym**	**Dimension**	**Dimension Acronym**
Green Product Design	GPD	Design for Disassembly Design for Environment Design for Recycling	DfD DfE DfR
Resource Commitment	RC	Resources	RC
Reverse Logistics Product Disposition	RLPD	Repair Recondition Remanufacture Recycle Disposal	-as is-
Business Performance	BP	Environmental Outcome Profitability Sales Growth	ENV PRO SG
Institutional Pressure	IP	Regulatory Pressure Ownership Pressure	PR PW

4.7.2 Factor Analysis: Green Product Design

Green product design is composed of two dimensions, namely design for disassembly (12 items) and design for recycling (10 items). The value of KMO measure of sampling adequacy is relatively good at 0.816 and Bartlett's test is significant at $p < 0.001$. The cumulative variance contributed by all three factors is 69.81 percent, exceeding the minimum value of 60 percent recommended by Hair et al. (2010). Results of the factor analysis presented three factors instead of two factors and three items were deleted because loadings were lower than 0.587. The items in design for recycling defined an additional theme and the emerging theme is named as 'design for environment'. One item belonging to design for disassembly (DfD01) is deleted due to high cross-loading on two factors (> 0.45) and two items of design for recycling (DfR08 and DfR09) are deleted due to cross-loading on three factors. Generally, loading of 0.4 explains 16 percent of variance in the dimension (Stevens, 2002) and item with significant loading will be chosen to represent the dimension in the event of cross-load. Additionally, logical judging on the wordings of scale item, also known as face validity method, is recommended when assigning item to corresponding dimension (Ho, 2006). Table 4.6 presents the rotated component matrix for green product design and the detailed result can be seen in Appendix C1.

Table 4.6
Factor Analysis for Green Product Design

Scale	Description of Items	Factors		
		1	2	3
DfD05	Design products that minimise the number of fasteners.	0.857		
DfD02	Design products that use modular components.	0.838		
DfD07	Design products that ease accessibility of joining elements.	0.829		

Table 4.6 *(Continued)*

DfD09	Design products that protect joining elements from corrosions and wear.	0.815		
DfD03	Design products that use snap fits in lieu of screws.	0.773		
DfD11	Design products that consider the weight, shape and size of structure for disassembly.	0.725		
DfD10	Design products that minimise the amount of force (or torque) required for disengaging parts or components.	0.703		
DfD08	Design products that avoid use of special tools or destructive disassembly techniques to disassemble joints.	0.696		
DfD04	Design products that avoid use of weld or adhesive.	0.672		
DfD06	Design products that ease accessibility of valuable components/materials.	0.661		
DfD12	Design product with clear identification of parts or components to facilitate disassembly.	0.639		
DfR02	Use raw materials that are compliant with environmental protection regulations.		0.872	
DfR04	Design of products to avoid or substitute the use of hazardous substances.		0.841	
DfR03	Design of products that reduce consumption of materials.		0.818	
DfR01	Use pollution-free raw materials in production.		0.808	
DfR10	Design packaging that is recyclable.		0.588	
DfR06	Design of products to allow use of recycled subassemblies or components.			0.894
DfR07	Design products that cluster materials to utilise their compatibility.			0.819
DfR05	Design of products to allow use of recycled materials.			0.813
Eigenvalues		9.184	2.446	1.633
Variance		48.34%	12.87%	8.60%
KMO and Bartlett's Test				
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.				0.816
Bartlett’s Test of Sphericity		Approx. Chi-Square		1098.14
		df		171
		Sig.		.000

Note: Items’ loading less than 0.40 are not displayed.

4.7.3 Factor Analysis: Resource Commitment

Resource commitment is a unidimensional variable that is measured by 3 items. The results of principal component analysis revealed that no rotation is required. KMO measure of sampling adequacy is good at 0.740 and Bartlett's test is significant ($p < 0.001$). Initial eigenvalue for the measurement items is 2.528 and they explained 84.28 percent of variance in the variable. Analysis on the scree plot revealed that the graph deflected after the first factor. Given that only single component is extracted, the summary of factor analysis in Table 4.7 presents the loadings of items and detailed results can be found in Appendix C2.

Table 4.7
Factor Analysis for Resource Commitment

<table>
<tr><th>Scale</th><th>Description of Items</th><th colspan="2">Factor</th></tr>
<tr><td>RC01</td><td>Technological resource commitment to reverse logistics.</td><td colspan="2">0.939</td></tr>
<tr><td>RC02</td><td>Managerial resource commitment to reverse logistics.</td><td colspan="2">0.912</td></tr>
<tr><td>RC03</td><td>Financial resource commitment to reverse logistics.</td><td colspan="2">0.903</td></tr>
<tr><td colspan="2">Eigenvalues</td><td colspan="2">2.528</td></tr>
<tr><td colspan="2">Variance</td><td colspan="2">84.28%</td></tr>
<tr><th colspan="4">KMO and Bartlett's Test</th></tr>
<tr><td colspan="3">Kaiser-Meyer-Olkin Measure of Sampling Adequacy.</td><td>0.740</td></tr>
<tr><td colspan="2" rowspan="3">Bartlett's Test of Sphericity</td><td>Approx. Chi-Square</td><td>169.88</td></tr>
<tr><td>df</td><td>3</td></tr>
<tr><td>Sig.</td><td>.000</td></tr>
</table>

4.7.4 Factor Analysis: Reverse Logistics Product Disposition

Reverse logistics product disposition variable is composed of five dimensions such as repair (6 items), recondition (8 items), remanufacture (8 items), recycle (11 items) and disposal (6 items). Data reduction is conducted using principal component analysis extraction method and Varimax orthogonal rotation technique. The KMO measure of sampling adequacy is high, at 0.827, and Bartlett's test of sphericity is significant. Five components were extracted because initial eigenvalues exceeded 1 and the composite explained 76.31 percent of variance in the variable. The communalities averaged at 0.763 and the range of values is 0.415 to 0.924. According to Field (2009) and Hair et al. (2010), they suggested that item with loading less than 0.587 are insignificant for a sample size of 89. Henceforth, items with loading less than the abovementioned value are excluded to aid interpretation of factors. For this variable, five items were deleted as three items (i.e. Disposal01, Disposal02 and Repair06) cross-loaded on three distinct factors whereas two items (i.e. Recyling10 and Recycling11) reported insignificant loading. Table 4.8 presents the rotated component matrix for RLPD and detailed results is enlisted in Appendix C3.

Table 4.8
Factor Analysis for Reverse Logistics Product Disposition

Scale		Description of Items	Factors				
			1	2	3	4	5
Remanufacture	05	Remanufacture involves product upgrade up to as-new quality level.	0.856				
	07	Remanufacture is the work of building a new product on the base of a used product.	0.840				
	03	Remanufacture inspects all modules and parts in the product.	0.838				
	04	Remanufacture involves disassembly up to part level.	0.828				
	02	Remanufacture is the work for returning product to at least OEM original performance specification.	0.802				
	06	Warranty for remanufactured product is highest compared to other disposition options.	0.800				
	01	This strategy involves collecting used products from customers for remanufacturing.	0.774				
	08	Suppliers are required to collect back remanufacturable product.	0.763				
Recondition	06	Recondition involves disassembly up to module level.		0.838			
	02	Recondition is the work for returning used product to a satisfactory working condition.		0.837			
	05	Recondition replaces all major components that have failed or that are on the point of failure.		0.803			
	03	Recondition inspects critical modules in the product.		0.797			
	04	Recondition extends functional use of the product.	0.429	0.790			
	01	This strategy involves collecting used product from customers for reconditioning.		0.773			
	07	Recondition involves product upgrade within specified quality level.		0.751			
	08	Warranty for reconditioned product is less when compared to remanufactured product.		0.702			
Recycling	05	Recycling procedures reduce the amount of energy required for extracting virgin material.			0.814		
	03	Procedures for recycling have been established.			0.811		

Table 4.8 *(Continued)*

	08	Recycle involves disassembly up to material level.			0.751		
	04	Procedures for handling hazardous materials for end-of-life products have been established.			0.723		
	06	Material recycling is the re-melt of materials to make new products.			0.722		
	07	Energy recycling is the extraction of heat from burning materials.			0.717		
	01	This strategy involves collecting used products from customers for recycling.			0.677		
	09	Recycle involves reusing materials from used products and components.			0.673		
	02	This strategy involves collecting used packaging from customers for recycling.			0.598		
Repair	02	Repair restore product to working order.				0.869	
	01	Repair is the correction of faults in a product.				0.829	
	04	Repair replaces broken parts that have failed.				0.806	
	05	Repair involves disassembly at product level.				0.722	
	03	Repair prolongs the product's lifecycle.				0.662	
Disposal	06	Disposal involves appropriate treatment of waste.					0.935
	05	Disposal involves appropriate dumping of waste.					0.907
	04	Disposal involves appropriate storage of waste.					0.821
	03	The amount of waste for disposal is minimised.					0.793
Eigenvalues			15.36	3.84	2.88	2.10	1.77
Variance			45.2%	11.3%	8.48%	6.17%	5.22%
KMO and Bartlett's Test							
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.						0.827	
Bartlett's Test of Sphericity			Approx. Chi-Square			2618.65	
			df			561	
			Sig.			.000	

Note: Items' loading less than 0.40 are not displayed.

4.7.5 Factor Analysis: Business Performance

Business performance is a multidimensional construct that is represented by environmental outcome (8 items), profitability (8 items) and sales growth (8 items). The results of principal component analysis with Varimax rotation revealed that KMO measure of sampling adequacy is 0.793 and Bartlett's test is significant at $p < 0.001$. Communalities averaged at 0.650 and all three factors extracted contribute 64.98 percent of variance to the variable. The results below are obtained after SG01 was deleted due to high cross-loadings on two factors. Due to the effect of small sample size, only loading greater than 0.587 or explain 34.5 percent of variance in a dimension are considered significant for interpretation. Table 4.9 summarises the results and further details are presented in Appendix C4.

Table 4.9
Factor Analysis for Business Performance

Scale		Description of Items	Factors		
			1	**2**	**3**
Profitability	05	Significant reduction in the cost for purchasing raw materials, components or subassemblies.	0.857		
	04	Significant reduction in cost of goods sold for recovered products.	0.817		
	08	Significant reduction in cost for waste disposal.	0.804		
	01	Significant improvement in revenue from after sale services.	0.766		
	02	Significant improvement in reclaiming reusable products.	0.752		
	07	Significant reduction in cost for waste treatment.	0.727		
	03	Significant reduction in inventory investment.	0.726		
	06	Significant reduction in the cost of packaging.	0.655		
Outcome	02	Significant reduction of waste water pollution.		0.851	
	05	Minimal occurrence in environmental accidents i.e. spills.		0.826	
	03	Significant reduction of solid waste generation.		0.795	

Table 4.9 *(Continued)*

Environmental	06	Minimal occurrence in fines or penalties pertaining improper waste disposal.		0.768	
	01	Significant reduction of air emission.		0.761	
	08	Significant improvement in commitment towards environmental management standards or practices.		0.729	
	04	Significant reduction of hazardous waste consumption.		0.651	
	07	Recognition or reward for superior environmental performance.		0.604	
Sales Growth	08	Significant improvement in sales growth.			0.868
	06	Significant improvement in relationship with customer to encourage repeat buyers.			0.834
	07	Significant improvement in corporate environmental reputation among environmentally conscious customers.			0.784
	05	Significant improvement in market share.			0.758
	03	Significant improvement in sales of new products through price discounts.			0.732
	04	Significant improvement in sales of new technologies by means of trade-in programs.			0.728
	02	Significant improvement in sales of used product at secondary market.	0.437		0.700
Eigenvalues			8.804	3.532	2.609
Variance			38.28%	15.36%	11.34%
KMO and Bartlett's Test					
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.					0.793
Bartlett's Test of Sphericity			Approx. Chi-Square		1343.55
			df		253
			Sig.		.000

Note: Items' loading less than 0.40 are not displayed.

4.7.6 Factor Analysis: Institutional Pressure

Institutional pressure variable presents two dimensions which is regulatory pressure (9 items) and ownership pressure (6 items). Principal component analysis extraction method and Varimax rotation technique is applied for factor analysis. Value of Kaiser's MSA is relatively good at 0.783 and Bartlett's test is significant at $p < 0.001$. Table 4.10 presents the results of rotated component matrix based on two factors computation and they contribute 62.01 percent of variance to the variable. Only PR03 was deleted due to insignificant loading value of below 0.587 and further details can be found in Appendix C5.

Table 4.10
Factor Analysis for Institutional Pressure

Scale		Description of Items	Factor 1	Factor 2
Regulatory Pressure	08	Environmental regulations present risk related to penalties due to non-compliance.	0.870	
	04	My firm's parent company sets strict environmental standards for my firm to comply with.	0.795	
	07	Environmental regulations present risk related to unacceptable product impacts.	0.771	
	06	Environmental regulations are important influence to the environmental practices of my firm.	0.767	
	01	By taking back products, my firm tries to reduce or avoid the threat from current environmental regulations.	0.716	
	02	By taking back products, my firm tries to reduce or avoid the threat of future environmental regulations.	0.715	
	09	Environmental regulations present risk related to banning or restriction of raw materials.	0.693	
	05	There are frequent government inspections or audits on my firm to ensure that the firm is in compliance with environmental laws and regulations.	0.651	
Ownership Pressure	03	Risk of difficulties in raising new capital or attracting new investors.		0.823
	04	Risk of lower share price due to shareholders' investment withdrawal.		0.806
	02	Risk of shareholder concerns when the company does not achieve environmental goals.		0.794
	01	Risk of shareholder discontent with environmental fines which lower profits.		0.726

Table 4.10 *(Continued)*

	06	Financial incentives offered by international organisations, such as United Nations, are significant motivators for my firm to implement reverse logistic.		0.688
	05	Financial incentives offered by the Malaysian government, such as grants and tax reductions, are significant motivators for my firm to adopt reverse logistic product disposition.		0.659
Eigenvalues			6.385	2.296
Variance			45.61	16.40
KMO and Bartlett's Test				
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.				0.783
Bartlett's Test of Sphericity			Approx. Chi-Square	912.079
			df	91
			Sig.	.000

Note: Items' loading less than 0.40 are not displayed.

4.7.7 Reliability Analysis

The reliability of a variable depends on how well the measurement items generate consistent results (Hair et al., 2010; Zikmund, 1991). The internal consistency of measurement items are assessed based on reliability coefficient, also known as Cronbach's alpha, where values above 0.70 are accepted (Nunnally, 1978) and if otherwise, the item that will improve Cronbach's alpha when deleted is identified. For this study, the reliability coefficients for all measurement items that exemplify the dimensions generated by factor analysis were well above 0.850. Therefore, no items were deleted during reliability analysis and Table 4.11 provides a summary of the results whereas detailed information of the analysis can be found in Appendix D.

Table 4.11
Summary of Reliability Analysis

Variables and Dimensions	No. of Items	Cronbach's Alpha
Green Product Design		
Design for Disassembly	11	0.943
Design for Environment	5	0.863
Design for Recycling	3	0.912
Resource Commitment	3	0.907
Reverse Logistics Product Disposition		
Repair	5	0.899
Recondition	8	0.959
Remanufacture	8	0.969
Recycle	9	0.897
Disposal	4	0.896
Business Performance		
Environmental Outcome	8	0.903
Profitability	8	0.920
Sales Growth	7	0.922
Institutional Pressure		
Regulatory Pressure	8	0.904
Ownership Pressure	6	0.873

4.8 Descriptive Analysis

Descriptive analysis is conducted to gather overall responses on the final dimensions of variables understudy. Mean and standard deviation statistics for antecedents and outcome of reverse logistics product disposition, as well as moderating variable, are presented in Table 4.12. Responses to all the dimensions for each variable examined in this study were collected on a five-point scale.

As shown in Table 4.12, design for environment ($\mu = 4.04$, $\sigma = 0.82$) was the most regular application of green product design. This indicated that reducing consumption of hazardous material, avoid and/or substitute use of hazardous substances, and other environmentally conscious design attributes related to choice of material are important factors in developing greener products. Firms allocated some degree of resource ($\mu = 3.41$, $\sigma = 0.95$) for developing RLPD capabilities. In terms of reverse logistics product disposition, repair ($\mu = 3.46$, $\sigma = 1.05$) is the most applied product recovery option implemented by E&E manufacturing firms whereas remanufacturing ($\mu = 2.42$, $\sigma = 1.17$) exhibited low to moderate extent of existence thus indicating that remanufacturing is not a common practise. In terms of the business performance derivable from reverse logistics, respondents have indicated that environmental outcome ($\mu = 3.88$, $\sigma = 0.80$) is a relatively significant business benefit whereas profitability ($\mu = 3.10$, $\sigma = 0.94$) and sales growth ($\mu = 3.01$, $\sigma = 1.07$) are both significant only to a certain degree. On the other hand, regulatory pressure ($\mu = 3.80$, $\sigma = 0.77$) exert moderately high influence to firm’s practices and legislative requirements are more influential than owner’s interest ($\mu = 3.00$, $\sigma = 0.95$) in inducing firms to adopt specific processes.

Table 4.12
Mean Score and Standard Deviations of Variables

Variables and Dimensions	Mean	Standard Deviation
Green Product Design		
Design for Disassembly	3.12	1.01
Design for Environment	4.04	0.82
Design for Recycling	3.21	1.18
Resource Commitment	3.41	0.95
Reverse Logistics Product Disposition		
Repair	3.46	1.05
Recondition	2.77	1.19
Remanufacture	2.42	1.17
Recycle	2.71	1.04
Disposal	3.87	1.01
Business Performance		
Environmental Outcome	3.88	0.80
Profitability	3.10	0.94
Sales Growth	3.01	1.07
Institutional Pressure		
Regulatory Pressure	3.80	0.77
Ownership Pressure	3.00	0.95

4.9 Modified Research Framework

Based on factor analysis and reliability testing, Figure 4.11 presents a modified research framework to illustrate the relationships between multidimensional constructs of this study. There are some amendments to the number of items that measured the multidimensional constructs. Ten items, equivalent to 9.7 percent of items were deleted, and ninety three (93) items remained for multivariate analysis. The most significant modification concerned green product design where the items intended for design for recycling measured an additional theme, also known as design for environment. Nevertheless, green product design and resource commitment are analysed as antecedents to reverse logistics product disposition and business performance as the outcome is moderated by institutional pressure.

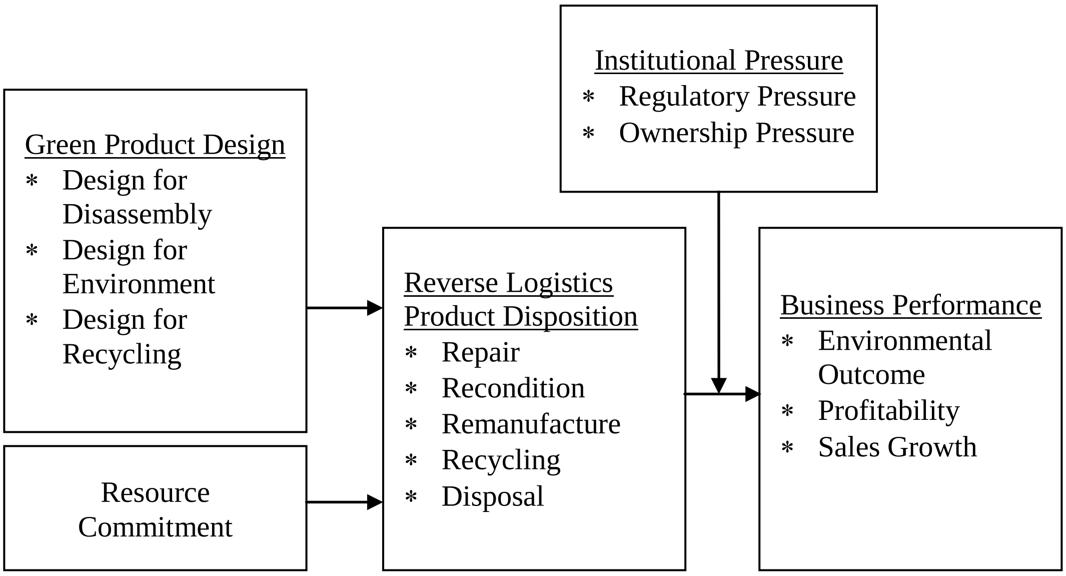


Figure 4.11
Modified Research Framework

4.10 Restatement of Hypotheses

Based on modified research framework, four hypotheses for testing the antecedents and outcome of reverse logistics product disposition are listed as follow;.

H1. Green product design has a significant relationship with reverse logistics product disposition.

H1a. Design for disassembly has a significant relationship with reverse logistic product disposition.

H1b. Design for environment has a significant relationship with reverse logistic product disposition.

H1c. Design for recycling has a significant relationship with reverse logistic product disposition.

H2. Resource commitment has a significant relationship with reverse logistics product disposition.

H3. Reverse logistics product disposition has a significant relationship with business performance of reverse logistics.

H3a. Repair has a significant relationship with business performance.

H3b. Recondition has a significant relationship with business performance.

H3c. Remanufacture has a significant relationship with business performance.

H3d. Recycle has a significant relationship with business performance.

H3e. Disposal has a significant relationship with business performance.

H4. Institutional pressure has significant moderating effect on the relationship between reverse logistics product disposition and business performance.

H4a. Regulatory pressure moderates the relationship between RLPD and environmental outcome.

H4b. Regulatory pressure moderates the relationship between RLPD and profitability.

H4c. Regulatory pressure moderates the relationship between RLPD and sales growth.

H4d. Ownership pressure moderates the relationship between RLPD and environmental outcome.

H4e. Ownership pressure moderates the relationship between RLPD and profitability.

H4f. Ownership pressure moderates the relationship between RLPD and sales growth.

4.11 Pearson's Correlation Analysis

Prior to hypotheses testing, Pearson's product-moment correlation test is performed to examine the association of two metric variables. Positive correlation coefficient, r, represents direct association between variables whereas a negative value indicates that the variables are inversely associated (Hair et al., 2010). When r value is zero, the variables are not associated to one another. According to Cohen (1988), the strengths of correlations are categorised as small ($r = 0.10$ to 0.29), medium ($r = 0.30$ to 0.49) and large ($r = 0.50$ to 1.00). Table 4.13 and Table 4.14 present the summary of two-tailed Pearson's product-moment correlation for two dependent variables; (1) reverse logistics product disposition; and, (2) business performance, respectively.

These tests are preliminary analyses to identify the presence of interrelationships between dimensions of variables. For the variables in Hypothesis 1, dimensions of GPD have significant positive relationship with dimensions of RLPD where the strength of correlations are; medium to strong range ($0.313 \leq r \leq 0.704$) for design for disassembly (DfD) and dimensions of RLPD, weak to strong range ($0.290 \leq r \leq 0.525$) for design for environment (DfE) and dimensions of RLPD, and medium range ($0.344 \leq r \leq 0.443$) for design for recycling (DfR) and dimensions of RLPD. In comparing the strength of relationships between dimensions of GPD and RLPD, the correlation coefficient between DfD and RLPD is strongest compared to other dimensions of GPD.

For the variables and dimensions in Hypothesis 2, the correlation between resource commitment and RLPD dimensions is positive and significant for recycle ($r = 0.221$, $p < 0.05$) and disposal ($r = 0.356$, $p < 0.001$) whereas resource commitment shares positive but insignificant correlation with repair, recondition and remanufacture. For

Hypothesis 4, although regulatory pressure only correlates significantly with repair ($r = 0.241$, $p < 0.05$) and disposal ($r = 0.440$, $p < 0.001$), the remaining dimensions of RLPD correlates with ownership pressure at moderate strength. In fact, Baron and Kenny (1986) recommended that moderator shares no significant correlation with predictor (RLPD) and criterion (BP) variable so that the effect of interaction term can be interpreted with minimal interventions. With reference to Table 4.14, there are significant positive correlations shared between institutional pressure (IP) and business performance (BP) at dimensional level ($0.318 \leq r \leq 0.476$, $p < 0.01$).

Table 4.13
Pearson's Product-Moment Correlation (Dependent Variable: RLPD)

Hypothesis	**Independent Variable**	**Dependent Variable (Reverse Logistics Product Disposition)**				
		Repair	**Recondition**	**Remanufacture**	**Recycle**	**Disposal**
H1	Design for Disassembly	0.704***	0.559***	0.552***	0.530***	0.313**
	Design for Environment	0.428***	0.301**	0.203†	0.290**	0.525***
	Design for Recycling	0.443***	0.364**	0.344**	0.423***	0.197†
H2	Resource Commitment	0.092	0.142	0.067	0.221*	0.356***
H4	Regulatory Pressure	0.241*	0.169	0.133	0.175	0.440***
	Ownership Pressure	0.183†	0.315**	0.338**	0.360***	0.103

Significant levels (2-tailed): ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; †$p < 0.10$

Results of correlation test imply association between variables but do not necessarily indicate a causation relationship (Zikmund, 1991). For the variables and dimensions in Hypothesis 3, all dimensions of RLPD, excluding disposal, are positively correlated with profitability at medium strength ($0.398 \leq r \leq 0.437$, $p < 0.001$). This initial evidence proved that investing in product recovery may turnaround and profit as Table 4.14 also revealed that sales growth in ISO 14001 certified E&E companies, is correlated with the presence reconditioning and remanufacturing activities. On the contrary, only disposition options such as recycle and disposal is positively correlated with environmental outcome at 95 percent confidence level. For the purpose of hypotheses testing, correlation analysis has pointed out possible causal relations and linear regression will analyse the predictive power between the variables in the following sections. The correlation matrix of multidimensional constructs is presented in Appendix E.

Table 4.14
Pearson's Product-Moment Correlation (Dependent Variable: BP)

Hypothesis	**Independent Variable**	**Dependent Variable (Business Performance)**		
		Environmental Outcome	**Profitability**	**Sales Growth**
H3	Repair	0.041	0.417***	0.079
	Recondition	0.174	0.398***	0.249*
	Remanufacture	0.183	0.401***	0.458***
	Recycle	0.260*	0.437***	0.160
	Disposal	0.271*	0.113	0.024
H4	Regulatory Pressure	0.348***	0.458***	0.318**
	Ownership Pressure	0.330**	0.462***	0.476***

Significant levels (2-tailed): ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; †$p < 0.10$

4.12 Linear Regression Analysis

Multiple regression analysis was used to test the hypotheses in regards to antecedents and outcome of reverse logistics product disposition (RLPD). Hierarchical regression analysis was applied for testing the influence of institutional pressure on business performance of RLPD. Prior to requesting regression analyses, the assumptions on multicollinearity, normality, linearity, homoscedasticity and independence of error terms were assessed concurrently. Multicollinearity referred to the extent of correlation between independent variables and this aspect was measured based on value of tolerance and variance inflation factor (VIF). Value lesser than 0.1 for tolerance and more than 10.0 for VIF indicated presence of problems associated with multicollinearity. As all independent variables had tolerance greater than 0.40, multicollinearity did not create issues to this study. For outliers and multivariate normality, Figure 4.9 and Figure 4.10 in Section 4.6 were regression standardised residuals for RLPD and BP. Both figures showed bell-shaped normal distribution where standardised residuals (z-scores) were within the range of -3.0 and +3.0 (Warner, 2008), indicating that there was no significant presence of outlier.

Appendix F1-F8 presented the results of multiple regression analyses which included charts on Histogram, Scatterplot, Normal P-P Plot of Regression Standardised Residual and Partial Regression Plot. Data transformation is advised when significant departures or deviations are detected. Compared to histogram and scatterplot, normal probability plots was more feasible for assessing normality in small sample size where cumulative standardised residuals line ought to follow the diagonal line of cumulative normal distribution (Hair et al., 2007) to meet the normality assumption (p. 72). The residual plots in appendix F1-F5 were relatively close to the diagonal lines without substantive departures, indicating that the distribution of data fulfils the assumptions of normality. Unlike Normal P-P Plot, Scatterplot combined residuals from several independent variables and data that are distributed in resemblance with a rectangle along the centre area of the plot, without curvilinear or horse-shoe data pattern (Tabachnick & Fidell, 1983) to indicate no serious violation to linearity. Partial regression plots are recommended to analyse the relationship between independent and dependent variables. When effects of other independent variables are controlled, the examination of plots in appendix F1-F8 revealed that data pattern have no obvious curvilinear relationship and the assumptions on linearity and homoscedasticity are met. In terms of independence of adjacent error terms, Ho (2006) recommended that the Durbin-Watson statistics should be within the acceptable range of 2.00 ± 0.50.

In terms of sample size, Field (2009) recommended that the formulae to estimate ideal size as 10 to 15 observations per predictor variable whereas Hair et al. (2010) recommended minimum case-to-variable ratio of 5:1. Generally, larger sample size is preferred and extensive efforts were taken to increase the response rate for improving the reliability of linear regression analyses. When RLPD is the outcome variable, the antecedents are composed of two variables where one of them has three dimensions. As soon as RLPD becomes predictor variable, five dimensions are regressed against outcome variable. For both models, the size of sample size exceeded the minimum ratio suggested by Hair. Green (1991, as cited in Field, 2009, p. 222) suggested two rules of thumb to determine minimum sample size based on two regression objectives, that is to test overall model fit or to test the individual predictors. Sample size of 89 for this study fulfils the Green's first formula ($50 + 8k$, where k is the number of predictors) but fell short by approximately 20 percent for the second formula ($104 + k$). Nevertheless, inadequacy of sample size degrades the results but hardly invalidate the regression results. As there was no serious violation to the basic assumptions of regression analysis, multivariate analyses proceed to estimate the R square and standardised beta coefficients to test the contributions of predictors to the model.

Based on the work of Hackman and Oldham (1976) and Locke (1969), this study managed the multidimensional constructs by aggregating the ratings of underlying dimensions which measured the constructs. Similar to an earlier study by Skinner et al. (2008), who analysed RL disposition strategies in American automotive industry, this study conducted variable- and dimensional- level regression analyses. With reference to Table 4.15, GPD accounted for 54.5 percent of variance in RLPD ($F = 23.622$, $p < 0.001$), which subsequently becomes the predictor variable to account for 24.4 percent of variance in BP ($F = 6.944$, $p < 0.001$). To test hypothesis 4, the relationships between predictors (RLPD) and moderators (IP) towards outcome (BP) variables are influenced by significance of interaction terms. On overall, relationships at constructs level were statistically significant and the following subsections present results of; (i) multiple regression analyses, and (2) hierarchical regression analyses to test the moderating influence of institutional pressure, that is composed of regulatory and ownership pressure.

Table 4.15
Multiple Regression Analyses: Green Product Design, Resource Commitment, Reverse Logistics Product Disposition and Business Performance

Hypotheses	Independent Variable	Dependent Variable	R Square	ANOVA
H1	GPD	RLPD	0.545	23.622***
H2	RC	RLPD	0.103	2.342†
H3	RLPD	BP	0.244	6.704***
H4	IP	BP	0.373	12.348***

Significant levels: ***p < 0.001; **p < 0.01; *p < 0.05; †p < 0.10

4.12.1 Multiple Regression Analyses on the Relationship between Antecedent Variables and Reverse Logistics Product Disposition

A two-step hierarchical regression analysis was carried out to where the first prediction equation is comprised of control variable and the second prediction equation reanalysed the data with the inclusion of independent variables and their dimensions. Firm size is statistically controlled to analyse the true nature of relationships understudy (Eltayeb et al., 2010; Zhu & Sarkis, 2007) and the variance explained by control variable is reflected by size of difference between R^2 and R^2 change in Table 4.16. The table provided evidences on the influence of anteceding factors towards reverse logistics product disposition (RLPD). Without aggregating the dimensions of green product design, a series of regression analyses revealed that DfD positively influence repair ($\beta = 0.712$, $p < 0.001$), recondition ($\beta = 0.612$, $p < 0.001$), remanufacture ($\beta = 0.644$, $p < 0.001$) and recycle ($\beta = 0.399$, $p < 0.01$). The tests also showed that design for environment (DfE) has positive and significant influence on disposal ($\beta = 0.448$, $p < 0.001$) and repair ($\beta = 0.169$, $p < 0.10$). H1a and H1b are partially supported whereas H1c is not supported because design for recycling has no significant influence towards all the dimensions of RLPD. Despite the fact that resource commitment contributed negative beta coefficient to repair ($\beta = -0.148$, $p < 0.10$) but contributed positive beta coefficient to disposal ($\beta = 0.177$, $p < 0.10$), these evidences partially supported H2.

Table 4.16

Multiple Regression Analyses: Relationship between Green Product Design Dimensions and Resource Commitment with Reverse Logistics Product Disposition

Variables	Dependent Variables (Standardised Beta Coefficients)				
	Repair	**Recon-dition**	**Remanu-facture**	**Recycle**	**Disposal**
Step 1: Control Variable					
Small Firms	-0.129	-0.402*	-0.260	0.190	-0.082
Medium Firms	-0.048	-0.114	0.051	0.187	-0.039
Large Firms	-0.202	-0.397*	-0.272†	0.070	-0.036
Step 2: GPD					
DfD	0.712***	0.612***	0.644***	0.399**	0.126
DfE	0.169†	0.034	-0.055	0.036	0.448***
DfR	-0.034	-0.017	-0.013	0.129	-0.110
RC	-0.148†	-0.043	-0.068	0.121	0.177†
R^2	0.555	0.430	0.417	0.324	0.325
Adjusted R^2	0.508	0.367	0.353	0.254	0.255
R^2 Change	0.548	0.360	0.349	0.305	0.290
F Change	21.612***	9.952***	9.568***	7.561***	7.309***
F	11.916***	6.795***	6.537***	4.593***	4.676***
Durbin-Watson	2.074	1.926	2.221	2.260	1.713

Significant levels: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; †$p < 0.10$

Multicollinearity among independent variables in the regression models is measured using two criterions, where the cut-off value for (i) tolerance value is 0.10 and above, and (ii) variance inflation factor (1/Tolerance) is 10.0 and below (Hair et al., 2010). Multicollinearity is not a problem because the results of the regression analyses, as seen in Appendix F1-F5, showed that the value of multicollinearity criterions across all four independent variables are within the acceptable range of $0.547 \leq$ Tolerance ≤ 0.749 and $1.335 \leq$ Variance Inflation Factor ≤ 1.829.

4.12.2 Multiple Regression Analyses on the Relationship between Reverse Logistics Product Disposition and Consequent Variable

With reference to Table 4.15, aggregated RLPD explained 24.4 percent of variance in business performance (BP) and the F-statistic of the regression model is 6.704, significant at $p < 0.001$. Unlike Table 4.15, more detailed evidence on the influence of RLPD on firm's business performance is presented on Table 4.17.

When all five disposition activities are regressed against environmental outcome, the total variance explained by the model is 14.0 percent ($F = 1.345$, $p > 0.10$) and none of the dimensions of RLPD are significant predictors to the environmental aspects of reverse logistics business performance. Subsequently, when RLPD is regressed against profitability, the total variance explained by the model is 35.5 percent ($F = 4.543$, $p < 0.001$) where both repair ($\beta = 0.217$, $p < 0.10$) and recycling ($\beta = 0.280$, $p < 0.05$) were statistically significant predictors. Consequently, when RLPD are regressed against sales growth, the total variance explained by the model is 34.2 percent ($F = 4.292$, $p < 0.001$) and remanufacture was a unique and significant predictor where standardised beta, β is 0.647 ($p < 0.001$). On the other hand, recondition and disposal are disposition options that did not make any significant contribution to business performance of RLPD in all three regression models. As such, three hypotheses that are partially supported are hypothesis 3a, hypothesis 3c and hypothesis 3d whereas two hypotheses that are not supported are hypothesis 3b and hypothesis 3e. Table 4.17 summarises three regression models where business performance acts as the multidimensional outcome variable that comprised of environmental outcome, profitability and sales growth.

Table 4.17

Multiple Regression Analyses: Relationship between Reverse Logistics Product Disposition Dimension and Business Performance

Independent Variables	**Dependent Variables (Standardised Beta Coefficients)**		
	Environmental Outcome	**Profitability**	**Sales Growth**
Step 1: Control Variable			
Small Firms	-0.044	0.137	0.025
Medium Firms	-0.073	0.053	0.033
Large Firms	0.012	0.311†	0.351*
Step 2: RLPD			
Repair	-0.182	0.217†	-0.135
Recondition	0.093	0.211	-0.058
Remanufacture	0.080	0.081	0.647***
Recycle	0.200	0.280*	-0.062
Disposal	0.212	-0.129	-0.057
R^2	0.140	0.355	0.342
Adjusted R^2	0.036	0.277	0.262
R^2 change	0.131	0.324	0.261
F Change	2.013†	6.627***	5.244***
F	1.345	4.543***	4.292***
Durbin-Watson	2.2251	1.926	2.023

Significant levels: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; †$p < 0.10$

High correlation between independent variables creates multicollinearity issues. Based on the detailed regression results shown by Appendix F6-F8, multicollinearity is not a problem to the regression analyses between RLPD and dimensions of outcome variable because the value of multicollinearity criterions across all five independent variables are within the acceptable range of $0.408 \leq$ Tolerance ≤ 0.799 and $1.252 \leq$ Variance Inflation Factor ≤ 2.454.

4.12.3 Moderating Influence of Regulatory Pressure on Reverse Logistics Product Disposition and Business Performance

Hierarchical regression analysis (HRA) is conducted to analyse the moderating influence of regulatory pressure on the relationship between reverse logistics product disposition (RLPD) and business performance (BP). The hypotheses are tested based on four steps moderated HRA where; (i) control variable is regressed with dimensions of business performance, (ii) Step 2 involves the inclusion of RLPD dimensions as predictors, (iii) Step 3 involved the inclusion of institutional pressures, and (iv) two-way interaction terms are analysed in Step 4. Hence, three hierarchical regression models are developed to empirically test the influence of one moderating variable on all three dimensions of the outcome variable. If the interaction terms are significant, graphs of regression slopes that represented the relationships between predictor and outcome variable are developed to reflect the strength and direction of the interaction across value (or level) of the moderator (Frazier, Tix, & Barron, 2004).

<u>Business Performance: Environmental Outcome</u>

With reference to Table 4.18, the inclusion of control variable such as firm size in Step 1 did not contribute significant variance to firms' environmental outcome. Step 2 indicated that RLPD explained 14.0 percent of variation in environmental outcome but none of the dimensions are statistically significant predictor. When moderator is introduced at Step 3, regulatory pressure explained an additional 6.5 percent of variance and F Change is significant at $p = 0.024$. For Step 4, the total variance explained with the inclusion of interactions terms is 39.6 percent, where R^2 change is 19.0 percent and additionally, F Change is significant at $p = 0.005$.

Table 4.18

Hierarchical Regression Analysis: Moderating Influence of Regulatory Pressure on RLPD and Environmental Outcome of BP

Variables	Step 1	Step 2	Step 3	Step 4
Control Variable				
Small Firms	-0.087	-0.044	0.063	0.197
Medium Firms	-0.080	-0.073	-0.009	0.232
Large Firms	0.000	0.012	0.038	0.236
Independent Variables				
Repair		-0.182	-0.230	3.266**
Recondition		0.093	0.116	-3.313*
Remanufacture		0.080	0.078	0.282
Recycle		0.200	0.178	-0.850
Disposal		0.212	0.110	0.461
Moderator				
Regulatory Pressure			0.302*	0.652
Interactions				
Repair x Regulatory Pressure				-4.754***
Recondition x Regulatory Pressure				4.423*
Remanufacture x Regulatory Pressure				-0.378
Recycle x Regulatory Pressure				1.131
Disposal x Regulatory Pressure				-0.375
R^2	0.009	0.140	0.206	0.396
Adjusted R^2	-0.033	0.036	0.096	0.255
R^2 Change	0.009	0.131	0.065	0.190
F Change	0.218	2.013	5.347	3.784
Sig. F Change	0.884	0.088	0.024	0.005
F	0.218	1.345	1.869†	2.810**
Durbin-Watson	1.909			

Significant levels: ***p < 0.001; **p < 0.01; *p < 0.05; †p < 0.10

Only regression models from Step 3 and Step 4 are valid due to significant F-value at 1.869 ($p < 0.10$) and 2.810 ($p < 0.01$), respectively. Only two interaction terms are statistically significant in predicting environmental outcome of business performance. The interaction term between repair and regulatory pressure is significant where β value is -4.754 ($p < 0.001$). The other significant interaction term is recondition and regulatory pressure and β value is 4.423 ($p < 0.05$). Based on Sharma, Durand, and Gur-Arie (1981), they recommended that if significant interaction was found and moderator is not related to the outcome variable, the moderating variable is identified as a pure moderator. For this instance, regulatory pressure is a quasi moderator as it is related to environmental outcome. Durbin-Watson statistics was within acceptable range. Refer to Appendix G1 for more results of this analysis. Post-hoc test is conducted to illustrate the effect of significant interactions among groups that endure various levels of regulatory influences. In order to investigate the effects of continuous moderating variable, a dichotomous variable is created for regulatory pressure by using median as the cut-off point to categorise groups with low and high scores. Thereafter, how the association between predictor and criterion variables differs across groups becomes evident.

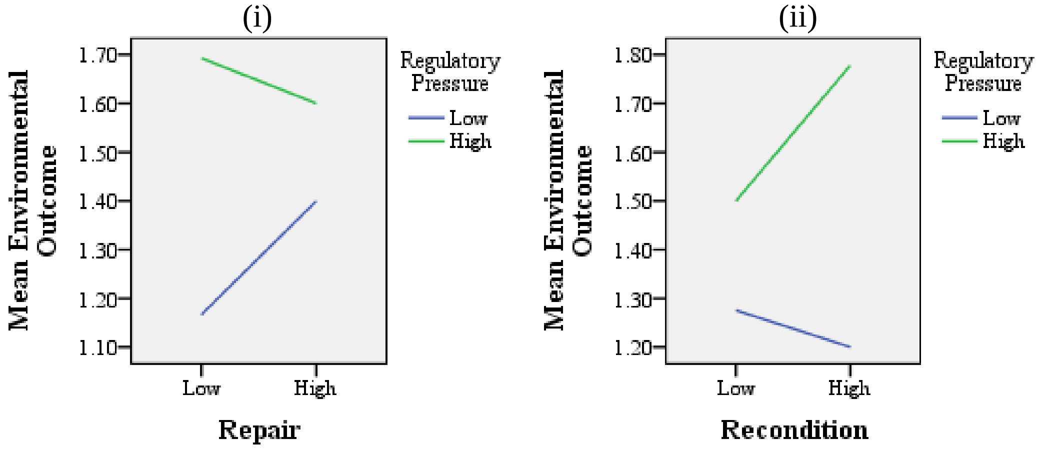


Figure 4.12
Moderating Influence of Regulatory Pressure on Relationship between (i) Repair, (ii) Recondition and Environmental Outcome

Based on Figure 4.12 (i), repair as an RLPD option is negatively related to environmental outcome when the presence of regulatory pressure is high. However, when the risk of violating regulations is low, better environmental outcome is related to higher presence of product repair. In terms of product recondition, Figure 4.12 (ii) indicates that the existence of this disposition activity is positively related to environmental outcome when regulatory pressure is high but negatively related with environmental outcome when regulatory pressure is low. This result is the evidence that regulatory influences induce firms to be environmentally friendlier by restoring products' functional use to extend products' lifecycle. Therefore, the rate of electrical and electronic product replacements is lowered and this brings about reduction in waste generation. However, when regulatory pressure is low, higher existence of recondition activities does not improve firms' environmental outcome.

Business Performance: Profitability

Table 4.19 presents the results of hierarchical regression for analysing the influence of regulatory pressure towards profitability of RLPD. The inclusion of firm size as control variable in Step 1 did not put forth significant variance to firms' profitability because F change is not significant. Step 2 indicated that RLPD explains 35.5 percent of variation in profitability, where recycling and repair contributes significant beta coefficients to the equation. Step 3 introduces moderator into the regression model and regulatory pressure explains an additional 16.5 percent of variance and F Change is significant at $p < 0.001$. The value of beta coefficient attributed to regulatory pressure is significant ($\beta = 0.479$, $p < 0.001$). When interaction terms are included in Step 4, total variance explained by the model is 11.0 percent higher and F change is significant where p value is 0.007.

All three regression models in Step 2, Step 3 and Step 4 had F-value of 4.543, 7.816 and 7.292 respectively and they were significant at $p < 0.001$. R^2 change attributed to the presence of interaction terms is interpretable only if value of F change in Step 4 is significant. As significant interaction was found and moderator was related to the outcome variable, Sharma, Durand, and Gur-Arie (1981) advocated that regulatory pressure exerts quasi moderating effect on the profitability of RL activities. Based on Table 4.19, all five interaction terms were statistically significant. For this regression analysis, Durbin-Watson statistics was 1.724, within acceptable range of 2.00 ± 0.50, and Appendix G2 presents more results of the abovementioned analysis.

Table 4.19

Hierarchical Regression Analysis: Moderating Influence of Regulatory Pressure on RLPD and Profitability of BP

Variables	Step 1	Step 2	Step 3	Step 4
Control Variable				
Small Firms	0.147	0.137	0.306*	0.580***
Medium Firms	0.130	0.053	0.154	0.384**
Large Firms	0.273	0.311†	0.352*	0.620***
Independent Variables				
Repair		0.217†	0.141	2.080**
Recondition		0.211	0.247†	-4.786***
Remanufacture		0.081	0.078	2.206**
Recycle		0.280*	0.244*	-0.983
Disposal		-0.129	-0.291**	1.368*
Moderator				
Regulatory Pressure			0.479***	0.777*
Interactions				
Repair x Regulatory Pressure				-2.702*
Recondition x Regulatory Pressure				6.276***
Remanufacture x Regulatory Pressure				-2.610**
Recycle x Regulatory Pressure				1.373†
Disposal x Regulatory Pressure				-2.234**
R^2	0.031	0.355	0.520	0.630
Adjusted R^2	-0.010	0.277	0.453	0.543
R^2 Change	0.031	0.324	0.165	0.110
F Change	0.767	6.627	22.277	3.569
Sig. F Change	0.516	0.000	0.000	0.007
F	0.767	4.543***	7.816***	7.292**
Durbin-Watson	1.724			

Significant levels: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; †$p < 0.10$

The post hoc graphs in Figure 4.13 revealed that the presence of product disposition activities such as (i) repair, (ii) recondition, (iii) remanufacture and (iv) recycling activities share positive and significant relations with profitability when regulatory pressure exerts both low and high influences to current marketplace. A comparison of the slope of the regression lines revealed that the influence of regulatory pressure have the potential to improve the profitability of RLPD activities. Such situation is not applicable to disposal activity because regulatory pressure influences firm to dispose waste in environmentally friendly manner and this incurs additional expenditure on non-added value activities. Unlike disposal, recycling is profitable and Figure 4.13(iv) showed that manufacturers who recycle gain more profit when the influence of regulatory pressure is high but the regression slope is comparatively steeper when regulatory pressure is low.

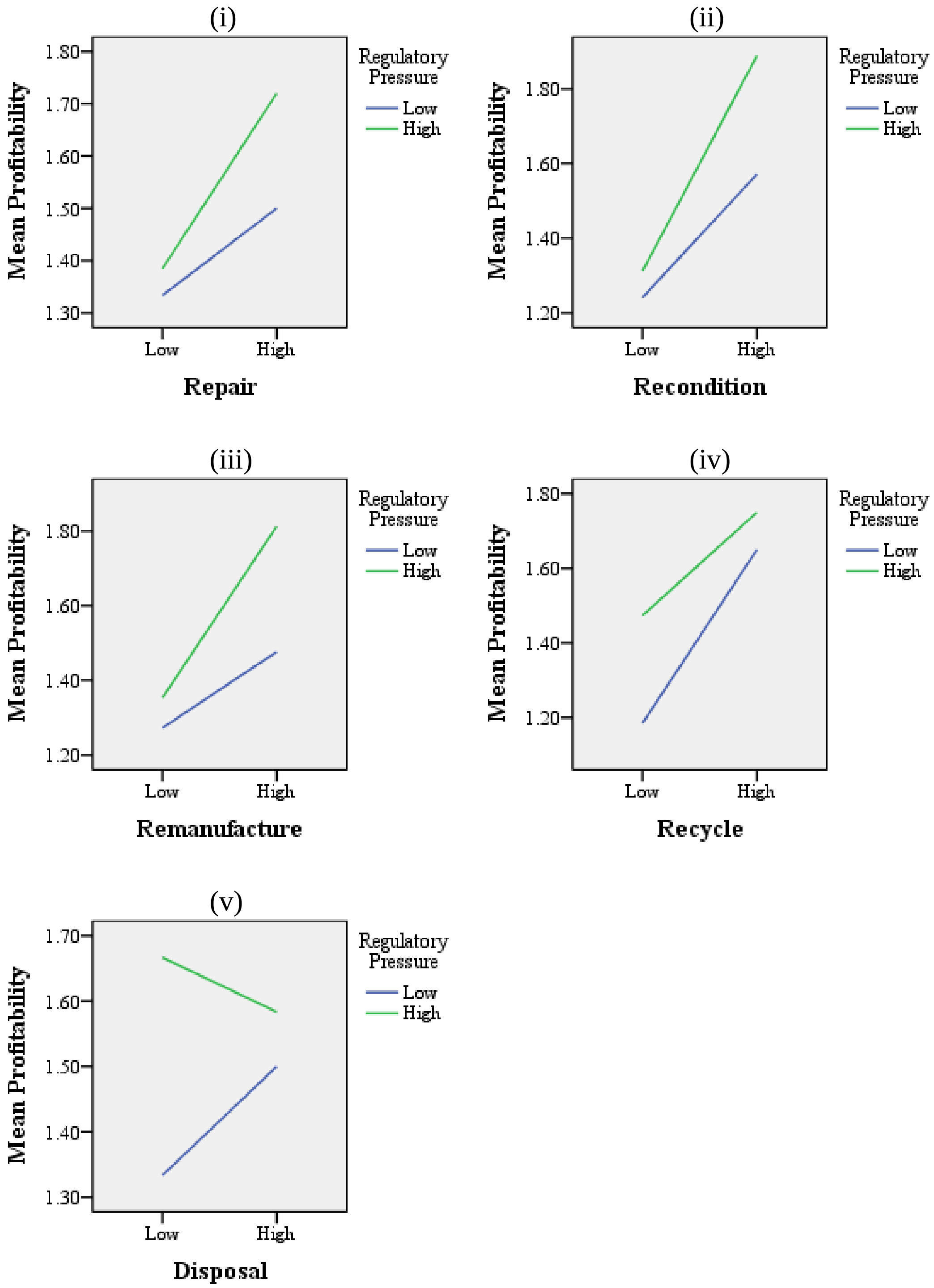


Figure 4.13
Moderating Influence of Regulatory Pressure on Relationship between (i) Repair, (ii) Recondition, (iii) Remanufacture, (iv) Recycle, (v) Disposal and Profitability

Business Performance: Sales Growth

Table 4.20 presents the results of hierarchical regression for analysing the influence of regulatory pressure towards sales growth of RLPD. The inclusion of firm size as control variable at Step 1 did not contribute significant variance to firm's sales growth. Step 2 indicated that RLPD explains 34.2 percent of variation in sales growth with remanufacture as the only statistically significant predictor ($\beta = 0.647$). Step 3 introduced moderator into the regression model and regulatory pressure explained an additional 8.6 percent of variance and F Change is significant at $p = 0.003$. The value of beta coefficient attributed to regulatory pressure is significant ($\beta = 0.345$). When interaction terms are included in Step 4, total variance explained by the model increased to 61.1 percent (R^2 change = 0.184) and F change is significant at $p < 0.001$.

On overall, the regression models in Step 2, Step 3 and Step 4 were valid because F-value is significant at $p < 0.001$ and they are 4.292, 5.402 and 6.744 respectively. Four out of five interaction terms were statistically significant in predicting sales growth in firm's business performance. The interaction terms between recondition and regulatory pressure ($\beta = -6.055$, $p < 0.001$), remanufacture and regulatory pressure ($\beta = 4.366$, $p < 0.001$), recycling and regulatory pressure ($\beta = -2.046$, $p < 0.05$) and, disposal and regulatory pressure ($\beta = 2.006$, $p < 0.05$) contributed significant beta coefficients. The significance of F-change in Step 4 indicated that regulatory pressure is a significant quasi moderator. With regards to Durbin-Watson statistics, value of 1.983 are within acceptable range of 2.00 ± 0.50 and more results of the analysis can be seen in Appendix G3.

Table 4.20

Hierarchical Regression Analysis: Moderating Influence of Regulatory Pressure on RLPD and Sales Growth of BP

Variables	Step 1	Step 2	Step 3	Step 4
Control Variable				
Small Firms	-0.041	0.025	0.147	-0.157
Medium Firms	0.125	0.033	0.106	-0.121
Large Firms	0.289	0.351*	0.380*	0.096
Independent Variables				
Repair		-0.135	-0.190	-0.349
Recondition		-0.058	-0.032	4.889***
Remanufacture		0.647***	0.645***	-2.965***
Recycle		-0.062	-0.088	1.643*
Disposal		-0.057	-0.174	-1.682**
Moderator				
Regulatory Pressure			0.345**	0.754*
Interactions				
Repair x Regulatory Pressure				0.372
Recondition x Regulatory Pressure				-6.055***
Remanufacture x Regulatory Pressure				4.366***
Recycle x Regulatory Pressure				-2.046*
Disposal x Regulatory Pressure				2.006*
R^2	0.081	0.342	0.428	0.611
Adjusted R^2	0.042	0.262	0.349	0.521
R^2 Change	0.081	0.261	0.086	0.184
F Change	2.084	5.244	9.734	5.668
Sig. F Change	0.110	0.000	0.003	0.000
F	2.084	4.292***	5.402***	6.744***
Durbin-Watson	1.983			

Significant levels: ***p < 0.001; **p < 0.01; *p < 0.05; †p < 0.10

The post hoc graphs illustrated in Figure 4.14 reveal that the presence of: (i) reconditioning; and (ii) remanufacturing activities share positive and significant relations with sales growth for both low and high influence from regulatory pressure. The positive relationship for remanufacturing and sales growth is stronger when regulatory pressure is low. These statistically significant interactions showed that recovery is an operational strategy for extending useful life of products and subassemblies thus maximising the quantity of remarketable goods at both primary and secondary market. Based on Sharma et al. (1981), the presence of pure moderator must fulfil two criteria that is; (1) interaction variable is significant, and (2) no significant relationship shared between moderator and criterion variable. Since regulatory pressure is related with sales growth at (β = 0.345, $p < 0.01$), regulatory pressure is a quasi moderator variable.

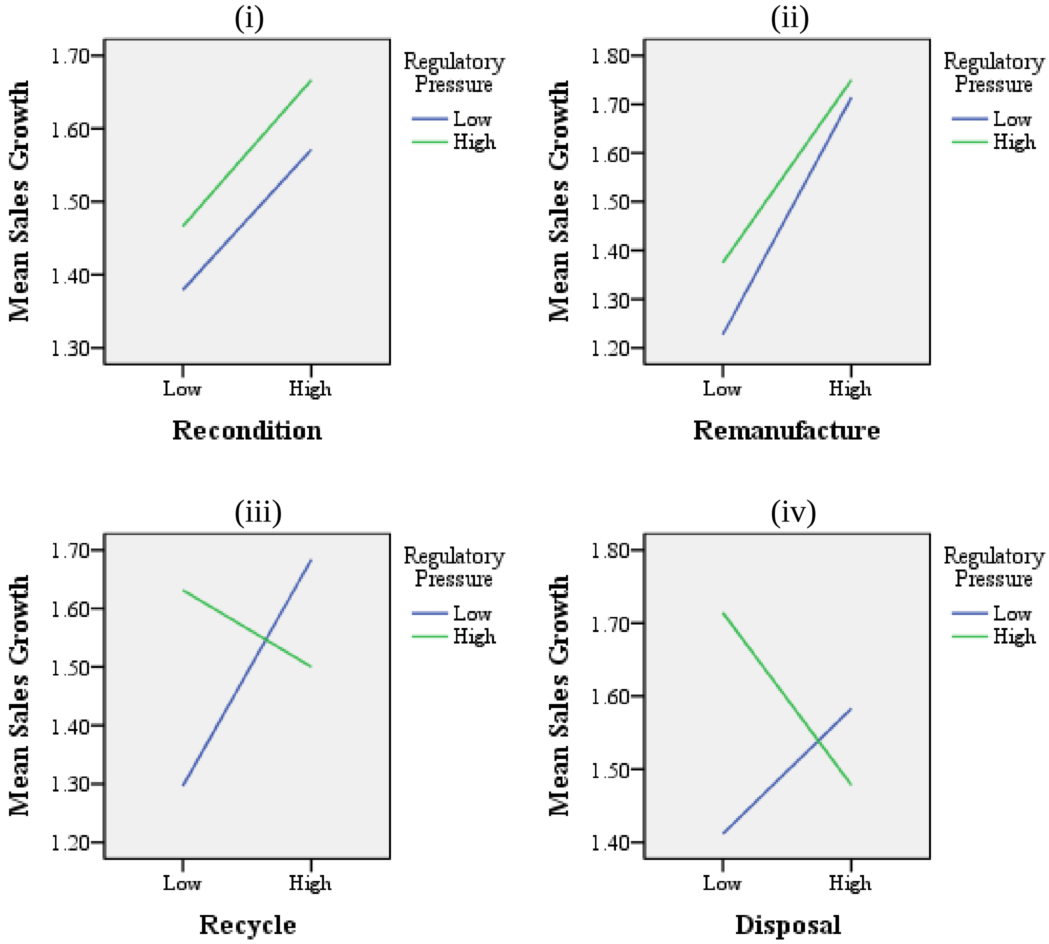


Figure 4.14
Moderating Influence of Regulatory Pressure on Relationship between (i) Recondition, (ii) Remanufacture, (iii) Recycle, (iv) Disposal and Sales Growth

Figure 4.14 (iii) and Figure 4.14 (iv) indicate that recycling and disposal activities are positively related with sales growth when regulatory pressure is low but negatively related with sales growth when regulatory pressure is high. Post hoc graphs showed that high influence exerted by regulatory pressure is a hindrance to sales growth for both recycling and disposal activities and this may be attributed to regulatory restrictions exerted on quality of products that re-enter primary and secondary markets. Instead, when regulatory pressure is low, sales growth increases as recycling may be broadly defined to include recovery and reuse of parts and/or whole product.

4.12.4 Moderating Influence of Ownership Pressure on Reverse Logistics Product Disposition and Business Performance

Hierarchical regression analysis is conducted to analyse the moderating influence of ownership pressure on the relationship between reverse logistics product disposition (RLPD) and business performance (BP). Business performance is a multidimensional construct that comprised of environmental outcome, profitability and sales growth.

Business Performance: Environmental Outcome

With reference to Step 1 in Table 4.21, F-change attributed to control variable such as firm size is not significant whereas Step 2 indicated that RLPD explained 14.0 percent of variation in environmental outcome but none of the dimensions of RLPD is significantly related to the dependent variable. Step 3 introduced moderator variable into the regression model and ownership pressure explained an additional 5.8 percent of variance and F Change is significant at $p = 0.03$. The value of beta coefficient attributed to ownership pressure is significant ($\beta = 0.272$, $p < 0.05$). When interaction terms are included in Step 4, total variance explained by the model increased to 35.7 percent (R^2 change = 0.159) and F change is significant at $p < 0.05$.

On overall, two regression models at Step 3 and Step 4 fits the data well because F-value is 1.786 ($p < 0.10$) and 2.379 ($p < 0.05$) respectively. The significance of F-change in Step 4 indicated that ownership pressure exerts significant moderating influence on the environmental outcome of RLPD. However, only two out of five interaction terms are statistically significant at $p < 0.01$ and they are; recondition and ownership pressure ($\beta = -2.809$), and remanufacture and ownership pressure ($\beta = 2.821$). Based on Sharma, Durand, and Gur-Arie (1981), statistically significant interactions and the relationship between moderator and outcome variable are two criteria to verify ownership pressure as quasi moderator. In regards to Durbin-Watson statistics, value of 2.088 are within acceptable range of 2.00 ± 0.50 and Appendix G4 presents more results of the analysis.

Table 4.21
Hierarchical Regression Analysis: Moderating Influence of Ownership Pressure on RLPD and Environmental Outcome of BP

Variables	Step 1	Step 2	Step 3	Step 4
<u>Control Variable</u>				
Small Firms	-0.087	-0.044	-0.033	-0.062
Medium Firms	-0.080	-0.073	-0.105	-0.265
Large Firms	0.000	0.012	-0.033	-0.089
<u>Independent Variables</u>				
Repair		-0.182	-0.170	-0.561
Recondition		0.093	0.043	2.135**
Remanufacture		0.080	0.057	-2.085**
Recycle		0.200	0.121	0.736†
Disposal		0.212	0.227†	0.601
<u>Moderator</u>				
Ownership Pressure			0.272*	0.908
<u>Interactions</u>				
Repair x Ownership Pressure				0.656
Recondition x Ownership Pressure				-2.809**
Remanufacture x Ownership Pressure				2.821**
Recycle x Ownership Pressure				-0.868
Disposal x Ownership Pressure				-0.726
R^2	0.009	0.140	0.198	0.357
Adjusted R^2	-0.033	0.036	0.087	0.207
R^2 Change	0.009	0.131	0.058	0.159
F Change	0.218	2.013	4.708	2.962
Sig. F Change	0.884	0.088	0.034	0.019
F	0.218	1.345	1.786†	2.379*
Durbin-Watson	2.088			

Significant levels: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; †$p < 0.10$

As seen in the post hoc graphs in Figure 4.15, reconditioning and remanufacturing activities share positive relationship with environmental outcome when firms are exposed with both low and high ownership pressure. However, both recovery activities exert stronger positive relationship when the influence of ownership pressure is high. These statistically significant interactions are evidences to show that environmentally conscious owners who exert environmental or economic interest in reverse logistics operation are prospective drivers to the implementation of product recovery strategies.

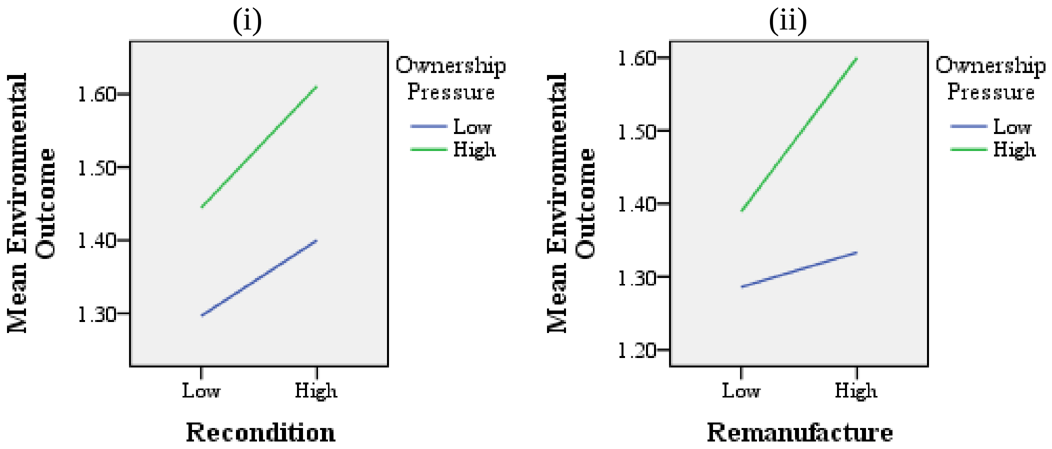


Figure 4.15
Moderating Influence of Ownership Pressure on Relationship between (i) Recondition, (ii) Remanufacture and Environmental Outcome

Business Performance: Profitability

Table 4.22 presents the results of hierarchical regression for analysing the influence of ownership pressure towards profitability of RLPD. In Step 1, firm size as a control variable did not contribute significant variance whereas the regression model in Step 2 indicated that RLPD contributed 35.5 percent of variance in profitability where recycling and repair are statistically significant predictors. Moderator is introduced into the regression model in Step 3 and ownership pressure explained an additional 6.8 percent of variance and F Change is significant at $p = 0.007$. The value of beta coefficient attributed to regulatory pressure is significant ($\beta = 0.294$, $p < 0.01$). When interaction terms are included in Step 4, total variance explained by the model increased to 57.4 percent (R^2 change = 0.151) and F change is significant at $p < 0.01$.

On the whole, all three models of Step 2, Step 3 and Step 4 are valid and F value is significant at 4.543, 5.297 and 5.769 ($p < 0.001$) respectively. Based on Step 4 (refer to Table 4.22), two out of five interaction terms are statistically significant in predicting profitability of reverse logistics. Two out of five interaction terms, namely remanufacture and ownership pressure ($\beta = 3.040$, $p < 0.001$), and recondition and ownership pressure ($\beta = -1.977$, $p < 0.05$) contributed significant beta coefficients. The presence of significant relation between ownership pressure and profitability are evidences to identify ownership pressure as quasi moderator variable. With regards to Durbin-Watson statistics, value of 1.796 are within acceptable range of 2.00 ± 0.50, and more results of the analysis can be seen in Appendix G5.

Table 4.22

Hierarchical Regression Analysis: Moderating Influence of Ownership Pressure on RLPD and Profitability of BP

Variables	Step 1	Step 2	Step 3	Step 4
Control Variable				
Small Firms	0.147	0.137	0.148	0.156
Medium Firms	0.130	0.053	0.019	-0.124
Large Firms	0.273	0.311†	0.262	0.183
Independent Variables				
Repair		0.217†	0.230†	0.308
Recondition		0.211	0.156	1.685**
Remanufacture		0.081	0.056	-2.210***
Recycle		0.280*	0.193	0.391
Disposal		-0.129	-0.113	0.177
Moderator				
Ownership Pressure			0.294**	0.561
Interactions				
Repair x Ownership Pressure				-0.151
Recondition x Ownership Pressure				-1.977*
Remanufacture x Ownership Pressure				3.040***
Recycle x Ownership Pressure				-0.275
Disposal x Ownership Pressure				-0.563
R^2	0.031	0.355	0.423	0.574
Adjusted R^2	-0.010	0.277	0.343	0.474
R^2 Change	0.031	0.324	0.068	0.151
F Change	0.767	6.627	7.657	4.242
Sig. F Change	0.516	0.000	0.007	0.002
F	0.767	4.543***	5.297***	5.769***
Durbin-Watson	1.796			

Significant levels: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; †$p < 0.10$

Based on the significant interaction terms in Step 4, two post hoc graphs were developed to illustrate the positive relationship shared between disposition activities such as product recondition and product remanufacture with firm's profitability. Figure 4.16 (i) indicates that the positive relationship between recondition and profitability is relatively similar in strength but differed in value when the influence of ownership pressure is low or high. On the other hand, Figure 4.16 (ii) indicated that the interaction slope in the presence of high ownership influence was steeper and this slope indicated that positive relationship shared between the product remanufacture and profitability is relatively stronger.

When compared to other RLPD options, remanufactured products has higher profit margin because as-new goods fetch better value in primary and secondary market. Other than additional investment required, the complexity of this recovery option was a hindrance because most of the time, product remanufacturing activities are not firms' core operating objectives. As such, the influence of institutional pressure especially ownership pressure was important to leverage the allocation of priorities or resources to assist the generation of profit from remanufacturing activities. Since ownership pressure is related to profitability ($r = 0.462$, $p < 0.001$), ownership pressure is a quasi moderator.

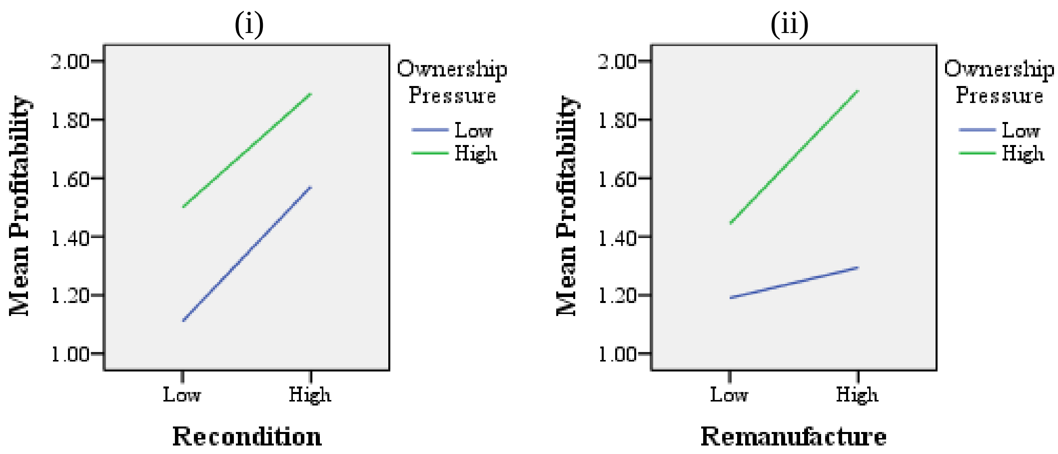


Figure 4.16
Moderating Influence of Ownership Pressure on Relationship between (i) Recondition, (ii) Remanufacture and Profitability

Business Performance: Sales Growth

Table 4.23 presents the results of hierarchical regression for analysing the influence of ownership pressure towards sales growth of RLPD. Step 1 revealed that firm size as a control variable do not explain significant variance and Step 2 indicated that RLPD explains 34.2 percent of variation in sales growth, where remanufacture is a unique contributor to the equation. Step 3 introduced moderator into the regression model and ownership pressure explained an additional 11.4 percent of variance and F Change is significant at $p < 0.001$. The value of beta coefficient attributed to ownership pressure is significant ($\beta = 0.380$, $p < 0.001$). When interaction terms are included in Step 4, total variance explained by the model is 9.2 percent higher and F change is significant at $p = 0.045$.

F value are significant ($p < 0.001$) for all regression models in Step 2 ($F = 4.292$), Step 3 ($F = 6.057$) and Step 4 ($F = 5.193$). The interaction terms between remanufacture and ownership pressure ($\beta = 2.041$, $p < 0.05$), and recondition and ownership pressure ($\beta = -1.402$, $p < 0.10$) are significant. Based on the model in Step 4, ownership pressure is quasi moderator variable ($\beta = 0.380$, $p < 0.001$) as F change is significant and it is related to outcome variable. Durbin-Watson statistics is within acceptable value of 1.714, and Appendix G6 presents more results of the analysis.

Table 4.23

Hierarchical Regression Analysis: Moderating Influence of Ownership Pressure on RLPD and Sales Growth of BP

Variables	Step 1	Step 2	Step 3	Step 4
Control Variable				
Small Firms	-0.041	0.025	0.040	0.048
Medium Firms	0.125	0.033	-0.012	-0.095
Large Firms	0.289	0.351*	0.287†	0.250
Independent Variables				
Repair		-0.135	-0.118	0.222
Recondition		-0.058	-0.128	0.932
Remanufacture		0.647***	0.616***	-0.879
Recycle		-0.062	-0.173	0.051
Disposal		-0.057	-0.037	0.376
Moderator				
Ownership Pressure			0.380***	1.203*
Interactions				
Repair x Ownership Pressure				-0.617
Recondition x Ownership Pressure				-1.402†
Remanufacture x Ownership Pressure				2.041*
Recycle x Ownership Pressure				-0.296
Disposal x Ownership Pressure				-0.691
R^2	0.081	0.342	0.456	0.548
Adjusted R^2	0.042	0.262	0.381	0.442
R^2 Change	0.081	0.261	0.114	0.092
F Change	2.084	5.244	13.616	2.434
Sig. F Change	0.110	0.000	0.000	0.045
F	2.084	4.292***	6.057***	5.193***
Durbin-Watson	1.714			

Significant levels: ***p < 0.001; **p < 0.01; *p < 0.05; †p < 0.10

Without the influence of ownership pressure, remanufacture is the only product disposition activity that has direct relationship with sales growth. With reference to Figure 4.17, post hoc graphs showed that the relationship between both product recondition and product remanufacture with sales growth is stronger when ownership pressure is highly influential. These significant interactions showed that the interests of owners or shareholders are important because firm achieve better organisational performance to maximise shareholders' wealth and subsequently, this may lead to shareholder retention. The interest of owners is an important driver to extend firms' operating activities to include reverse logistics because investment recovery is an underdeveloped business activity that minimises firms' environmental liabilities. This initiative promises substantial economic value through reuse of functional subassemblies to manufacture used or new product that contained used parts for redistribution at various channels of the secondary market. Based on Sharma et al. (1981), ownership pressure can be identified as a quasi moderator variable because it is related to sales growth ($\beta = 0.380$, $p < 0.001$).

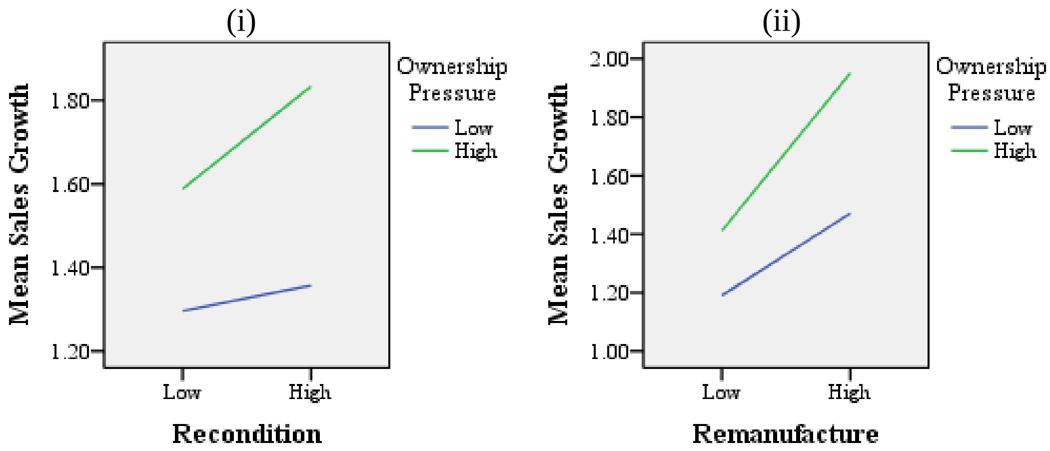


Figure 4.17
Moderating Influence of Ownership Pressure on Relationship between (i) Recondition, (ii) Remanufacture and Sales Growth

4.13 Summary of Hypothesis Testing

The findings of the multivariate analyses conducted in this chapter are summarised in Table 4.24. The results of hypotheses testing are presented as follow:

Table 4.24
Summary of Hypotheses Testing

Hypotheses		Results
H1	**Green product design has a significant relationship with reverse logistics product disposition.**	**Partially supported**
H1a	Design for disassembly has a significant relationship with reverse logistic product disposition.	Partially supported
H1b	Design for environment has a significant relationship with reverse logistic product disposition dimensions.	Partially supported
H1c	Design for recycling has a significant relationship with reverse logistic product disposition dimensions.	Not supported
H2	**Resource commitment has a significant relationship with reverse logistics product disposition.**	**Partially supported**
H3	**Reverse logistics product disposition has a significant positive relationship with business performance of reverse logistics.**	**Partially supported**
H3a	Repair has a significant relationship with business performance.	Partially supported
H3b	Recondition has a significant relationship with business performance.	Not supported
H3c	Remanufacture has a significant relationship with business performance.	Partially supported
H3d	Recycle has a significant relationship with business performance.	Partially supported
H3e	Disposal has a significant relationship with business performance.	Not supported

Table 4.24 *(Continued)*

H4	**Institutional pressure has significant moderating effect on the relationship between reverse logistics product disposition and business performance.**	**Supported**
H4a	Regulatory pressure moderates the relationship between RLPD dimensions and environmental outcome.	Supported
H4b	Regulatory pressure moderates the relationship between RLPD and profitability.	Supported
H4c	Regulatory pressure moderates the relationship between RLPD and sales growth.	Supported
H4d	Ownership pressure moderates the relationship between RLPD and environmental outcome.	Supported
H4e	Ownership pressure moderates the relationship between RLPD and profitability.	Supported
H4f	Ownership pressure moderates the relationship between RLPD and sales growth.	Supported

4.14 Validation of Research Findings

The empirical findings of this research are validated by respondents who volunteered to contribute their opinions on the final results. Four managers of Environmental, Health and Safety Department from small-sized (1), medium-sized (2) and large-sized (1) indicated that their firms dedicated resources to after-sales service operations to address defective products which returned from downstream customers. Their customers were not necessarily end-users and they may comprise of assemblers and distributors. Company A handovers extended responsibility on end-of-use and end-of-life products to distributors due to geographical barriers. On the other hand, Company B is receptive towards returns as they actively recover obsolete and products that are damaged during transportation. Company C indicated that their parent company is observant towards the environmental impact exerted by subsidiary companies. In addition, Company D is a multinational company that are proactive in pollution prevention initiatives and they considered the trade-off between cost of inspection, cost of rework and loss due to scrap if products fail customer's receiving inspection.

Table 4.25 summarises respondents' qualitative information on firm's commitment to reverse logistics activities. All the respondents indicated that their companies attempt to reduce or substitute use of hazardous materials and engage the service of authorised waste recyclers to facilitate environmentally compliant recycling and disposal of products or inventories which contain scheduled waste. Although recycling is a rent-seeking practise, Company D revealed that outsourcing waste reprocessing activities is called for as they are not firm's core operating business. The respondents validated the influence of green design aspects onto recovery friendly products and confirmed that RLPD contributes to firm's business performance only to a limited extent.

Table 4.25

Validity of Research Findings: Respondents' Take on Firms' Reverse Logistics Activities

	Company A	**Company B**	**Company C**	**Company D**
Type of business	OEM	Subcontractor	OEM	OEM
Does your firm accept returns?	Yes. Manufacturing-related return.	Yes. Manufacturing- and distribution-related return.	Yes. Manufacturing-related return.	Yes. Manufacturing-related return.
Does your firm have in-house product designing?	No. Finished products were manufactured based on customers' requirements.	Yes. Design mould for product assembly process.	Yes. Design according to customers' requirements.	Yes. Local plant focuses on continuous improvement of existing product.
Does green product design facilitate product recovery?	DfD: - Ease of separation. - Ease of accessibility. DfE: - No difference. DfR: - Does not use recycled material to avoid product safety and quality issues.	DfD: - Ease of separation. DfE: - Subject to customer requirement. DfR: - Use new material on E&E product. - Use new and recycled material on auto parts.	DfD: - Ease of accessibility. DfE: - Restrict use of hazardous substances. DfR: - Does not use recycled material.	DfE: - Minimise exposure to hazardous substances. DfR: - Does not use recycled material.

Table 4.25 *(Continued)*

	Company A	Company B	Company C	Company D
Does your firm conduct product recovery activities?	Repair: Address quality issue. Remanufacture: Modify semi-finished products to fulfil demand from existing customers. Recycle: Parts or waste materials.	Repair: Replace defective components. Recycle: Parts or waste materials. Disposal: Take-back outdated or expired goods	Repair: Replace defective components. Remanufacture: Upgrade software program for older generation products to resell as new products. Recycle: Parts or waste materials.	Repair: Address quality issue and perform 100% testing. Recycle: Products, component or waste materials.
Does your firm conduct packaging recycling activities?	Yes. Only limited to 'return requested' pallets, carton boxes and etc.	Yes. Carton boxes and plastic trays.	Yes. Pallets, carton boxes, cage, bubble wrap and etc.	Yes. Carton boxes, wooden pallets, tubes, trays and etc.
Does your firm engage waste management service?	Yes. Wastes are recycled and disposed by licensed waste collectors.	Yes. Wastes are recycled and disposed by authorised waste collectors.	Yes. Firms pay handling cost to authorised scheduled waste contractors to recycle, dispose and incinerate waste.	Yes. Wastes are sold to licensed waste collectors according to market value for proper recycling and disposal.

Table 4.25 *(Continued)*

	Company A	**Company B**	**Company C**	**Company D**
What are the environmental goals in your firm?	- Minimise CO_2 emission. - Minimise energy usage. - Waste reduction	- Comply with CHRA requirements. - Proper handling of SW110 waste.	- Minimise material and water usage. - Reduce waste and processing chemical. - Green purchasing.	- Minimise greenhouse gas emissions. - Energy-efficiency. - Waste reduction. - Waste-water recycling.
Regulatory Compliance	MS14001, RoHS, Japanese Industrial Standards (JIS).	ISO 14001, RoHS, Canon Green Procurement, JIS.	MS14001, RoHS, REACH, UKAS Quality Management.	ISO 14001, WEEE, RoHS, ISO 26000, JIS, OHSAS 18001.
Additional information	Firm are accountable to transportation cost of products or returns which failed receiving inspection. Only accept returns from first-hand customers or distributors. Do not accept end-of-use returns and end-user claims.	Upon customers' request, firm sends assembled product to independent tester (i.e. SGS Shah Alam) to assess for compliance with RoHS requirements.	Firm are accountable to transportation cost of products or returns which failed receiving inspection. Due to pressure from parent company, environmental impact of products are monitored and minimised.	Firm bears the cost whole batch inspection if one defective unit failed receiving inspection. Generally, ICs with distorted lead can be recovered but the entire batch will be disposed if defectives within encapsulated ICs are costly to inspect and/or recover.

4.15 Conclusion

This chapter presents the results of data analyses on ISO 14001 certified electrical and electronic manufacturers, who implemented reverse logistics activities for products and/or packaging materials. Descriptive statistics, chi square test for early and late respondents, and missing value analysis were conducted to address the presence of response bias. For goodness of measure, factor analysis and reliability testing are conducted to statistically evaluate the measures of green product design, resource commitment, reverse logistics product disposition, business performance of reverse logistics and institutional pressure. The hypothesis testing is carried out using linear regression analysis to test the relationship of antecedents and consequent variables with reverse logistics product disposition options. Subsequently, moderated hierarchical regression analysis was performed to analyse the influence of institutional pressures on the relationships understudy, where both regulatory pressure and ownership pressure are identified as quasi moderator variables. Chapter 5 examines the findings of this chapter in detail to comprehend the status quo of reverse logistics practices in Malaysia.

CHAPTER 5

DISCUSSIONS AND CONCLUSION

5.1 Introduction

This chapter discusses the findings of data analyses to assess the comprehensiveness of survey results towards research objectives. Previous literatures are compared with this research to explain the relationships that were supported and vice versa. Managerial implications, practical implications and theoretical contributions are discussed to provide in-depth insights on the current trend of manufacturing practices. The limitations are presented and suggestions for further research are pointed out as well to recognise some shortcomings related to this study. This chapter ends with a conclusion of the findings.

5.1.1 Recapitulation of the Study's Findings

The importance of reverse logistics among Malaysian electrical and electronic manufacturing firms has not been given adequate attention even though this business activity is an investment recovery opportunity. Furthermore, growth of environmental awareness accentuates the importance of reverse logistics and in time, manufacturers' who disengage themselves from environmentally beneficial programs will lose out to competitors when environmentally conscious consumers lend their support to brands that reuse and/or recycle products. Consequently, creating recoverable value is imminent to generate a reputation on social responsibility other than the potential monetary benefits from redistribution of products to existing or secondary markets. Previous study showed mixed result in the contribution of reverse logistics product disposition towards firm's performance. Consequently, this study analysed the interdependence of green supply chain practises and extended the concept of reverse logistics by investigating the moderating effect of institutional pressure such as regulatory and ownership pressure.

Based on green supply chain, reverse supply chain and environmental management literatures (Eltayeb & Zailani, 2010; Guide & Van Wassenhove, 2003; Skinner et al., 2008; Sroufe, 2003; Talbot et al., 2007; Zhu & Sarkis, 2007; Zhu et al., 2007), a theoretical model was developed to empirically test the relationships between the constructs which emerged from factor analyses. As mentioned in Chapter 3, the sampling frame comprised of organisations who have established environmental management system in E&E manufacturing industry. Such firms are presumed to be conscious towards negative repercussions disseminated by end-of-pipeline waste management and implement reverse logistic activities to consume resources efficiently. The research instruments were adapted from previous studies and factor analysis on green product design developed design for disassembly, design for recycling and an additional theme is named as design for environment. Hypothesised relationships focused on testing green product design and resource commitment as antecedents and business performance as outcome of reverse logistics product disposition. As strict enforcement is just a matter of time, the relationship between RLPD options towards business performance under varying level of institutional pressure, i.e., regulatory and ownership pressure, were examined.

To serve as reference purpose, a recap on the research objectives presented in chapter 1 is shown as follow;

1. To investigate the relationship between green product design and reverse logistics product disposition.
2. To investigate the relationship between resource commitment and reverse logistics product disposition.
3. To investigate the relationship between reverse logistics product disposition and business performance.
4. To examine the moderating effect of regulatory pressure and ownership pressure on the relationship between reverse logistics product disposition and business performance.

Based on research objectives, the following excerpts provide a brief summary the findings:

* In regards to the first and second objective, this study found that green product design is related to all five reverse logistics product disposition options whereas resource commitment is only related to two recovery options that is repair and disposal. As green product design is measured by design for disassembly, design for environment and design for recycling, about fifteen (15) relationships are identified for testing hypothesis 1. Multiple regression analyses revealed that six out of fifteen relationships are statistically significant and they provided partial support to the hypothesis. However, design for recycling revealed no significant association with product dispositions options including recycling and disposal.

* For the third research objective, the effect of reverse logistic product disposition on business performance of reverse logistics partially supports Hypotheses 3.

Business performance is comprised of environmental outcome, profitability and sales growth but only three out of fifteen relationships are significant. Remanufacture is the only disposition option that contributes to sales growth whereas both repair and recycling has positive significant relationship with profitability. On the other hand, none of the product disposition activities is related to environmental outcome.

* With reference to the fourth research objective, empirical results supported the hypothesis related to the moderating influence of regulatory pressure and ownership pressure on the relationship between reverse logistics product disposition and business performance. Four-step moderated hierarchical regression analyses are carried out and the significance of interaction terms in predicting dimensions of business performance validated that regulatory pressure and ownership pressure are quasi moderators.

5.2 Discussion

The results of this study are discussed in a predetermined sequence. Specifically, the relationship between antecedent factors and reverse logistics product disposition, followed by the relationship between reverse logistics product disposition and business performance, and finally, the moderating effect disseminated by institutional pressure on the relationship of interest.

5.2.1 Antecedents of Reverse Logistics Product Disposition

Of the four anteceding factors, only three predictors entered the regression equation to lend their contributions to the first and second research objective. They, in the order of importance, are design for disassembly, design for environment and resource commitment.

Green Product Design

Results of multiple regression analyses at Table 4.15 presents empirical evidence on the contribution of green product design on reverse logistics product disposition. Hypothesis 1 is partially supported because design for disassembly is significantly related to reverse logistics product disposition options except for disposal, design for environment is significantly related to product repair and disposal whereas design for recycling is not related to any product disposition options.

With reference to the correlation analysis in Table 4.13, the positive influence exerted by design for disassembly in regression analysis is anticipated as this dimension is strongly correlated with all product disposition options except for disposal. This could be attributed to the fact that design for disassembly is not required for handling mass of by products, subassemblies and/or products with limited recoverable value. Unlike design for disassembly, both design for environment and design for recycling correlate with reverse logistics product disposition options at medium strength.

Organisations who are practising reverse logistics in their business operations invest in recovery by evaluating recoverable value, functional qualities and level of complexity within products that undergo various mode of disposition. The results of regression analyses showed that if firms are investing in reverse logistics, in the order of highest to lowest importance, design for disassembly is an indispensable product characteristic for repair, remanufacture, recondition and recycle. The findings of this study supported previous researches (Desai & Mital, 2003; Dowie, 1994; Guide Jr et al., 2000; Ijomah et al., 2007; Mathieux et al., 2008; Veerakamolmal & Gupta, 2000; Zuidwijk & Krikke, 2008; Zussman et al., 1994) based on empirical evidences. The results supported the work of Mathieux et al. (2008), who proposed that product redesigning is one of the main solutions for reducing cost of recovery. In fact, Ijomah et al. (2007) pointed out that low disassemblability deters remanufacturing activities. For example, when disengaging parts joined by welds and adhesives, there is a high chance that a layer of residue will create aesthetic damage to joint surfaces because both materials are strong and can only be separated through application of heat and force. Other than minimising number of fasteners, the preferred alternatives for joint materials is the ‘breakable snap fits’, threaded fasteners and shape memory fasteners, where lesser force (or torque) is required for disengaging parts thus reducing prospects of aesthetic damages. The choice of joints strongly influences accessibility of reusable subassemblies. For instance, product disassembly takes precedence during product inspection, parts removal and quality tests when company invest in recovery activities such as product repair, recondition and remanufacture. If neither those are applicable, disassembly is required to extract valuable material during recycling.

Previous studies (Eltayeb et al., 2010; Zhu et al., 2007) analysed green product design and reverse logistics as green practices of green supply chain management. Unlike their research, this research analysed the direct relation between both components because many literatures have suggested design attributes that define environmentally conscious products (Bogue, 2007; Knemeyer et al., 2002; Sarkis, 1998). Design for disassembly was not taken into account in describing ecodesign at previous empirical researches and the result of this study showed that disassemblability is an important product attribute for time-sensitive recovery (repair, recondition, remanufacture) and cost-efficient recovery (recycle). The findings of this study is most supportive of Desai and Mital (2003), who described disassembly friendly characteristics that ease complexities associated with product recovery activities. The attributes of products that facilitate product disassembly include the level of force (or torque) required to disengage parts, type of disassembly tools, accessibility of joints or grooves, and size, shape or weight of targeted parts. These attributes create complexity during product disassembly stage thus elevating the cost of recovery. For this reason, ease of separation is a prerequisite to facilitate investment recovery and this aspect is not as important for products bound to be disposed due to limited residual value.

Design for environment is a component that deduced from factor analysis. This component is defined by the items that measured design for recycling and the underlying theme of this isolated component conveyed use of environmentally friendly material and reduce use of hazardous substances. On the other hand, design for recycling described product attributes that supports recycling programs by accommodating use of recyclable and recycled materials. The items that measured design for environment suggested that environmentally conscious materials are not necessarily recyclable materials. Based on the correlation analysis, design for environment is significantly related to disposal, quite significantly related to repair and significantly related to other disposition options at low strength. Talbot et al. (2007) is one of the few authors that defined design in the context of closed loop supply chain as design for ease of manufacture and design with reduced consumption of raw material. Unlike the result of this study, Talbot pointed out that environmentally friendly design attributes are strongly correlated with all type of recovery and reuse activities related to reverse supply chain.

However, the results of regression analyses revealed that design for environment only exert significant positive relation with repair and disposal. Manufacturing firms regardless of type of industry have to bear the cost of disposal for solid waste. Higher expenditure is required to dispose leachate that contains traces of heavy metal because only engineered landfill site can protect the environment from harmful contaminations. As such, design for environment of this study is a design strategy that focused on reducing consumption of raw material along with encouraging use of material that complies with environment protection regulations so that cost of waste management dwindles. In terms of repair, this recovery option is comparatively simpler and its relation with design for environment showed that repair is an activity that accommodates repeated use and maintenance. By restricting use of certain hazardous substances and promoting use of safer alternative material, repair activities are made simpler because risks of exposures exerted by hazardous materials are minimised thus reducing complexity of handling environment and/or requirement. This significant positive relations is supported by Talbot et al. (2007). In prolonging product's usefulness, other diposition options are supposed to experience the same positive relationship but the outcome of this study could be affected by the fact that repair and disposal are two most sought after options among E&E manufacturers in Malaysia.

Hypothesis 1c depicts that there is a relationship between design for recycling and reverse logistics product disposition options but regression analyses presented by Table 4.16 did not provide statistically significant results to support this predictor. This insignificance may have resulted from lack of manufacturer's interest in product take-back initiative for the purpose of asset recovery. Kriwet et al. (1995) and Zussman et al. (1994) are among the pioneer authors who recommend the design for recycling concept when integrating recyclability into products. Moreover, limited studies empirically tests the significance of this relationship because researchers exert higher interest in the performance of green supply chain initiatives (Chen, 2008; González-Benito & González-Benito, 2005; Hervani et al., 2005; Sroufe, 2003; Zhu et al., 2007) compared to analysing the interrelationship of green practices that are somewhat dependent of one another. When compared a previous study, Zhu et al. (2007) identified design for recycling and design for environment as measurement items of ecodesign whereas sales of excess and/or used materials and/or inventory defined investment recovery. Their study did not conduct a regression analysis on the interdependence of both variables but correlations analysis revealed that they are associated at positive and medium strength. According to some respondents, in-house recycling is not a common practice as compared to engaging the service of contract recyclers. In the latter scenario, third party recyclers will collect recyclable materials and/or waste from manufacturers to recover raw materials by means of shredding, sorting, crushing and put through chemically processing so that in return, an industrial waste composition analysis will serve as guidance to calculate reimbursement value, where the volume and quality of recovered material are the main determinants.

Design for recycling and recycling ought to share a straightforward relationship but their insignificance was a natural indication that this design aspect would not be related to higher level of product recovery. Lack of awareness towards hazards of e-waste may have contributed to insignificant relationship between design and recovery and this condition is accentuated by weak establishment of e-waste recycling system and infrastructure for RL management. Based on Lee and Na (2010), they argued that not enough incentives were provided to motivate the adoption of environmentally-friendly designs and their revelation derived from a comparison study that focused on recycling systems in the East Asian market such as Japan, Korea and Taiwan. In those countries, Terazono et al. (2006) pointed out that electronic waste and/or recycling regulations were enforced much earlier, i.e., Japan's Home Appliances Recycling Law and Promotion of Effective Utilization of Resources Law (2001), Korea's Extended Producer Responsibility in Recycling Law (2003) and Taiwan's Waste Disposal Act (1998). In other words, producers' responsibilities among manufacturers who operate in Malaysia were behind the abovementioned countries by a minimum of five years advancement gap. This included development of greener products and product take back programs. Take-back legislation in Malaysia is under formulation and the subtle presence of coercive pressure did little in encouraging the introduction of liberal return policy for collecting end-of-use EEEs. Since Lee and Na (2010) acknowledged the gap between design and recovery, this study is consistent with theirs as design for environment and design for recycling is partially related and not related with reverse logistics product disposition. Intriguingly, 50.6 percent of ISO 14001 certified E&E manufacturing firms who participated in this study are Japanese and Taiwanese-owned. They experienced low coercive pressure from Malaysian government as compared to stricter legislated manufacturing environment instituted at their home countries. Therefore, lower cost of conformance attracts multinational corporations to maintain a passive response towards environmental responsibility.

In recent studies, Gobbi (2011) highlighted the importance of products' residual values by identifying two categories of reverse supply chain that served different objectives of recovery. Value-driven reverse chain is developed for products with high residual value (i.e. repair, refurbish and remanufacture) whereas legislation-driven reverse chain served recyclables with dismissible residual value as soon as operating cost of recycling is taken into consideration. Designing the reverse supply chain was important to accommodate the trade-off between cost and efficiency in pertinence to each disposition options. As Gobbi (2011) argued that some of the factors that distinguished between high-value and low-value recovery are cost of product recovery and blueprint of the product design, this study examined the role of green product design to maximise recoverable value and the contribution of design for disassembly is proven for value-seeking disposition options. Conversely, design for recycling is not associated with other product disposition options as this design aspect is meant to efficiently recover products with minimal residual value. Nevertheless, design for recycling is unable to predict recycling activities and this could be attributed to a relatively lenient environmental setting experienced by Malaysian manufacturing industry. A directive on e-waste management along with a framework for enforcement must be introduced but from this point onwards, the extent of influence exerted by regulatory enforcement is discussed further in later sections.

Green product design is taken into consideration during product development because this concept represents manufacturer's interest in integrating environmental and economical considerations unto products. Regardless of proactive or reactive environmental strategy, Talbot (2005) proposed that integrating recoverability criteria during product development phase influences at least two stages of product life cycle and they are the product use and maintenance stage, and product end-of-life stage. In this study, green product design has a significant role in minimising the difficulties and challenges experienced by reverse logistics operation because the design aspect of a product is a major influence to time-efficient and cost-effective product recovery. Some researchers provided brief descriptions on reverse logistics in the Malaysian context and they indicated that a majority of companies have yet to optimise the benefits of reverse logistics (Abdullah et al., 2011; Amelia et al., 2009; Eltayeb & Zailani, 2010; Junaidah, 2010). In fact, Eltayeb and Zailani observed that the focus of green supply chain initiatives in Malaysia, from the order of highest to lowest preference, is eco-design, green purchasing and reverse logistics. As such, the benefits of reverse logistics when integrated to organisation's business practices have yet to conclude. The findings of this study partially support the relationship between green product design and reverse logistics product disposition where design for disassembly is an elementary characteristic that profoundly alleviate the complexities associated with asset recovery. The questionnaire of this study also incorporated a multiple choice question to investigate barriers for executing reverse logistics operations.

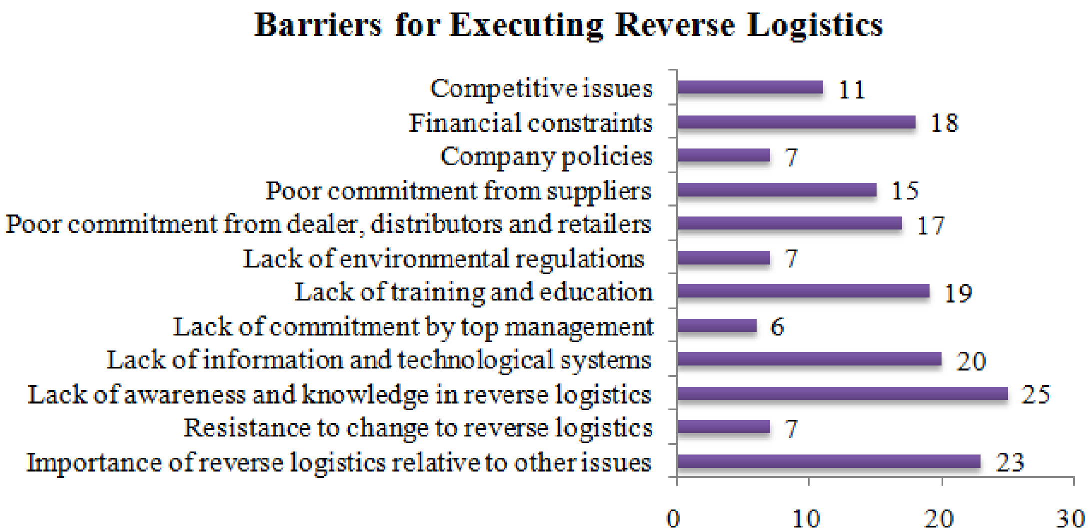


Figure 5.1
Barriers of Reverse Logistics Execution among Sample Respondents

With reference to Figure 5.1, the top three barriers of reverse logistics implementation are lack of awareness and knowledge in reverse logistics, importance of reverse logistics relative to other issue, and lack of information and technological systems. These barriers indicated that manufacturers may have sidelined reverse supply chain activities to focus in core business operations. At least fifteen respondents indicated poor commitment from suppliers and poor commitment from dealers, distributors and retailers as barriers and these showed that the culture of product recovery across supply chain players is weak. In conclusion, the responses to all twelve barriers showed that there is substantial lack of interest or awareness towards environmental and economic benefits of reverse logistics. Such environment is unfavourable in nurturing traits of green product that potentially unveil obscured benefits from reverse logistics product disposition.

Resource Commitment

Based on Table 4.13, commitment of resources is correlated with recycling and disposal but displayed no correlations with other product recovery activities. This is an initial indicator that current manufacturing practise is barely investing managerial, technical and financial resources in creating recoverable value in their E&E products. Hypothesis 2 is partially supported because results of multiple regression analyses at Figure 4.16 presents empirical evidence on the contribution of resource commitment on reverse logistics product disposition, particularly repair and disposal.

Daugherty et al. (2001) is one of the pioneer author who analysed the influence of resource commitment in fulfilling one of the objectives of reverse logistics program specifically, recovery of assets. Their study suggests that only management resource commitment is positively correlated with asset recovery at weak strength. By aggregating management, technical and financial resources to represent resource commitment, this study finds that resource commitment is negatively associated with repair activity but positively associated with disposal. Daugherty et al. (2001) explained that the disconnection between commitment of resources and asset recovery could be attributed to the fact that reverse logistics is at development stage.

As this study extend from Skinner's (2008) research, their results revealed that the interaction terms between resource commitment with product dispositions strategies for predicting reverse logistics performance had a mix of significant and non significant interaction terms. According to Sharma et al. (1981), the insignificant interaction terms in moderated hierarchical regression analysis suggest that moderator variable could be an exogenous, predictor, intervening, antecedent or suppressor. As such, resource commitment is analysed as predictor for this study because managerial, technical and financial resources are required to assist reclamation of values in returns. However, the findings of this study partially supported this assertion and there is likelihood that findings obtained from the western manufacturing environment may not be generalised to Asian settings. Results of study implied that the commitment of resources on repair gains cost-effectiveness with higher rate of repair activity and secondly, a number of organisations are more interested in environmentally compliant disposal by investing resources in appropriate storing, dumping and treatment of disposable including backward flowing in-process inventories (e.g. defects) and by-products. According to some environmental management representatives, engaging the service of third-party waste collectors is a common approach for managing recyclable and disposable waste. To our knowledge, there have been very few, if any, studies that investigate the role of resource commitment on reverse logistics and this study is a depth deeper as it focused on reverse logistics product disposition options.

5.2.2 Consequent of Reverse Logistics Product Disposition

The business performance of reverse logistics product disposition options was analysed using linear regression analyses to address the third research objective. Of the five predictors of business performance, only three product disposition options are significant predictors of profitability and sales growth whereas none is associated with environmental outcome. The support and reasoning that led to these results are presented in following sections.

Environmental Outcome

Based on scale measurement, the mean score of environmental outcome is 3.88 and this value denotes relatively significant improvement in firms' environmental outcome during the last three years. Upon controlling the effect of firm size, Table 4.17 revealed that none of the reverse logistics product disposition options if associated with environmental outcome. The results indicated that improvement of firms' environmental management practices and the overall reduction in generation of hazardous waste or emissions are not attributed to the implementation of reverse logistics activities.

The results of this study is best compared with a study by Eltayeb et al. (2010) due to similarities of environmental settings such as country of origin, type of industry, environmental certification, and traits of respondents particularly job designation of chosen representatives. Their study revealed that reverse logistics, as one of the green supply chain initiatives, does not contribute to firm's environmental outcome and the results of current study also showed that E&E manufacturing industry in Malaysia are not convinced that reverse logistics elevate environmental performance among firms. This situation is attributed to none other than the fact that reactive environmental practices are widely adopted and most firms are reacting to such requirements for the mere purpose of compliance. In addition, respondents did not lend their support to the concept of collecting used products for disposal because they perceived this activity as non-value adding. Generally, the firms operating in Malaysia are not actively pursuing this strategy because there are no apparent consumer pressure and regulatory pressure to specifically induce producer's responsibility in managing end-of-use and end-of-life electrical and electronic equipments. Based on a study conducted by Abdullah et al. (2011), organisations from various demographic profiles are accepting returns but the implementation of reconditioning, remanufacturing and recycling activities to recover value and/or material are relatively minimal. Terazono et al. (2005) reported the absence of policy or legislation that governs waste management in Malaysia whereas Terazono et al. (2006) pointed out that 60 percent of the dump sites in Malaysia are open dumping grounds that are being poorly managed. In addition, Amelia et al. (2009) mentioned that environmental issues, in their study within the automotive industry, have not been thoroughly addressed and suggested that more research concerning design for reuse are required to encourage reusability of parts and components for vehicles that have reached after usage phase.

Other studies have been conducted to analyse the influence of environmental management practices, that share equivalent objectives with reverse logistics product disposition, towards firm's environmental performance (Mathieux et al., 2008; Sroufe, 2003; Yang et al., 2011; Zhu, Sarkis, & Geng, 2004; Zhu et al., 2007). Other than Eltayeb et al. (2010), the findings of this study may be inconsistent with previous empirical researches due to differences in the interpretation of terms related to reverse logistics such as 'investment recovery', 'environmental management practices', 'environmental recycling practices', 'environmental waste practices', 'green process design' and 'ecosystem friendly'. Some of the terms refer to responsible management of waste such as responsible recycling and disposal whereas others analysed this aspect as sales of excess and/or scrapped inventories and materials to recover cost of investment. Unlike previous studies, this study extends from Skinner et al. (2008), who delineated various product disposition strategies based on product's residual value to facilitate multiple recovery loops. However, Skinner's study did not assess the environmental performance of disposition strategies and this did not add to the limited amount empirical results suitable for comparing and evaluating the environmental outcome of product disposition options.

In addition, Zhu et al. (2008b) proclaimed that inadequate recycling system including absence of knowledge and technology for efficient recycling is a factor that inhibit rate of recycling. Some examples of more advanced technologies that improves the recycling process are Post-shredder Separation Technology and X-ray equipment (Zuidwijk & Krikke, 2008). According to a report by Basel Action Network (as cited in, Sarkis, Helms, & Hervani, 2010b), shipments of electronic products that contain hazardous material have travelled from developed to developing countries on the grounds of 'remanufactured goods' or 'second hand goods' but they are ultimately dumped at the receiving country for the purpose of cost-effective management of waste. The occurrence of such situation reflects the shortcomings of reverse logistics implementation where developing nation who are not well-informed suffer negative repercussions for accepting and processing toxic products otherwise known as waste.

Furthermore, the abundant supply of raw materials to fulfil demand from mass production is among the main reasons that shun manufacturing companies or third party service provider from investing in new and costlier technologies that treat recoverable waste in an efficient manner. From the customer's perspectives, Junaidah

(2010) examine public awareness towards electrical and electronic waste and her study revealed that due to the absence of take-back policy, Malaysian consumers are not aware of e-waste collection points and only a fraction of used EEEs were sent to recycling centres. In general, there is not enough attention spent on pollution prevention initiatives even though the discussions above denoted that product recovery is beneficial to the environment. The current state-of-the-art practises do not encourage a widespread adoption of reverse logistics product disposition to warrant significant association with environmental outcome.

Profitability

Upon controlling the effect of firm size, Table 4.17 revealed that reverse logistics product disposition options particularly repair and recycle have significant positive influence on firm's profitability, a dimension that measures business performance of reverse logistics. Based on the measurement scale, the mean score for profitability is 3.10 and this value denotes that firms have experienced significant (i.e. to some degree) improvement in profitability related to reverse logistics during the last three years. The significant relationship between recycling and profitability was supported by Skinner et al. (2008) and even though disposal was considered important, the amount of resources required for investing in reverse logistics and the interest of cost containment or revenue protection may have reversed potentially positive influence contained in products bound for disposal. Furthermore, Skinner's results are aligned with the results of the current study where recondition and remanufacture do not exert significant influence towards firm's profitability. On the other hand, repair is another dimension that was not taken into account by previous study and repair exerts significant and positive influence in acquiring profit for reverse logistics performance outcome.

Apparently, organisations are receptive towards repair because warranty service is provided for every purchase of electrical and electronic products as part of after-sales service (De Brito & Dekker, 2003; King et al., 2006; Rogers et al., 2010; Srivastava & Srivastava, 2006). Thereafter, repair dispatches returns back to the distribution channels once the quality standard of products passed a series of diagnostics tests. According to Srivastava and Srivastava, repair requires lesser capital investment as it is skills-oriented whereas remanufacture demands greater capital investment because upgrading an existing product is a technology-oriented process. At hindsight, repair maximises sales of whole and functional products at relatively lower cost of recovery or rework when compared to the amount of resources required to operationalise other disposition options. From the perspective of resource-based view, the findings of this research suggested that investing resources in product repair is a service-offering that best fit capability-performance relationship. In the event of cherry-picking, firms who seek to liberalise their return policy gains the most benefit from investing in repair as part of rent-seeking strategy because revenue from resell, charges for repair services and/or customer satisfaction often exceed the cost of repairing defective units.

Industry clockspeed and type of recovery accommodated by firms have profound influence to reverse logistics performance (Fernández & Kekäle, 2005). In this study, electrical and electronic products are sensitive to speed of recovery and Gobbi (2011) stated that profitability of repair is highly reliant on the tradeoff between cost and timely product recovery. Most importantly, a major portion of product’s residual value closes the supply chain loop through repair and this disposition option is also the least complex but requires timely recovery to achieve cost effective redistribution of products at primary or secondary market. Naturally, the characteristics of reusable products ought to keep away from functional and fashion (i.e. out of trend products) obsolescence to facilitate the re-entry of used products into secondary market (King et al., 2006). Additionally, in the instance where customers return products for warranty claim, a manufacturer that does not repair has to spend a hefty amount to replace malfunctioned products with new ones and this is undesirable for business.

The other dimension of reverse logistics product disposition that exerts statistical significant results when regressed against profitability is recycling. As mentioned in this study, recycling is a series of process for extracting recyclable material from used products, subassemblies or components including collecting, dismantling, shredding, sorting and processing material for reuse in new products when original products or components loss their identity and functionality. This means that recycling is the utmost sound strategy when the remains of a product contain minimal residual value and processed raw material can be extracted as secondary source of raw material. Other empirical researches that supported the significant contribution of recycling towards firm's performance are found in the work by Sroufe (2003), Chan and Fang (2007), Zhu and Sarkis (2007) and Eltayeb et al. (2010). According to Sroufe (2003), the implementation of environmental waste and recycling practices that comply with objectives of environmental management system enhanced operations performance and the findings of their study are evidence to claim that recycling is profitable. Gobbi (2011) noted in their writing that cost-efficient management of waste recycling is the primary objective. Their study along with the findings of present study verified that recycling recoups cost of invested materials because the handling cost for disposing waste are minimised by offsetting it with value of recoverable material especially precious and/or heavy metals including lead, mercury, aluminum, steel, copper, nickel, gold and other smaller traces of ferrous materials commonly found in electrical and electronic equipments.

Unlike Zhu and Sarkis (2007) who described reverse logistics activities as ‘investment recovery’, Chan and Fang (2007) employed the term ‘ecocystem friendly’ to describe recovery of end-of-life product and enable reusability of materials and products. The terms extracted from both studies are some examples to show that most empirical studies did not analyse distinct reverse logistics activities. Generally, results of this study are partially supported by the findings of Chan and Fang, who found that the adoption of ecosystem friendly initiatives predicts economic benefits. From the perspective of practises and performance pertaining green supply chain management, Zhu and Sarkis found that investment recovery has significant positive relation with negative and positive economic performance. This showed that positive advantages derivable from investment recovery offset negative economic benefits. For instance, reduced fee in managing waste and smaller expenditure spent for purchasing materials compensate the increased cost of operation and employee training. However, the results presented by Eltayeb et al. (2010) is in marked contrast with previous researches as they revealed that reverse logistics is not related to economic outcome but contributes to cost reduction. The findings of this study acknowledge the business benefits of product repair and recycling in recovering assets.

With respect to the discussion above, the finding of the present study revealed that recondition, remanufacture and disposal are three dimensions that are not related to profitability. The passive influence exerted by reconditioning and remanufacturing activities is consistent with Skinner et al. (2008) but the outcome of disposal, which was supposed to be related with profitability appeared to oppose Skinner’s findings. In fact, their study showed that without committing resource to reverse logistics, none of the disposition strategies are related to the effectiveness of economic performance. Other than conducting the study among automotive firms in North America, another reason that caused the discrepancies of results between both findings is attributed to the scope of dimensions applied for measuring economic performance of reverse logistics, where Skinner's study took cost containment, asset recovery, profitability, reduced inventory investment and labour productivity into account. Unlike their study, the present study focuses on profitability by narrowing down the scope of economic benefits that can be derived from product recovery.

Two plausible explanations for the insignificant relationships in the current study are related to lesser than moderate existence of recondition and remanufacturing activities among E&E manufacturing companies of Malaysia and large amount of investment required for purposes such as; to develop skills or knowledge in diagnosing faulty products, to acquire equipment or technology that facilitate recovery of usable subassemblies, and, to build facilities to accommodate reverse processing of returns or backward flow products. In addition, proper disposal is a cost bearing activity due to the absence of recoverable value in masses of 'waste'. Normally, manufacturers who are environmentally responsible invest in proper storage of waste and engage service providers to treat and dump industrial waste in regulatory compliant manners.

Sales Growth

Upon controlling the effect of firm size, Table 4.17 revealed that remanufacture is the only reverse logistics product disposition option that exerts significant influence on firm's sales growth, the third dimension for measuring business performance. Mean score for sales growth attributed to reverse logistics is 3.01 and based on the measurement scale, this value indicate that firms have experienced significant (i.e. to some degree) improvement in sales growth during the last three years. Conversely, repair, recondition, recycle and disposal are insignificant predictors to sales growth.

In order to improve sales growth at primary or secondary market, remanufacturing recovers product by conserving finished goods to as-new quality to fulfil demand from pre-identified market (Ijomah et al., 2007). Unlike repair and recondition, remanufactured product is restored through extensive testing and redistributed with additional marketing strategy. Normally, a special sales team is established to find the secondary market for reprocessed goods such as online sales (Genchev et al., 2011; Rogers et al., 2010). The results are also consistent with Montabon, Sroufe, & Narasimhan (2007), who conducted a thorough content analysis to suggest that proactive waste reductions strategies including remanufacturing, predicts sales growth.

Additionally, technology upgrade can be introduced into remanufactured products to compete with new products at a cost of fifty to sixty percent cheaper (Thierry et al., 1995) but high initial investment made remanufacturing process unattractive or unable to break-even and this condition is amplified with low volume of products being remanufactured. Although remanufacture does not contribute to environmental and monetary benefits, sales of remanufactured products to specific groups of customers, with or without brand recognition, expand firms' market share. As products' lifecycle is influenced by variation in country setting and new products are not introduced throughout global market simultaneously, the considerable presence of secondary market or customers explains the positive findings of this study. According to Anderson and Ginsburgh (1994, as cited in Heese et al., 2005), they concurred that sales growth is influenced by the presence of secondary market because customers who anticipate secondary resale value have greater inclination to buy new products.

Given that this study is one of the pioneer researches that analysed the influence of reverse logistics product disposition, referrals to environmental management studies to clarify current findings are imperative. Yang et al. (2011) presented some consistencies as they found no significant relationship between environmental management practices and market growth. In other words, environmentally beneficial activities may not be the best decision for improving sales because extending product's useful life is optional and is considered environmental obligations by choice.

As mass of recyclables and disposables are not merchandises that are sold to customers, it is sensible for the present study to conclude that disposition activities such as recycling and disposal, do not have significant relationship with sales growth. However, repair and recondition activities do not exert influence on the sales growth of E&E products. In other words, manufacturers may invest in repair and recondition activities on returns particularly distribution- and customer-related returns (Rogers & Tibben-Lembke, 1999; Van Nunen & Zuidwijk, 2004) but they will not contribute to higher sales because returns that are collected from distributors, retailers and/or consumers are products that may be defective to require after sales services and to retain customer satisfaction. The only difference in the outcome for both disposition options is that repair is a more profitable recovery strategy than recondition because relatively smaller investment is required to solve minor malfunctions in products.

However, another reason for the insignificant influence of repair and recondition on sales growth dimension of business performance is possibly attributed to the cost of purchasing new products. If the second hand value of used products is modest, repairing or reconditioning products appear to be more lucrative for low income consumers. If the second hand value is high, the presence of trade in value substantially reduces the cost of investing in new products and this circumstance is most conducive to achieve higher level of sales (Heese et al., 2005). The trade-in value reimbursed to customer indirectly serves as price discounts and in order to attract repeat buyers, this value should be higher than revenue gained from sales to secondary market such as independent repair shops. Remanufacturing is one of the prominent strategies to fulfill both business and environmental interests because manufacturers enhance sales growth and be environmentally responsible to used products concurrently. However, this practise is not widespread among Malaysian customers because it is common that consumers seek independent repair service providers to prolong the usability of their products. There are strong evidence for such practices because electrical and electronic repair shop has brought upon the existence of backyard dismantling activities which involves a series of processes such as scavenging e-waste, salvation of usable parts, unsafe precious metal recovery by means of open air incineration or acid bath leaching, and lastly, disposing remnants along with municipal solid waste (Tengku-Hamzah, 2011). Since few OEMs sell parts for replacement, scrap dealers and scavengers are the main actors that cannibalise products to supply spare parts for repair and recondition activities at secondary market. Moreover, returns categorised as environmental returns are not welcomed by Malaysian manufacturers unless the returns are commercial returns that are warranted against manufacturing defects for specific period (Eltayeb & Zailani, 2010). Based on the explanations above, current practices do not translates into higher sales.

In conclusion, the results suggest that manufacturers who accommodate backward flowing products for the purpose of repair and recondition, with or without warranty coverage, will not influence sales growth unless marketing strategies especially discounts on new purchase are introduced in concurrent with reverse logistics initiatives particularly, extended producer’s responsibilities. For remanufactured equipments, issues in regards to brand recognition force manufacturers to find suitable secondary market to redistribute recovered products as new goods.

5.2.3 Moderating Variable: Institutional Pressure

In the effort to address the fourth research objective, the influence of institutional pressure on the business performance of reverse logistics product disposition options was examined using hierarchical linear regression analyses. Most of the interactions terms are significant where all three business outcome of product disposition options experience moderating influence exerted by regulatory pressure and ownership pressure. Table 5.1 presents the summary of moderating effects and further explanations to the relationships understudy are discussed in this section.

Table 5.1
Summary of Moderators

Criterion Variable: Business Performance	**Environmental Outcome**		**Profitability**		**Sales Growth**	
Moderator Variable: Institutional Pressure	PR	PW	PR	PW	PR	PW
Predictor Variable: Reverse Logistics Product Disposition						
Repair	QM		QM			
Recondition	QM	QM	QM	QM	QM	QM
Remanufacture		QM	QM	QM	QM	QM
Recycle			QM		QM	
Disposal			QM		QM	

Note: PR - Regulatory Pressure
PW - Ownership Pressure
QM - Quasi Moderator

Regulatory Pressure

The role of regulatory pressure as moderating variable was influential to the relationship between reverse logistics product disposition and business performance, where the statistically significant contributions are shown in Table 4.18 (p. 190), Table 4.19 (p. 193) and Table 4.20 (p. 196). It is important to note that level of regulatory pressure exerted by electronic waste management regulations differ across countries (Lee & Na, 2010; Terazono et al., 2006) and due to comparatively lenient environment in Malaysia, manufacturers operating in Malaysia take up voluntary approach in managing electronic waste or complying with international trade barriers particularly environmental restrictions imposed on exported products. The presence of regulatory pressure encourages producers to improve business performance of reverse logistics and this statement is supported by the results of this study because all five disposition options are somewhat moderated by regulatory pressure.

Darnall et al. (2008), Henriques and Sardosky (1996) and Zhu and Sarkis (2007) are among the advocators for regulatory pressure in environmental management studies whereas exploratory analysis by Tengku-Hamzah et al. (2011), Eltayeb and Zailani (2010) and Knemeyer et al. (2002) highlighted the importance of regulatory pressure towards reverse logistics. The present findings have slight inconsistencies with the research conducted by Zhu and Sarkis (2007). As this study focuses on reverse logistics instead of investment recovery, the mixed results exerted by various product disposition options showed that electrical and electronic manufacturing industry rely on regulatory pressure to reinforce or restrain the capability-performance relationship shared between RL product disposition and business performance. Such occurrence may be attributed to the delineation of dispositions options or dissimilarity in the environmental settings of both countries, i.e. Malaysia and China. Due to these reasons, the results of this study are comparable previous studies only to some extent.

Regulatory pressure exerts quasi moderating effect on the association between reverse logistics product disposition and environmental outcome (refer to Table 5.1). When regulations are in place, repair and recondition (otherwise insignificant without regulatory influence) are related to environmental outcome. The study conducted by Zhu and Sarkis (2007) provides the closest guidance for the current study but they indicated no significant relationship between investment recovery and environmental performance. As this idea has not been lauded previously, the contribution of current findings is noteworthy and additionally, the importance of regulatory bodies or agencies is empirically proven. Based on post hoc graphs at Figure 4.12, low regulatory pressure induces positive relationship between repair and environmental outcome but negative relationship is observed with high regulatory pressure. It is difficult to explain the contradicting effects exerted towards the repairing capability. Stock and Mulki (2009) suggest that this might be related to consumers' awareness and mistreatment of returns services where products could flow backwards for minor reasons and this may lead to unnecessary expenditures for managing emissions that were by products of return handlings. If returns consist of products with functional glitches that may disrupt and shorten product's life cycle in a significant manner, this study showed that recondition is a viable capability that benefits the environment especially among firms who experience high regulatory pressure. Additionally, Aizawa et al. (2008), King et al. (2006) and Eltayeb and Zailani (2010) are among the few authors who acknowledged the importance of regulations or legislative policy to extend goods' functional use so that they remain handy and unworthy of replacement.

Without the presence of regulatory pressure, only repair and recycling are associated with profitability. Under the presence of regulatory pressure, all five disposition options are associated with profitability (refer to Table 5.1). Post hoc graphs at Figure 4.13 showed that low regulatory pressure benefitted firms because higher implementation of each reverse logistics disposition options (repair, recondition, remanufacturing, recycling and disposal) is associated with higher profitability. The presence of higher regulatory pressure encourages dispositions options to achieve better profitability but this possibility applies to all except for product recycling and disposal. Environmental regulations require firms to address environmental issues in firms' operations but the profitability is dependent on the tradeoff between cost and return on investment of each disposition options. The present study is not consistent with those of Zhu and Sarkis (2007), who found that investment recovery do not contribute to positive economic performance in the event of regulatory intervention. In fact, current findings also showed that Skinner's (2008) study on economic performance of reverse logistics disposition strategies could turn out different if regulatory pressure is taken into account as they reported that only recycling and disposal are positively associated with economic performance.

Regulatory governance encourages firms to recover returned products. These legal requirements outline the role of stakeholders and indirectly force producers to assume responsibilities on equipments that have reached end-of-use or end-of-life at varying stages of product life cycle. From a broader perspective, producers are encouraged to be receptive to returns by endorsing liberal return policies. Although Trebilcock (2001) acknowledged that returns could be a stream of cost instead of revenue, Stock (2006) recognised that the introduction of return policies may initiate a series of time-sensitive disposition activities to maximise value and material recovery. Nevertheless, this study showed that manufacturers should accommodate returns particularly those intended for repair and recondition as both are ecologically and economically viable reverse logistic product disposition options.

In general, several authors (Ferrer & Swaminathan, 2010; Giuntini & Gaudette, 2003; Seitz & Wells, 2006; Stock, Speh, & Shear, 2002; Sundin, 2004) have indicated that remanufacturing is profitable because use of pre-processed raw materials to assemble remanufactured products reduce cost by forty-five to sixty percent as compared to new product delivery. Without regulatory influence, this study revealed no association between remanufacturing and profitability but when regulatory influence is taken into account, the post hoc graph revealed that a positive relation is present. As compared to conventional manufacturing processes, a collective effort is required to overcome the complexity associated with product remanufacture because the remanufacturing processes require different sets of skills and knowledge to recover backward flowing returns to as-new quality (Giuntini & Gaudette, 2003; Hazen et al., 2012). These complexities drive up the cost of recovery when products are not designed for remanufacture during product development phase. The presence of regulatory pressure makes remanufacturing a viable investment but firms must be well-equipped to receive returns in large scale to gain substantial benefits. The profile of respondents of this study may have influenced the results because only sixty-five percent (65%) of the sample are initiating implementation or have implemented reverse logistics on products. Most respondents may not have exerted full potential in reverse logistics operations thus downsizing the profitability associated with remanufacturing.

Recycling is the most fundamental recovery activity for reducing the amount of landfilled or incinerated waste. With the influence of regulatory pressure, the results of this study aligned with previous study to provide evidence that recycling is a profitable business (Skinner et al., 2008). Furthermore, Jorjani et al. (2004) and Rogers et al. (2010) are advocators of cost efficient recycling via bulk processing as more revenue are collected from mass recovery of low incentive materials. Precious metal recovery is the key commodity of recyclable products and MIDA has outlined the incentives for proper handling of toxic and hazardous waste at designated facilities as income tax exemption on 70 percent of statutory income and investment tax allowance of 60 percent of capital expenditure, whereby both incentives are available for a period of 5 years ("Malaysia Investment Development Authority: Incentive for Environmental Management," 2010). These incentives are obscured source of revenue for managing recyclable product in a regulatory compliant manner.

Adopting responsible and environmentally compliant disposal involve additional expenditure for engaging waste management and recycling agencies that are certified by Department of Environment, a provision under Environmental Quality (Scheduled Wastes) Regulations 2005 (Section 34B: Prohibition against placing, deposit, etc., of scheduled wastes). When regulatory pressure is low, profitability increases with higher disposal whereas a negative relationship is seen when regulatory pressure is high (refer to Figure 4.13). In other countries who have established law enforcement such as Japan, South Korea and Taiwan, producers bear physical and/or financial obligations for collecting and recycling electronic waste (Lee & Na, 2010). Two cost-bearing instances, particularly; (1) disposal of recyclable products, and (2) majority of collected products are disposable materials, incur economic strains on disposables. Producer's irresponsiveness has motivated external stakeholders to profit from illegal e-waste recovery but legislative requirements will eventually regulate hazardous waste management and/or exportation of e-waste to less developed countries. In fact, producers and independent recyclers are encouraged to form a systematic network to recycle and dispose waste. The preceding statement is supported by Tengku-Hamzah et al. (2011), who suggested that stakeholders such as local scavengers, scrap dealers and backyard dismantlers scattered throughout Malaysia should work collectively to support a centralised collection system for cost-efficient management of waste.

In terms of sales growth, regulatory pressure exert quasi moderating effect to render recondition and remanufacturing options positively related to sales whereas recycling and disposal options negatively related to sales (refer to Figure 4.14). Regardless of low or high regulatory pressure, sales growth increases with higher existence of product reconditioning and remanufacturing activities. As product recondition concerns product warranty and service policy, the findings of this study is supported because after-sales service is a customer satisfaction program that is associated with sales growth. In the event of dysfunctional products attributed to wear and tear of critical component and/or parts, also known as planned obsolescence, customers are persuaded to replace their product through trade-in promotion such as price discounts (Heese et al., 2005) to retain customer loyalty and ensure a steady stream of returns.

With or without regulatory pressure, the respondents in this study showed that remanufacture is a recovery option that favours sales growth. Hence, manufacturers should invest in product remanufacturing to serve secondary customers who are not as technologically sensitive. According to Purohit (1992, as cited in Heese et al., 2005), these customers cannot afford new products and are willing to pay for used products with marked-down value. As demand at secondary market grows, manufacturers must coalesce remanufacturing capability with buy-back because the presence of product's second hand value helps increase demand for new goods at primary market. In the instance of Malaysian market, recovered products from urban areas goes through a series of cleaning and testing including removal of brand recognition before re-introducing them to the rural market. If manufacturers are interested to remanufacture products for secondary market or behave in compliance with regulatory requirements, the primary market plays its role by introducing price discounts via trade-in to improve sales of new products and this subsequently generate supplies of reusable cores and/or components (Ferrer & Swaminathan, 2010). Therefore, remanufactured and new products share a symbiotic relationship to expand firm's market share.

For recyclable product, a strong positive relationship with sales growth occurs when regulatory pressure is low, but high regulatory pressure exhibit negative relationship between recycling and sales growth (refer to Figure 4.14). When regulatory pressure is low, independent recyclers buy electrical and electronic equipments so that usable parts are cannibalised to supply to scrap dealers and/or independent repair shops. In reality, local recyclers recover precious metal by means of open burning and acid bath. For developing country such as Malaysia, regulations or legislative framework for enforcement dedicated to electronic waste management (Rozana, 2009; Terazono et al., 2006) and extended producer responsibility are under development. Hence, DOE's 'Guideline for the Classification of Used Electrical and Electronic Equipment' is the reference to restrict exportation of recyclable e-waste. Even though Clause 101 in Solid Waste and Public Cleansing Management Bill 2007 outlined restrictions for reducing, reusing and recycling of controlled solid waste, Tengku-Hamzah et al. (2011) revealed that there is a widespread of illegal local backyard dismantling activities. Hence, this study showed that sales growth of recyclables will decline with the enforcement of current and future regulations because only premises of licensed recycling contractors are permitted to store, treat and dispose hazardous waste.

In terms of disposal and its significant relationship with sales growth, low regulatory pressure is associated with higher sales but this situation is otherwise when high regulatory pressure are in place. With low regulatory restrictions, second hand electrical and electrical equipments (EEE) from developed countries arrive in places including China, Vietnam, Cambodia, Africa and India (Balakrishnan et al., 2007; Greenpeace, 2009; Shinkuma & Huong, 2009). These exports explain the sales growth of disposables (also disguised as second hand EEEs) but most of the exports meant to be reprocessed for re-exporting will be absorbed by unauthorised recyclers.

Normally, reusable and recyclable parts are extracted to restore used products or to use as spare parts and the remaining remnants will be irresponsibly disposed. This approach is also known as green washing where corporations in developed countries try to portray green and clean image even though at least twenty to fifty percent of goods are disposed after second hand goods or exports are reprocessed through reclamation of parts or material. This situation occurs especially in countries where regulatory enforcement is weak. According to Lee and Na (2010), they disclosed that recycling rate of goods such as television, refrigerator, washing machine and air conditioner ranged between fifty to eighty percent in countries with comparatively more advanced recycling technology specifically Japan and Korea. However, there are evidences to show that second hand goods travel to unregulated countries for disposal. In the case of Malaysia, Department of Environment advised against importing of used EEE unless they are manufactured in the last three years (*Guidelines for the classification of used electrical and electronic equipment in Malaysia*, 2010) and exportation of hazardous waste is permitted only if local recovery facilities do not have the capabilities and capacities to process waste. Hence, preceding explanations showed that sales growth of disposal will decrease, in parallel with higher regulatory influence.

In conclusion, within the context of electrical and electronic industry in Malaysia, the existence of regulatory pressures improves the direct relationship between reverse logistics product disposition and business performance, and the effect of this pressure is most beneficial when repair, recondition and remanufacturing options are adopted as firms' reverse logistics operations.

Ownership Pressure

Ownership pressure exerts quasi moderating influence on the relationship between reverse logistics product disposition options and business performance. Based on Table 4.21 (p. 199), Table 4.22 (p. 202) and Table 4.23 (p. 205), the summary of results are presented in Table 5.1. Pressure exerted by owners' interest is significant for companies who recondition and remanufacture products to achieve better outcome in business performance.

As a component of institutional pressure, ownership pressure exerts internal influence to product's environmental stewardship (Henriques & Sadorsky, 1999; Hoffman, 2001; Jennings & Zandbergen, 1995). The effects of ownership pressure on organisational practice are seen in previous studies (Bansal & Clelland, 2004; Yang & Rivers, 2009), where researches highlighted the role of environmental legitimacy as one of the factors that reduces volatility of share prices. As there had been few previous studies which analysed the influence of ownership pressure on reverse logistics, researches that portrayed some interrelations with current study served as reference for explaining current results. For instance, Eltayeb and Zailani (2011) discussed the importance of expected business benefit as the only significant driver of reverse logistics and this aspect is indirectly associated with current study because maximisation of shareholder's wealth is the main interest of owners or investors. Nonetheless, the observations of this study is consistent with the notion highlighted in institutional theory, which suggests that the inclusion of ownership pressure is significant (Buysse & Verbeke, 2003; Darnall et al., 2008; Henriques & Sadorsky, 1996) as this aspect behaves as moderator to strengthen the capability-performance relationship among environmentally proactive firms.

When ownership pressure is low, there is a positive association between product recondition and product remanufacture with firm’s environmental outcome and under the instance of high ownership pressure, the strengths of this positive relationship is better (refer to Figure 4.15). Similar patterns were noticed with other measures of business performance that is profitability and sales growth. Previous studies have analysed the role of institutional pressure (Miemczyk, 2008; Zhu & Sarkis, 2007) on reverse logistics but both studies did not elaborate on the influence of ownership pressure towards product recovery. Uncertainties in the benefits of recovery have created heterogeneous responses for handling returns within the current industry subsector and isomorphic approaches towards returns have yet to emerge or tackled by previous studies. Owners have capacities to exert institutional influence unto top management’s decisions particularly, firm’s business goals (Yang & Rivers, 2009). This study recognized the significance of owners’ interest on environmental legitimacy and recognised the contributions of product recovery capabilities towards firm’s business performance. Environmental reputation is one of the aspects that attract and retain capital investments.

For electrical and electronic equipments which contain considerable recoverable value, they are viable second hand goods to serve demands from pre-identified secondary markets. As the residual value of used products degrades quicker than new products, the former type of products has to be conserved in a time-sensitive manner by means of responsive supply chain. Credits from recovery of goods comes in the form environmental goodwill and firms who recover valuable parts and modules by emphasising on timing, quantity and quality of returns will gain substantial monetary benefits as a result of product’s extended usefulness. In maximising profitability from product re-entry under the influence of technology clockspeed, product recondition and remanufacture have been proven to be most strategic because only some components are rendered obsolete due to incremental product innovation, being the current trend of new product offerings. In other words, most of the components across products from the same generation could be analogous and this is advantageous to the business viability of reverse logistics. Therefore, the threat of technological leap is not as critical when compared to the resistance expressed to the notion of sustainable business. As such, the existence of ownership pressure is important to pave the way for product recondition and remanufacture to generate a host of business benefits.

Comparatively, only a handful of literatures related to logistics and supply chain management studies are using institutional theory (Defee, Williams, Randal, & Thomas, 2010). Even though institutional theoretic perspectives set the rules and ideology as guidance for isomorphic practices among the broader society, only a handful of studies have analysed the contribution of institutional actors identified by Hoffman (2001). These actors are important as they drive homogenised organisational actions, structures as well as beliefs and there are even fewer studies that analysed the influence of owners as institutional actors. For this particular study, ownership pressure or the interest of shareholders potentially influence environmentally responsible practices among firms.

Conversely, the results of this study showed that employing ownership pressure is not influential to other reprocessing strategies particularly repair, recycle and disposal. None of these disposition options is associated with the measures of business performance and the absence of these relationships is attributed to several reasons. Firstly, returns that needed to be repaired include instances of product recalls, are products with quality issues and warranted by producers (Autry, 2005). Here, liberal return policies served as a customer satisfaction program to minimise negative repercussions resulted from malfunctioned products. After-sales service provides firm with opportunities to address unforeseen errors and successively reduce customer turnover. Simultaneously, customers who seek repair services may be enticed to replace their used equipment with newer models and this is advantageous for both buyer and seller. Therefore, repair is a must-have recovery program for manufacturers to induce customer loyalty and product repair is a withstanding recovery option which conceptualised reverse logistics activities. Secondly, firms are responsible for recycling returns and disposing by-products or products in an environmentally compliant manner. This is particularly true for companies who have received ISO 14001 certification for their environmental management systems and under the enactment of Solid Waste and Public Cleansing Management Bill 2007, Clause 71(7) outlined the responsibility of owners and/or occupier of premises in preventing unauthorised placement and disposition of controlled solid waste. In conclusion, ownership pressure does not exert moderating influence to alter the strength of the relationships understudy because reverse logistics product disposition options such as repair, recycling and disposal are organisational norms administered by institutional actors other than owners or shareholders.

5.3 Implications of the Study

In this section, conceptual implication, practical implication and limitations and suggestion for future studies are discussed based on empirical results. These implications are imperative to manufacturing companies who pursue reverse logistics as capability to achieve better business performance.

5.3.1 Conceptual Implications

This research is a consolidation of past empirical researches to develop the concept of reverse logistics product disposition (Daugherty et al., 2001; Eltayeb et al., 2010; Hazen et al., 2012; Skinner et al., 2008), green product design (Desai & Mital, 2003; Kriwet et al., 1995; Talbot et al., 2007; Zhu et al., 2007), resource commitment (Daugherty et al., 2001; Jack et al., 2010; Richey et al., 2005a) and institutional pressure (Darnall et al., 2008; Miemczyk, 2008; Sarkis et al., 2010a; Zhu & Sarkis, 2007). This empirical research adapts a comprehensive model that validates variables across disciplines, such as reverse supply chain and green supply chain management.

Most of the previous study measured reverse logistics as a whole and only one recent study by Skinner et al. (2008) analysed a range of aspects that defined reverse logistics disposition strategies. They proposed that this study be extended to examine multiple industries at various country settings to develop better theoretical framework that focuses on various disposition options, to be adopted by backward flowing products. Additionally, Knemeyer et al. (2002) proposed to measure the impact of green design on reverse logistics activities. This study adds to the current understanding on design attributes that are associated with product recovery, and which of these recovery options contribute to firm's business performance from environmental and economic perspective. In this study, green product design is a construct composed of design for disassembly and design for recycling but the scales of design for recycling created an additional factor that was named as design for environment. The instrument was tested and it demonstrated validity and reliability. Design aspects are knowledge-based resources that facilitate recovery and the outcome is dependent on mode of product disposition. The study is consistent with resource-based theory, which stated that dynamic capabilities are firm's abilities in acquiring, adjusting and employing resources (i.e. human, capital and knowledge) to pursue recovery capabilities that are advantageous to firm's business performance. Firms who did not consider design that ease product disassembly will find that recovery operations are complex and costly.

Although institutional pressure have gained acceptance in environmental management studies, Zhu and Sarkis (2007) and Darnall et al. (2008) have motivated this study to investigate these measurements in the current setting. Regulatory pressure and ownership pressure are two dimensions that could alter the strength of capability-performance relationships experienced by both environmentally proactive and reactive firms. These institutional theoretic perspectives are important factors for determining the success of reverse logistics because firms gain competitive advantage by operating in an environmentally proactive manner, in concurrent with requirements of internal and external business environment.

As most of the previous studies were conducted in diverse industry settings, the respondents of this study consists of Malaysian manufacturing firms from electrical and electronics industry subsector. Furthermore, these companies have obtained ISO 14001 certification on their environmental management system thus elevating the quality of insights that could well be beneficial for future studies.

5.3.2 Practical Implications

According to Department of Environment, the volume of electronic waste generated in Malaysia is 163,339.8 metric tonnes and approximately 78 percent of the waste are disposed via landfill and incineration (*Environmental Quality Report*, 2010). Under the influence of legislative requirements, the findings provide evidences that end-of-life EEE discards are materials for profitable recycling whereas end-of-use EEE products is a rich source of reusable components, parts and subassemblies including, whole products. By leveraging reverse logistics product disposition activities with the business operations of firms from electrical and electronic industry subsector, the overall cost of new or used products with used parts is substantially lower due to multiple recovery loops. Even though these products are sold at marked-down price, the obscured presence of profit margin warrants positive effect on firm's profitability as well as environmental reputation. Additionally, the survey also clarified a misconception that firms do not accept returns because at least 65 percent of the sample respondents have dedicated reverse logistics activities on products whereas 72 percent of the companies are committed to reuse or recycle packaging materials.

Apart from presenting statistical evidences on the outcome of reverse logistics implementation, this study demonstrated the importance of design characteristics that supports product recovery because most products are designed for cost-effective manufacture and assembly process, where little attention was invested on extending product's useful life. Management is encouraged to integrate design for disassembly into product as this design aspect is most beneficial for firms who considered the prospects of repairing, reconditioning, remanufacturing and recycling parts and/or products. The disassemblability of products is an important factor for minimising the amount of time, skills and force required to disengage parts for reuse or recycling. On top of that, firms are advised to design for environment since subassemblies or products with little residual value will be disposed eventually. However, the presence of hazardous substances complicate the disposal procedures as firms must exercise compliance to the guideline for storing, treating and disposing controlled solid waste or scheduled waste. Furthermore, restrictions imposed on transboundary movement of waste have led managers of firms operating in Malaysia to commit resources in waste management as well as designing cleaner products to relieve the economic burden of e-waste disposal. Rather than investing in end-of-pipeline waste management, this study confirmed that the business benefits of reverse logistics product disposition options are viable due to the influence of legislative requirements. Managers should be more proactive to develop end-of-use design aspects that facilitate the complexity of product recovery to improve the prospects of recoverable assets in EEEs.

Additionally, firms are advised to observe and pre-empt the evolvement of legal framework for managing e-waste or surpass the requirements by becoming environmental leaders in pollution prevention initiatives. Regulations provide guidelines to inculcate firm's accountability on products and the performance of reverse logistics improved for the better when industrial practices are regulated. Other than experiencing vulnerability due to noncompliance towards national legislatives, internal pressure such as shareholder retention also exerts significant influence. ISO 14001 certified firms are encouraged to embark on recoverable EEEs which contain substantial residual value. Management are obliged to protect firm's reputation by adopting appropriate measures that mitigate threats to environment and human health while at the same time, create substantial monetary and non-monetary values (e.g. environmentally friendly image) to organisations. For this study, the interest of firm's owner influenced the business performance of product recondition and remanufacture.

5.3.3 Limitations and Suggestions for Future Studies

Although this research presents interesting findings on the antecedents and outcome of reverse logistics product disposition, this study is not without its limitations. The sample respondents of this study are electrical and electronic manufacturing firms and this industry subsector is experiencing growth. Consequently, the findings of this study cannot be generalised to other industry subsectors such as; (1) agriculture, construction, food and beverage, furniture, chemical and others because these products are significantly different in nature, and (2) automobile as this industry has approached mature stage. However, future research on factors affecting reverse logistics product disposition can be revised to suit the abovementioned industries.

This study targeted ISO 14001 certified E&E manufacturing companies operating in Malaysia and the number of responses collected is satisfactory after undertaking a series of follow ups. Due to the cross-sectional nature of this study, this research can be duplicated to include non-ISO 14001 certified companies to improve the quality of data and inherently enhance the generalisability of findings. For this study, pilot test was conducted to minimise errors attributed to misinterpretation of ambiguous wordings as well as to ensure that no questions overlap across variables. In future, a longitudinal study is recommended as it would be practical to assess the antecedent and outcome of reverse logistics implementation after a period of time. Additionally, other variables may have affected the phenomenon understudy, to a lesser or greater extent, and they should be investigated to develop this research area.

For this study, the target respondents are primarily managers of environmental, health and safety department or environmental management representatives who are well-versed with the environmental impact of products and processes across functional departments. This could be a limitation because department managers may not have a complete picture of firm's strategic objectives and only 14.6 percent of respondents held senior management positions or higher. Ideally, representative from asset recovery department is most preferred but initial phone calls did not manage to identify such individuals. According to several respondents, details in regards to products that require rework or recovery particularly those that returned from end users are strictly confidential because respondents do not want to risk customer finding out that new products had been rejects or fitted with used parts. A case study research design such as use of semi-structured interview questions and focus group could obtain in-depth information on the issues that challenge successful implementation and management of reverse logistics program for electrical and electronic equipments. In addition, research should also emphasise on critical success factors to ascertain the prospects of profit margin in end-of-use EEEs.

Finally, this study on reverse logistics product disposition is limited to two anteceding variables and one outcome variable, i.e., green product design, resource commitment, business performance and one moderating variable, i.e., institutional pressure. The values of R^2 in regression models did not exceed 0.5 and this showed that future study should be expanded to analyse the influence other predictors such as liberalised return policy (Autry, 2005), reverse logistics program formalisation (Richey et al., 2005b), technical and financial capability (Chan & Fang, 2007), organisational learning and management support (Zhu et al., 2008a) in developing reverse logistics capabilities. Other outcome variables that can be considered in extending the current framework are customer satisfaction (Shang et al., 2010), operational responsiveness and operational service quality (Skinner et al., 2008) and negative economic performance (Zhu et al., 2007).

5.4 Conclusion

Globalisation has encouraged the emergence of customers, who are environmentally conscious and supports green business practices. Amidst stiff competition, firms are compelled to liberalise return policies to assume responsibilities in end-of-use and end-of-life products apart from managing conventional take-back practices for purchase-related, production-related and distribution-related returns. The capability to profit from returns is a business advantage because products circulating at primary market are secondary source of material and energy to capitalise in multiple recovery loops, particularly redistribution of secondary products. Apart from better environmental reputation, the adoption of recovery friendly product attributes reduces the complexity of product disposition and relieves firms who are interested in developing a responsive reverse supply chain to take advantage of products with time-sensitive residual values. The economics of product recovery does not materialise over a short period of time but its potential can be realised when selected components of FSC manufacturing operations collaborates and align with the convenience required by distinct product disposition options.

The empirical findings of this study recognised the contribution of green product design and resource commitment in predicting various reverse logistics product disposition options within electrical and electronic manufacturing industry. Ecodesign and reverse logistics are two components of green supply chain management and regression analyses revealed that design for disassembly and design for environment are two dimensions of green product design that are significantly related to product disposition options. As RL activities are primarily labour intensive tasks, findings of this study gave academician and managers a stronger basis to assimilate knowledge in redesigning attributes of products that counteract with difficulties in identifying, assessing, disengaging and handling functional parts of products, which may or may not require special handling requirements The abovementioned design considerations are crucial for firms who seek to generate business benefits from reverse logistic.

The interrelationships between reverse logistics product disposition options and business performance were significant only to a certain extent. However, the presence of regulatory and ownership pressure significantly improved the relationships of interest. Specifically, manufacturers' performance appeared to be facilitated by regulative enactment and enforcement, including threat of violation and risk of legal case action suit. Currently, DOE of Malaysia have established guideline to restrict importation and exportation of e-waste whereas producer's responsibility is briefly outlined by Environmental Quality (Scheduled Wastes) Regulation 2005 and Solid Waste and Public Cleansing Management Bill 2007. Eventually, higher level of enforcement and further amendment to this provision will congregate key industry players to react in the interest of pollution prevention via product recovery. With considerations to present norms, also known as social conducts, and global manufacturing environment, the findings of this study served a stronger basis for managers to invest in reverse logistics product disposition as the benefits are evident. Concurrently, firms who adopt environmentally proactive strategy, not only demobilise the threats exerted by current legislative requirement but may also set the forthcoming standards that serve as reference for policymakers.

On top of it, voice of owners or shareholders was a significant factor in strengthening the relationship between recondition and remanufacture with business performance especially for public listed company, who issue stock options to gather investment capital. Both disposition options fulfil ecological and economical interest even though products sold at secondary market generally fetch lower price, where profit margin might be lesser. Additionally, most respondents represented foreign-owned companies who invested generously in Malaysia and green supply chain practices adopted by parent company are exemplar to the business practices of subsidiary firms. As negative image affects parent company's reputation and product's brand image, owners may intervene due to risks of violation or undesirable environmental accidents.

Overall, this chapter presents the discussion and conclusion based on the statistical results derived during hypotheses testing. In addition to theoretical and practical contributions, the study outlines the limitations and presents suggestions for future researches. The research objectives have been substantiated and it is most constructive if the green product design concept is utilised and developed at greater scale to improve the capability of firms' reverse logistics product disposition. The relationships of these environmentally proactive practices have contributed to the body of knowledge, in the field of reverse and green supply chain management.

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APPENDICES

APPENDIX A : Questionnaire

QUESTIONNAIRE

REVERSE LOGISTICS PRODUCT DISPOSITION
AMONG MANUFACTURING FIRMS IN MALAYSIA

UUM College of Business ∞ Universiti Utara Malaysia ∞ 06010 UUM Sintok
Kedah Darul Aman ∞ Malaysia
2011

Date:

Dear Respondents,

Survey on Green Product Design and Reverse Logistics Product Disposition

This is a study to investigate the relationship between reverse logistic product disposition options and their business performance. Upon recognising the sluggish development in reverse logistics activities, we are investigating the influence of green product design during early stages of product development on subassemblies and materials recovery. This survey seeks to support conservation of resources and will unveil some motivating prospects of product recoverability such as profitability and environmental sustainability in particular.

Your organisation is randomly selected to participate in this survey from FMM-MATRADE Industry Directory for Electrical and Electronics 2007/2008. Therefore, your feedback represents other companies enlisted with Federation of Malaysian Manufacturers. As your knowledge and experience towards current industrial practices has significant contributions towards academic field, we hope that you will occupy some of your valuable time to complete the survey.

In terms of confidentiality, rest assure that data will be recoded to maintain respondents' anonymity. For your convenience, a postage paid return envelope is enclosed. We would appreciate it much if you would return the completed questionnaire within 7 days from the date of this letter.

Lastly, this questionnaire is preferably answered by representatives from the management level or other equivalent person who is well-versed in the area of reverse logistic and environmental management.

Thank you for taking the time to complete this questionnaire. Should you have any questions or suggestions, we are willing to correspond in order to enhance the value of your feedback.

Once again, your support is invaluable to this study.

Sincerely,
Ms. Jolyne Khor Kuan Siew
Assoc. Prof. Dr. Zulkifli Mohamed Udin
Email : jolyne_kuansiew@yahoo.com
Mobile No. : 019-4885486

DEFINITIONS OF KEY TERMS

For your convenience, the terms in the questionnaire are defined as follow;

1.	Green Product Design	Is corporate proactive approach for integrating product design and environmental considerations without compromising product's function and quality, including innovations for recovering product value throughout its life cycle prior to disposal.
2.	Reverse Logistics	The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal.
3.	Reverse Logistics Product Disposition	The term is self-explanatory, also known as disposition options which are industry and product-specific, where decision-making highly depends on conservable value in used products. Products are reincarnated for efficient consumption and disposal of resources by recovering materials and energy invested within products, modules or components to reuse in forward supply chain to gain environmental and business benefits.
4.	Product Return or "Take Back"	Three categories of products are manufacturing returns (rework or by-product), distribution returns (unsold or obsolete product) and customer returns (product under warranty or end-of-use returns).

REVERSE LOGISTICS PRODUCT DISPOSITION AMONG MANUFACTURING FIRMS IN MALAYSIA

SECTION A: COMPANY PROFILE

Please tick (√) the column that best reflect your organisation.

Q1. What is the subsector of E&E industry that best describes your company?

- ☐ Electronic Components
- ☐ Consumer Electronics
- ☐ Industrial Electronics
- ☐ Electrical Products

Q2. What is the type of business of your company?

- ☐ Original Equipment Manufacturer
- ☐ Custom Manufacturer - Subcontractor
- ☐ Distributor / Trading / Retail
- ☐ Electronic Design Services
- ☐ Electronic Manufacturing Services
- ☐ Electronic Repair Services
- ☐ Others, please specify: ____________________

Q3. What is the ownership status of your company?

- ☐ Locally-owned
- ☐ Government-owned
- ☐ Joint venture ownership
- ☐ American-owned company
- ☐ Japanese-owned company
- ☐ European-owned company
- ☐ Others, please specify: ____________________

Q4. How long has your company been in the business?

- ☐ Less than 5 years
- ☐ 6 - 10 years
- ☐ 11 - 15 years
- ☐ 16 - 20 years
- ☐ More than 20 years

Q5. How many employees does your company have?

- ☐ Less than 50
- ☐ 51 - 150
- ☐ 150 - 500
- ☐ 501 - 1000
- ☐ 1001 - 2000
- ☐ More than 2000

Q6. What is the status quo of reverse logistics activities in your company?

Please select the level of reverse logistics implementation for products and packaging.

Products	Packaging	
☐	☐	Not considering it
☐	☐	Planning to consider it
☐	☐	Considering it currently
☐	☐	Initiating implementation
☐	☐	Implementing it currently

Q7. What are the barriers for executing reverse logistics in your company?

- ☐ Importance of reverse logistics relative to other issues
- ☐ Resistance to change to reverse logistics
- ☐ Lack of awareness and knowledge in reverse logistics
- ☐ Lack of information and technological systems
- ☐ Lack of commitment by top management
- ☐ Lack of training and education
- ☐ Lack of environmental regulations
- ☐ Poor commitment from dealer, distributors and retailers
- ☐ Poor commitment from suppliers
- ☐ Company policies
- ☐ Financial constraints
- ☐ Competitive issues

Q8. What are the export markets for the products of your company?
Please select one or more options which are applicable.

☐ Asian	☐ North America	☐ Europe
☐ African	☐ South America	☐ Others, please specify:
☐ Middle East	☐ Pacific Ocean	______________________

Q9. What is the range of financial performance achieved by your company?

Total Current Assets	Average Annual Revenue	
☐	☐	Less than RM 10 million
☐	☐	RM 10 to 25 million
☐	☐	RM 25 to 100 million
☐	☐	RM 100 to 500 million
☐	☐	More than RM 500 million

Q10. What is the business' source of influence for addressing environmental issues?
Please select one or more options which are applicable.

- ☐ WEEE (Waste Electrical and Electronic Equipment Directive)
- ☐ RoHS (Restriction of Hazardous Substances Directive)
- ☐ ISO 14001 Environmental Management System Standard
- ☐ Others, please specify: ______________________ (E.g. REACH, CERES, etc.)

Q11. What are the types of hazardous substances that your company attempts to reduce or eliminate? *Please select one or more options which are applicable.*

☐ Lead	☐ Polybrominated biphenyls (PBBs)
☐ Mercury	☐ Polybrominated diphenyl ethers (PBDEs)
☐ Cadmium	☐ Others, please specify:
☐ Hexavalent chromium	______________________

SECTION B: RESOURCE COMMITMENT

*In this section, please 'circle' or 'bold' the appropriate response that best indicate the level of **resource commitment to reverse logistics**[1] based on the following scale.*

Not at All	A Little Bit	To Some Degree	Relatively substantial	Substantial
1	2	3	4	5

Q	In my company, the level of resource commitment is…	1	2	3	4	5
01	Technological resource commitment to reverse logistics.	1	2	3	4	5
02	Managerial resource commitment to reverse logistics.	1	2	3	4	5
03	Financial resource commitment to reverse logistics.	1	2	3	4	5

SECTION C: GREEN PRODUCT DESIGN

*In this section, kindly 'circle' or 'bold' the appropriate response that best indicate the **extent of existence** of green product design[1] from the perspective of design for disassembly and design for recycling based on the following scale.*

Very Low Extent	Low Extent	Moderate Extent	High Extent	Very High Extent
1	2	3	4	5

Design for Disassembly (Ease of Separation); is designing the product to reduce the complexity and cost for separating functional modules, components or materials in the effort of conserving resources for future use through reuse, recycling and remanufacturing.

Q	During the last three years, my company…	1	2	3	4	5
01	Focus on reducing the cost for dismantling products.	1	2	3	4	5
02	Design products that use modular components.	1	2	3	4	5
03	Design products that use snap fits in lieu of screws.	1	2	3	4	5
04	Design products that avoid use of weld or adhesive.	1	2	3	4	5
05	Design products that minimise the number of fasteners.	1	2	3	4	5
06	Design products that ease accessibility of valuable components/materials.	1	2	3	4	5
07	Design products that ease accessibility of joining elements.	1	2	3	4	5
08	Design products that avoid use of special tools or destructive disassembly techniques to disassemble joints.	1	2	3	4	5
09	Design products that protect joining elements from corrosions and wear.	1	2	3	4	5
10	Design products that minimise the amount of force (or torque) required for disengaging parts or components.	1	2	3	4	5
11	Design products that consider the weight, shape and size of structure for disassembly.	1	2	3	4	5
12	Design product with clear identification of parts or components to facilitate disassembly.	1	2	3	4	5

[1] Please refer to page 2 for the definition of 'reverse logistics' and 'green product design'.

Design for Recycling; is designing the product that enable material reuse from used products or components by developing recyclability and durability in products, including the intention to reduce the consumption of natural resources.

Q	During the last three years, my company…	1	2	3	4	5
01	Use pollution-free raw materials in production.	1	2	3	4	5
02	Use raw materials that are compliant with environmental protection regulations.	1	2	3	4	5
03	Design products that reduce consumption of materials.	1	2	3	4	5
04	Design products to avoid or substitute the use of hazardous substances.	1	2	3	4	5
05	Design products to allow use of recycled materials.	1	2	3	4	5
06	Design products to allow use of recycled subassemblies or components.	1	2	3	4	5
07	Design products that cluster materials to utilise their compatibility.	1	2	3	4	5
08	Design product for reuse, recycle, recovery of materials, component parts.	1	2	3	4	5
09	Design packaging with higher durability to enable multiple reuse.	1	2	3	4	5
10	Design packaging that is recyclable.	1	2	3	4	5

SECTION D: REVERSE LOGISTICS PRODUCT DISPOSITION

For this section, please indicate the ***extent of existence*** *of reverse logistics product disposition*[2] *options in your firm. Kindly 'circle' or 'bold' the appropriate response that best represents current practices on product recovery based on the following scale.*

Very Low Extent	Low Extent	Moderate Extent	High Extent	Very High Extent
1	**2**	**3**	**4**	**5**

Repair; is the work of fixing and replacing malfunctioning components or modules in order to restore the existing used product to working order.

Q	In my company…	1	2	3	4	5
01	Repair is the correction of faults in a product.	1	2	3	4	5
02	Repair restore product to working order.	1	2	3	4	5
03	Repair prolongs the product's lifecycle.	1	2	3	4	5
04	Repair replaces broken parts that have failed.	1	2	3	4	5
05	Repair involves disassembly at product level.	1	2	3	4	5
06	Warranty for repaired product is less when compared to remanufactured product.	1	2	3	4	5

[2] Please refer to page 2 for definitions of 'reverse logistics' and 'reverse logistic product disposition'.

Recondition; involve some level of product disassembly in order to restore the existing used product to specific working condition by testing and repairing or replacing some components or modules which have failed or about to fail.

Q	In my company…	1	2	3	4	5
01	This strategy involves collecting used product from customers for reconditioning.	1	2	3	4	5
02	Recondition is the work for returning used product to a satisfactory working condition.	1	2	3	4	5
03	Recondition inspects critical modules in the product.	1	2	3	4	5
04	Recondition extends functional use of the product.	1	2	3	4	5
05	Recondition replaces all major components that have failed or that are on the point of failure.	1	2	3	4	5
06	Recondition involves disassembly up to module level.	1	2	3	4	5
07	Recondition involves product upgrade within specified quality level.	1	2	3	4	5
08	Warranty for reconditioned product is less when compared to remanufactured product.	1	2	3	4	5

Remanufacture; is the process of restoring used product to at least original equipment manufacturer (OEM) performance specification which involve complete product disassembly before proceeding with extensive testing, restoration and replacement of worn-out or outdated components or modules.

Q	In my company…	1	2	3	4	5
01	This strategy involves collecting used product from customers for remanufacturing.	1	2	3	4	5
02	Remanufacture is the work for returning product to at least OEM original performance specification.	1	2	3	4	5
03	Remanufacture inspects all modules and parts in the product.	1	2	3	4	5
04	Remanufacture involves disassembly up to part level.	1	2	3	4	5
05	Remanufacture involves product upgrade up to as-new quality level.	1	2	3	4	5
06	Warranty for remanufactured product is highest compared to other disposition options.	1	2	3	4	5
07	Remanufacture is the work of building a new product on the base of a used product.	1	2	3	4	5
08	Suppliers are required to collect back remanufacturable product.	1	2	3	4	5

Recycling; is a series of process for extracting recyclable material from used products or components including collecting, dismantling, shredding, sorting and processing material for reuse in new products when original product or component loss their identity and functionality.

Q	In my company…	1	2	3	4	5
01	This strategy involves collecting used products from customers for recycling.	1	2	3	4	5
02	This strategy involves collecting used packaging from customers for recycling.	1	2	3	4	5
03	Procedures for recycling have been established.	1	2	3	4	5
04	Procedures for handling hazardous materials for end-of-life products have been established.	1	2	3	4	5
05	Recycling procedures reduce the amount of energy required for extracting virgin material.	1	2	3	4	5
06	Material recycling is the re-melt of materials to make new products.	1	2	3	4	5
07	Energy recycling is the extraction of heat from burning materials.	1	2	3	4	5
08	Recycle involves disassembly up to material level.	1	2	3	4	5
09	Recycle involves reusing materials from used products and components.	1	2	3	4	5
10	Suppliers are required to collect back recyclable product.	1	2	3	4	5
11	Suppliers are required to collect back recyclable packaging.	1	2	3	4	5

Disposal; involve the process of landfilling or incinerating parts or products on the condition that other disposition options are complex, not worthy of recovery and sales at aftermarket is almost non-existence.

Q	In my company…	1	2	3	4	5
01	This strategy involves collecting used products from customers for disposal.	1	2	3	4	5
02	This strategy involves collecting used packaging from customers for disposal.	1	2	3	4	5
03	The amount of waste for disposal is minimised.	1	2	3	4	5
04	Disposal involves appropriate storage of waste.	1	2	3	4	5
05	Disposal involves appropriate dumping of waste.	1	2	3	4	5
06	Disposal involves appropriate treatment of waste.	1	2	3	4	5

SECTION E: INSTITUTIONAL PRESSURE – REGULATORY AND OWNERSHIP

In this section, we would like to access the ***extent of influence*** *that institutional pressures exert unto your organisation. Please indicate your response based on the following scale.*

Very Low Extent	Low Extent	Moderate Extent	High Extent	Very High Extent
1	2	3	4	5

Q	Regulatory Pressure:	1	2	3	4	5
01	By taking back products, my firm tries to reduce or avoid the threat from **current** environmental regulations.	1	2	3	4	5
02	By taking back products, my firm tries to reduce or avoid the threat of **future** environmental regulations.	1	2	3	4	5
03	Environmental regulations in other countries, such as Europe, Japan and US induced my firm to adopt reverse logistics initiatives.	1	2	3	4	5
04	My firm's parent company sets strict environmental standards for my firm to comply with.	1	2	3	4	5
05	There are frequent government inspections or audits on my firm to ensure that the firm is in compliance with environmental laws and regulations.	1	2	3	4	5
06	Environmental regulations are important influence to the environmental practices of my firm.	1	2	3	4	5
07	Environmental regulations present risk related to unacceptable product impacts.	1	2	3	4	5
08	Environmental regulations present risk related to penalties due to non-compliance.	1	2	3	4	5
09	Environmental regulations present risk related to banning or restriction of raw materials.	1	2	3	4	5

Q	Ownership Pressure:	1	2	3	4	5
01	Risk of shareholder discontent with environmental fines which lower profits.	1	2	3	4	5
02	Risk of shareholder concerns when the company does not achieve environmental goals.	1	2	3	4	5
03	Risk of difficulties in raising new capital or attracting new investors.	1	2	3	4	5
04	Risk of lower share price due to shareholders' investment withdrawal.	1	2	3	4	5
05	Financial incentives offered by the Malaysian government, such as grants and tax reductions, are significant motivators for my firm to adopt reverse logistic product disposition.	1	2	3	4	5
06	Financial incentives offered by international organisations, such as United Nations, are significant motivators for my firm to implement reverse logistic.	1	2	3	4	5

SECTION F: BUSINESS PERFORMANCE FOR REVERSE LOGISTICS PRODUCT DISPOSITION

In this final section, we aim to assess the business benefits that encourage your firm to implement reverse logistics product disposition with the influence of green product design. Kindly indicate your response using the following scale.

Not at All	A Little Bit	To Some Degree	Relatively Significant	Significant
1	2	3	4	5

Environmental Outcome; *refers to firm's environmental responsibilities in reducing waste generation through proactive and reactive environmental management practices.*

Q	Environmental Outcome: During the last three years, my firm achieved…..	1	2	3	4	5
01	Significant reduction of air emission.	1	2	3	4	5
02	Significant reduction of waste water pollution.	1	2	3	4	5
03	Significant reduction of solid waste generation.	1	2	3	4	5
04	Significant reduction of hazardous waste consumption.	1	2	3	4	5
05	Minimal occurrence in environmental accidents i.e. spills.	1	2	3	4	5
06	Minimal occurrence in fines or penalties pertaining improper waste disposal.	1	2	3	4	5
07	Recognition or reward for superior environmental performance.	1	2	3	4	5
08	Significant improvement in commitment towards environmental management standards or practices.	1	2	3	4	5

Profitability; *refer to the prospective revenue derivable from reclaimable assets within work-in-progress inventories, manufacturing returns, distribution returns and customer returns where reusables are reprocessed to reenter forward supply chain.*

Q	Profitability: During the last three years, my firm achieved…..	1	2	3	4	5
01	Significant improvement in revenue from after sale services.	1	2	3	4	5
02	Significant improvement in reclaiming reusable products.	1	2	3	4	5
03	Significant reduction in inventory investment.	1	2	3	4	5
04	Significant reduction in cost of goods sold for recovered products.	1	2	3	4	5
05	Significant reduction in the cost for purchasing raw materials, components or subassemblies.	1	2	3	4	5
06	Significant reduction in the cost of packaging.	1	2	3	4	5
07	Significant reduction in cost for waste treatment.	1	2	3	4	5
08	Significant reduction in cost for waste disposal.	1	2	3	4	5

Sales Growth; *refers to the business marketing strategies of environmentally proactive companies where both new and used, products or technologies synergize to achieve sales objective within primary and secondary market.*

Q	Sales Growth: During the last three years, my firm achieved…..	1	2	3	4	5
01	Significant improvement in sales of used product at primary market.	1	2	3	4	5
02	Significant improvement in sales of used product at secondary market.	1	2	3	4	5
03	Significant improvement in sales of new products through price discounts.	1	2	3	4	5
04	Significant improvement in sales of new technologies by means of trade-in programs.	1	2	3	4	5
05	Significant improvement in market share.	1	2	3	4	5
06	Significant improvement in relationship with customer to encourage repeat buyers.	1	2	3	4	5
07	Significant improvement in corporate environmental reputation among environmentally conscious customers.	1	2	3	4	5
08	Significant improvement in sales growth.	1	2	3	4	5

GENERAL INFORMATION

Kindly provide us with some basic information about yourself. The information is not mandatory, but they are useful for analysing the survey results.

Q1. What is your designation in the company?

- ☐ Vice President or Above
- ☐ President's Assistant
- ☐ Managing Director
- ☐ General Manager
- ☐ Plant Manager
- ☐ Senior Manager
- ☐ Department Manager
- ☐ Executive
- ☐ Officer
- ☐ Others, please specify: ____________________

Q2. Which department do you belong to?

- ☐ President's Office
- ☐ Product Design Department
- ☐ Asset Recovery Department
- ☐ Environment, Health & Safety
- ☐ Engineering Department
- ☐ Warehouse / Logistics Department
- ☐ Operations Department
- ☐ Planning Department
- ☐ Others, please specify: ____________________

Q3. What is your length of service in the company?

- ☐ Less than 2 years
- ☐ 2 - 5 years
- ☐ 6 - 10 years
- ☐ 11 - 20 years
- ☐ More than 20 years

Q4. Would you like to receive a summary of the research under study?

If yes, please provide us your email address for future correspondence.

Q5. Please provide any additional information to further describe your company's practice that has not otherwise been addressed in this questionnaire:

" THANK YOU "

APPENDIX B1 Multivariate Normality (Dependent Variable: Reverse Logistics Product Disposition)

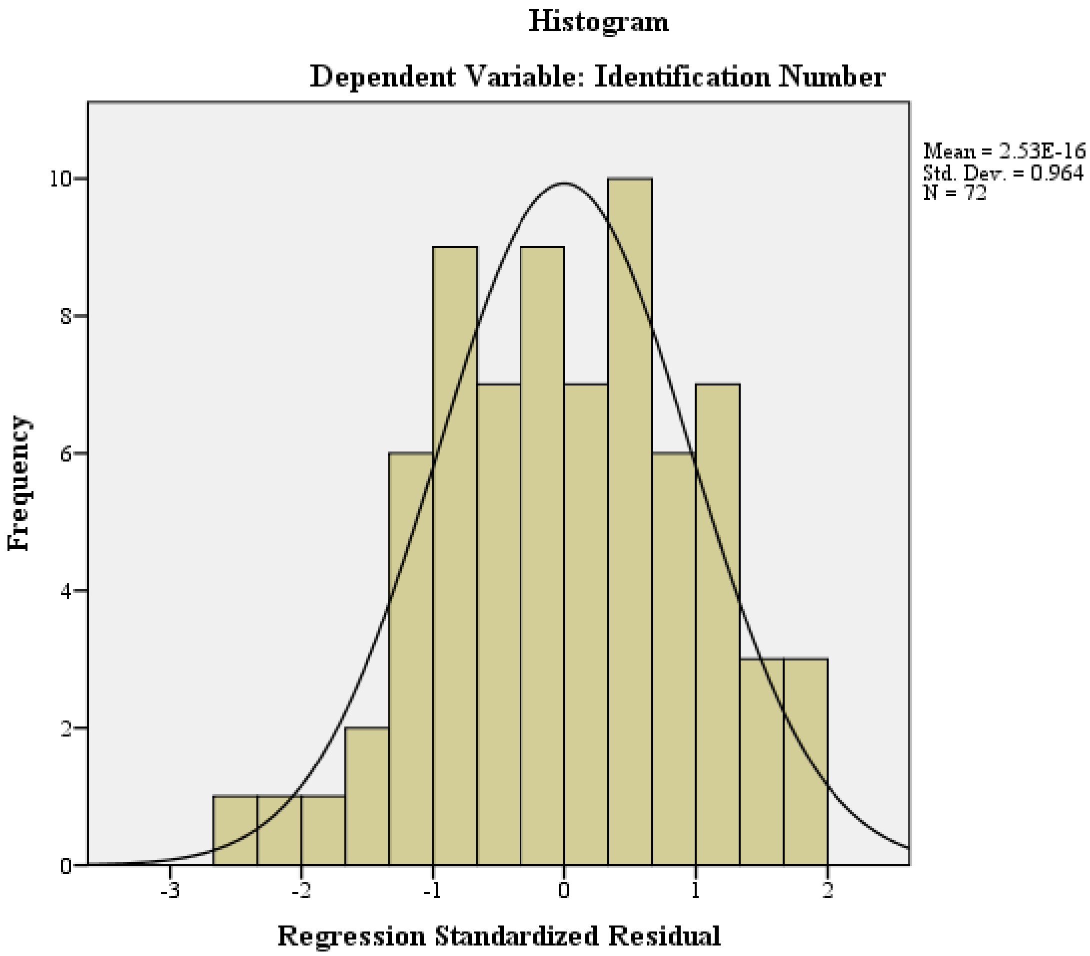
Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.445[a]	.198	.144	26.473

a. Predictors: (Constant), Disposal, Remanufacture, Repair, Recycle, Recondition

b. Dependent Variable: Identification Number

Charts



APPENDIX B2 Multivariate Normality (Dependent Variable: Business Performance)

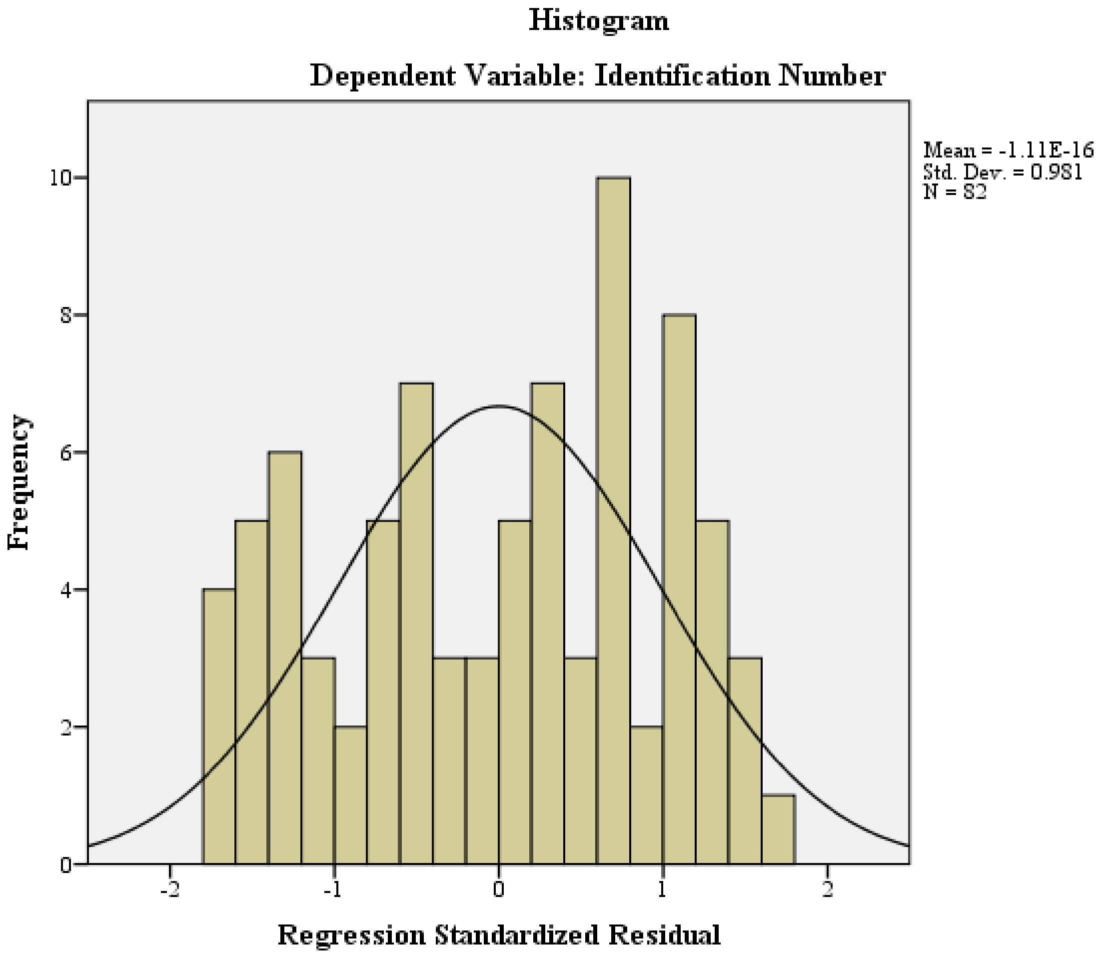
Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.187[a]	.035	.002	28.832

a. Predictors: (Constant), Sales Growth, Environmental Outcome, Profitability

b. Dependent Variable: Identification Number

Charts



APPENDIX C1 Factor Analysis (Scale: Green Product Design)

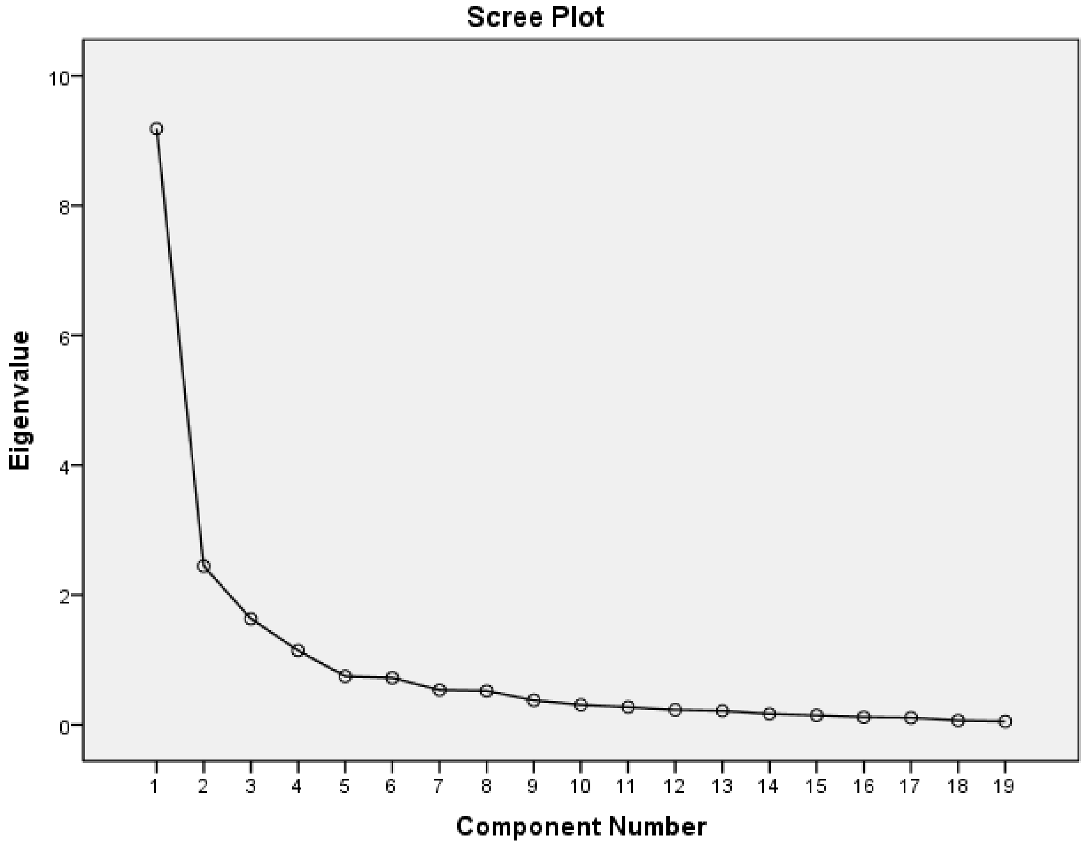
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.816
Bartlett's Test of Sphericity	Approx. Chi-Square	1098.144
	df	171
	Sig.	.000

Total Variance Explained

Compo-nent	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumula-tive %	Total	% of Variance	Cumula-tive %	Total	% of Variance	Cumula-tive %
1	9.184	48.339	48.339	9.184	48.339	48.339	6.624	34.861	34.861
2	2.446	12.872	61.210	2.446	12.872	61.210	3.609	18.997	53.858
3	1.633	8.597	69.807	1.633	8.597	69.807	3.030	15.949	69.807
4	1.146	6.032	75.839						
5	.747	3.930	79.769						
6	.724	3.809	83.578						
7	.537	2.826	86.404						
8	.522	2.746	89.150						
9	.377	1.986	91.136						
10	.307	1.618	92.754						
11	.274	1.441	94.195						
12	.230	1.213	95.408						
13	.215	1.132	96.541						
14	.168	.883	97.424						
15	.145	.765	98.189						
16	.118	.620	98.809						
17	.108	.569	99.378						
18	.067	.351	99.729						
19	.051	.271	100.000						

Extraction Method: Principal Component Analysis.



Component Transformation Matrix

Component	1	2	3
1	.801	.417	.429
2	-.416	.904	-.100
3	-.429	-.098	.898

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.

APPENDIX C2 Factor Analysis (Scale: Resource Commitment)

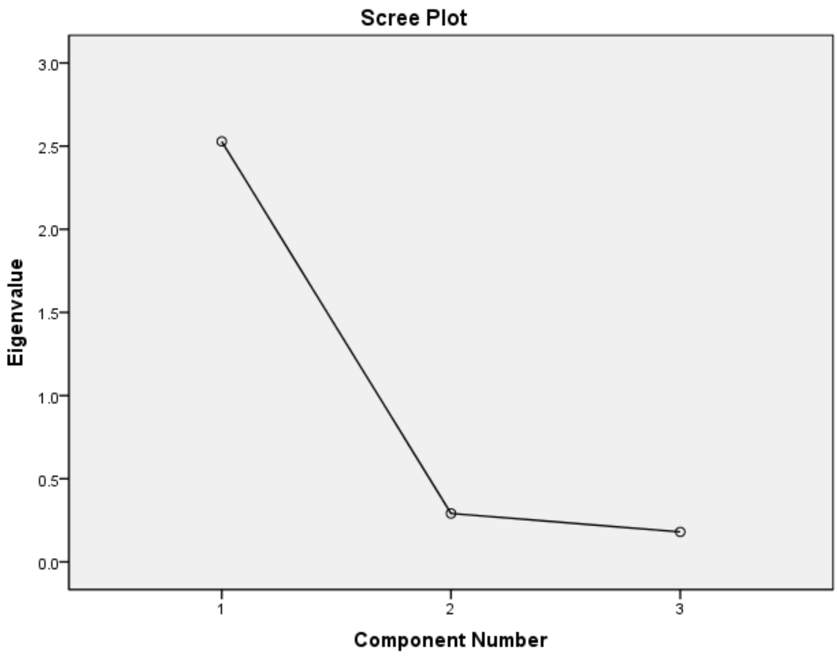
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.740
Bartlett's Test of Sphericity	Approx. Chi-Square	169.875
	df	3
	Sig.	.000

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.528	84.277	84.277	2.528	84.277	84.277
2	.291	9.706	93.984			
3	.180	6.016	100.000			

Extraction Method: Principal Component Analysis.



Rotated Component Matrix[a]

a. Only one component was extracted. The solution cannot be rotated.

APPENDIX C3 Factor Analysis (Scale: Reverse Logistics Product Disposition)

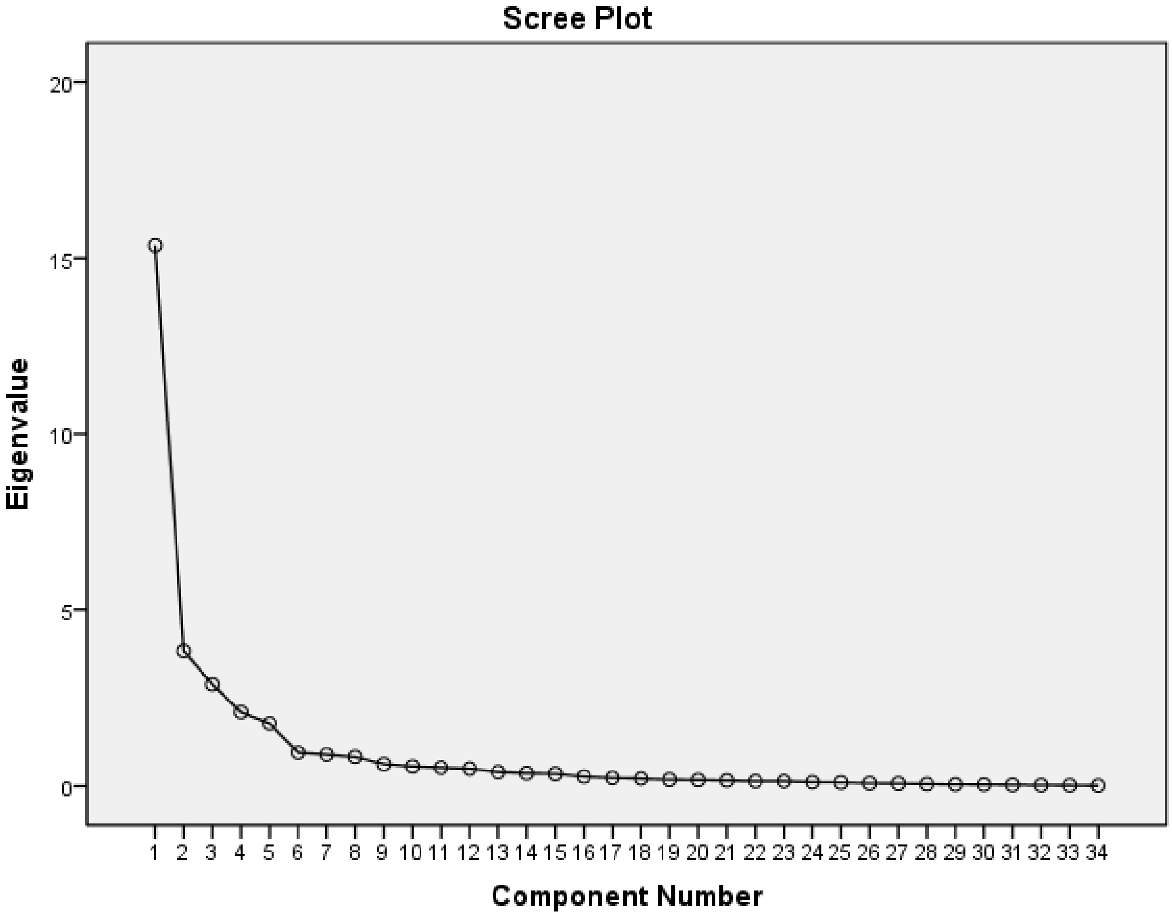
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.827
Bartlett's Test of Sphericity	Approx. Chi-Square	2618.650
	df	561
	Sig.	.000

Total Variance Explained

Com-po-nent	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumula-tive %	Total	% of Variance	Cumula-tive %	Total	% of Variance	Cumula-tive %
1	15.356	45.163	45.163	15.356	45.163	45.163	6.850	20.147	20.147
2	3.835	11.280	56.443	3.835	11.280	56.443	6.285	18.484	38.631
3	2.883	8.478	64.921	2.883	8.478	64.921	5.653	16.625	55.256
4	2.098	6.171	71.093	2.098	6.171	71.093	3.825	11.250	66.506
5	1.774	5.217	76.310	1.774	5.217	76.310	3.333	9.804	76.310
6	.951	2.797	79.107						
7	.893	2.626	81.733						
8	.824	2.424	84.157						
9	.620	1.822	85.980						
10	.552	1.624	87.604						
11	.519	1.525	89.129						
12	.489	1.438	90.567						
13	.395	1.163	91.729						
14	.362	1.065	92.795						
15	.345	1.015	93.810						
16	.268	.788	94.598						
17	.230	.677	95.275						
18	.211	.622	95.897						
19	.183	.539	96.436						
20	.172	.505	96.941						
21	.157	.463	97.403						
22	.140	.412	97.815						
23	.137	.404	98.220						
24	.113	.332	98.551						
25	.102	.300	98.851						
26	.081	.239	99.090						
27	.073	.215	99.304						
28	.055	.163	99.467						
29	.045	.133	99.600						
30	.043	.126	99.726						
31	.032	.096	99.822						
32	.025	.074	99.896						
33	.021	.061	99.957						
34	.015	.043	100.000						

Extraction Method: Principal Component Analysis.



Component Transformation Matrix

Component	1	2	3	4	5
1	.585	.556	.444	.351	.172
2	-.401	-.295	.632	.047	.592
3	-.266	.337	-.585	.366	.582
4	-.250	-.203	.090	.837	-.433
5	.603	-.671	-.231	.201	.305

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.

APPENDIX C4 Factor Analysis (Scale: Business Performance)

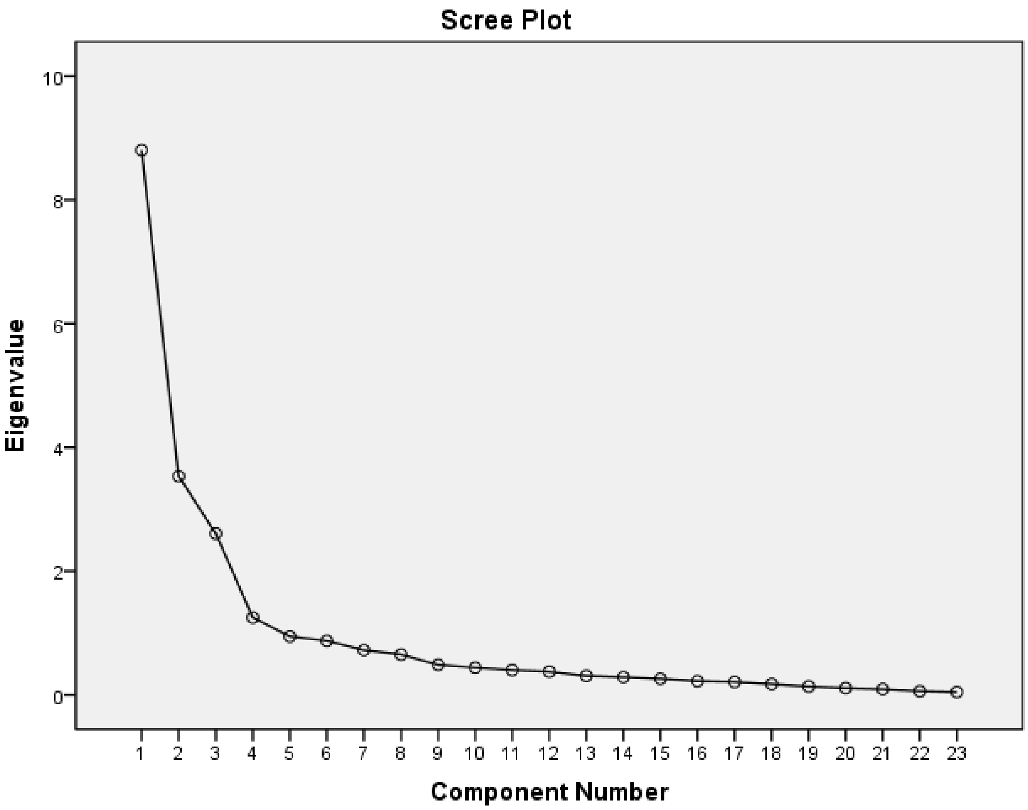
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.793
Bartlett's Test of Sphericity	Approx. Chi-Square	1343.545
	df	253
	Sig.	.000

Total Variance Explained

Com-ponent	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumula-tive %	Total	% of Variance	Cumula-tive %	Total	% of Variance	Cumula-tive %
1	8.804	38.279	38.279	8.804	38.279	38.279	5.400	23.478	23.478
2	3.532	15.358	53.637	3.532	15.358	53.637	4.885	21.240	44.718
3	2.609	11.343	64.981	2.609	11.343	64.981	4.660	20.262	64.981
4	1.250	5.433	70.414						
5	.945	4.110	74.524						
6	.874	3.802	78.326						
7	.723	3.142	81.468						
8	.651	2.830	84.298						
9	.487	2.118	86.416						
10	.442	1.920	88.336						
11	.402	1.746	90.082						
12	.376	1.634	91.716						
13	.308	1.341	93.057						
14	.288	1.252	94.308						
15	.260	1.131	95.439						
16	.222	.965	96.403						
17	.210	.911	97.315						
18	.175	.761	98.075						
19	.135	.588	98.664						
20	.110	.477	99.141						
21	.092	.400	99.541						
22	.060	.261	99.802						
23	.046	.198	100.000						

Extraction Method: Principal Component Analysis.



Component Transformation Matrix

Component	1	2	3
1	.660	.508	.554
2	-.320	.857	-.404
3	-.680	.089	.728

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.

APPENDIX C5 Factor Analysis (Scale: Institutional Pressure)

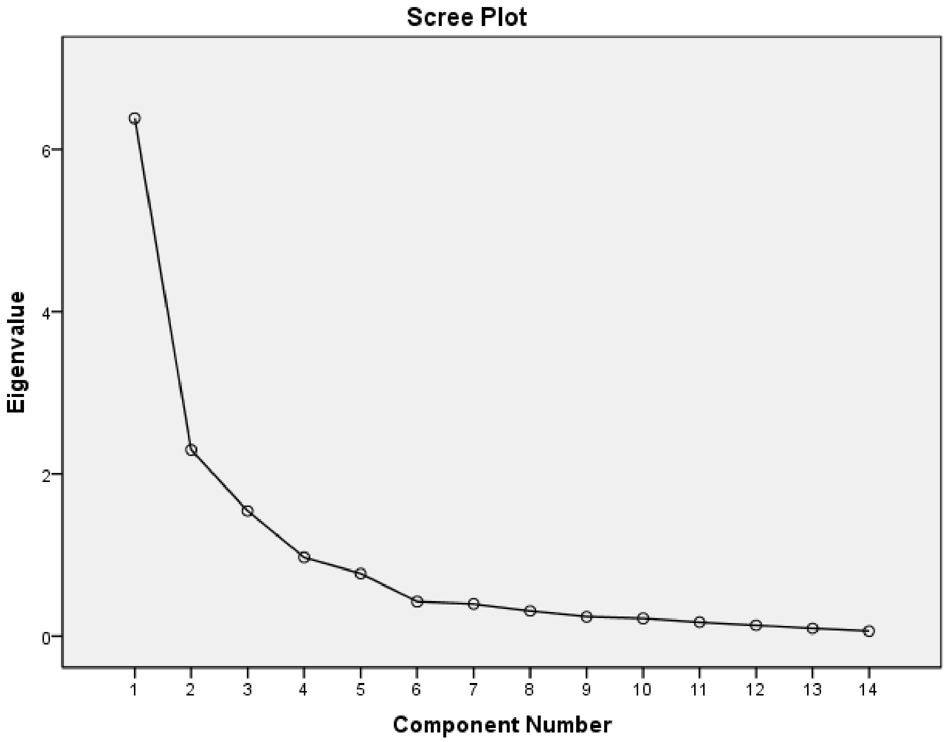
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.783
Bartlett's Test of Sphericity	Approx. Chi-Square	912.079
	df	91
	Sig.	.000

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.385	45.610	45.610	6.385	45.610	45.610	4.987	35.624	35.624
2	2.296	16.401	62.011	2.296	16.401	62.011	3.694	26.387	62.011
3	1.542	11.013	73.024						
4	.970	6.928	79.952						
5	.769	5.494	85.446						
6	.424	3.031	88.477						
7	.395	2.825	91.301						
8	.308	2.203	93.505						
9	.237	1.696	95.200						
10	.216	1.546	96.747						
11	.170	1.211	97.958						
12	.132	.943	98.901						
13	.094	.668	99.569						
14	.060	.431	100.000						

Extraction Method: Principal Component Analysis.



Component Transformation Matrix

Component	1	2
1	.811	.585
2	-.585	.811

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.

APPENDIX D Reliability Analysis

Scale: DfD

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.943	.943	11

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.602	.399	.843	.443	2.111	.009	11

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
DfD 02	30.99	98.014	.801	.820	.936
DfD 03	31.20	95.723	.794	.752	.936
DfD 04	31.04	97.807	.703	.768	.940
DfD 05	31.07	94.274	.865	.849	.933
DfD 06	30.62	99.944	.663	.592	.941
DfD 07	30.80	98.341	.799	.794	.936
DfD 08	31.01	98.191	.739	.587	.938
DfD 09	30.68	98.220	.729	.649	.938
DfD 10	30.90	98.945	.739	.676	.938
DfD 11	30.68	97.956	.749	.743	.938
DfD 12	30.57	99.661	.687	.646	.940

Scale: Design for Environment

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.855	.863	5

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.557	.348	.787	.439	2.261	.023	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
DfR 01	16.26	9.336	.707	.553	.815
DfR 02	15.88	10.363	.729	.666	.812
DfR 03	16.44	9.704	.768	.620	.799
DfR 04	15.99	10.247	.743	.689	.808
DfR 10	16.51	10.799	.455	.234	.884

Scale: Design for Recycling

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.910	.912	3

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.775	.708	.844	.136	1.193	.004	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
DfR 05	6.34	5.664	.771	.607	.915
DfR 06	6.49	5.663	.872	.774	.826
DfR 07	6.35	6.129	.822	.721	.870

Scale: Resource Commitment

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.906	.907	3

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.764	.710	.801	.091	1.129	.002	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
RC 01	6.90	3.768	.785	.628	.890
RC 02	6.67	3.667	.855	.732	.830
RC 03	6.83	3.889	.801	.661	.876

Scale: Repair

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.899	.899	5

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.640	.555	.797	.241	1.435	.006	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Repair 01	13.64	18.031	.774	.672	.871
Repair 02	13.73	17.417	.794	.723	.866
Repair 03	13.98	18.278	.735	.576	.880
Repair 04	13.93	17.766	.739	.592	.879
Repair 05	13.99	18.848	.705	.559	.886

Scale: Recondition

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.959	.959	8

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.743	.573	.877	.304	1.530	.008	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Recondition 01	19.50	71.533	.804	.766	.956
Recondition 02	19.21	68.568	.888	.844	.951
Recondition 03	19.00	68.747	.886	.824	.951
Recondition 04	19.08	68.847	.887	.841	.951
Recondition 05	19.01	67.266	.885	.843	.951
Recondition 06	19.16	68.081	.905	.855	.950
Recondition 07	19.09	71.498	.772	.696	.958
Recondition 08	19.30	73.254	.717	.586	.961

Scale: Remanufacture

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.969	.969	8

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.796	.683	.926	.243	1.355	.006	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Remanufacture 01	17.38	72.452	.770	.616	.970
Remanufacture 02	17.01	68.066	.893	.869	.964
Remanufacture 03	16.84	66.241	.912	.893	.963
Remanufacture 04	16.89	67.002	.929	.897	.962
Remanufacture 05	16.82	65.886	.940	.911	.961
Remanufacture 06	16.93	67.662	.854	.796	.966
Remanufacture 07	16.93	67.956	.904	.879	.963
Remanufacture 08	16.95	67.944	.818	.677	.968

Scale: Recycling

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.896	.897	9

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.492	.205	.668	.463	3.262	.011	9

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Recycling 01	21.39	66.549	.680	.543	.883
Recycling 02	21.04	69.140	.499	.417	.896
Recycling 03	20.11	64.077	.687	.590	.882
Recycling 04	19.91	64.902	.638	.535	.886
Recycling 05	20.70	64.035	.768	.606	.876
Recycling 06	20.85	65.079	.616	.501	.888
Recycling 07	21.56	67.917	.672	.602	.884
Recycling 08	20.92	62.789	.694	.603	.881
Recycling 09	20.86	63.019	.694	.508	.881

Scale: Disposal

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.893	.896	4

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.683	.482	.852	.371	1.770	.013	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Disposal 03	11.72	10.580	.671	.509	.895
Disposal 04	11.44	9.732	.861	.766	.829
Disposal 05	11.70	9.625	.687	.525	.895
Disposal 06	11.57	9.142	.859	.766	.825

Scale: Environmental Outcome

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.899	.903	8

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.538	.329	.811	.481	2.461	.016	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Env Outcome 01	27.36	30.965	.745	.687	.880
Env Outcome 02	27.25	30.996	.816	.756	.874
Env Outcome 03	27.34	32.617	.721	.664	.883
Env Outcome 04	27.25	33.045	.612	.499	.892
Env Outcome 05	27.17	30.483	.775	.749	.877
Env Outcome 06	27.14	31.637	.599	.655	.895
Env Outcome 07	27.94	31.765	.579	.471	.897
Env Outcome 08	27.14	33.759	.688	.568	.887

Scale: Profitability

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.920	.920	8

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.590	.391	.814	.423	2.082	.008	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Profitability 01	21.24	40.050	.720	.570	.910
Profitability 02	21.47	38.893	.713	.579	.911
Profitability 03	21.38	39.999	.709	.570	.911
Profitability 04	21.51	38.920	.782	.719	.905
Profitability 05	21.34	39.428	.784	.728	.905
Profitability 06	21.34	41.241	.625	.567	.917
Profitability 07	21.34	38.761	.739	.740	.909
Profitability 08	21.13	39.262	.792	.770	.904

Scale: Sales Growth

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.922	.922	7

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.630	.453	.756	.303	1.669	.008	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Sales Growth 02	18.17	38.842	.732	.589	.913
Sales Growth 03	18.03	38.856	.716	.634	.914
Sales Growth 04	18.23	37.764	.770	.644	.909
Sales Growth 05	17.81	38.989	.736	.611	.912
Sales Growth 06	17.51	38.409	.796	.660	.906
Sales Growth 07	17.23	40.569	.715	.656	.914
Sales Growth 08	17.64	37.869	.838	.741	.902

Scale: Regulatory Pressure

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.901	.904	8

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.539	.331	.886	.555	2.675	.019	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Regu Pressure 01	26.95	30.648	.661	.808	.891
Regu Pressure 02	27.01	30.614	.653	.816	.892
Regu Pressure 04	26.39	29.615	.720	.573	.885
Regu Pressure 05	26.50	31.578	.617	.566	.895
Regu Pressure 06	26.12	33.022	.682	.588	.891
Regu Pressure 07	26.63	31.127	.722	.657	.885
Regu Pressure 08	26.40	29.786	.833	.796	.875
Regu Pressure 09	26.49	30.831	.656	.679	.891

Scale: Ownership Pressure

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.870	.873	6

Summary Item Statistics

	Mean	Min	Max	Range	Max / Min	Var	N of Items
Inter-Item Correlations	.535	.225	.885	.661	3.941	.055	6

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Owner Pressure 01	14.76	23.551	.711	.816	.841
Owner Pressure 02	14.64	23.526	.755	.849	.834
Owner Pressure 03	14.78	23.269	.787	.805	.829
Owner Pressure 04	15.07	22.507	.759	.746	.832
Owner Pressure 05	15.28	25.227	.487	.648	.881
Owner Pressure 06	15.47	24.764	.555	.657	.868

APPENDIX E Correlation Analysis

Pearson's Product Moment Correlations

		DfD	DfE	DfR	RC	RLPD1	RLPD2	RLPD3	RLPD4	RLPD5	ENV	PRO	SG	PR	PW
DfD	r	1													
	Sig.														
	N	76													
DfE	r	.457**	1												
	Sig.	.000													
	N	76	85												
DfR	r	.600**	.432**	1											
	Sig.	.000	.000												
	N	76	80	80											
RC	r	.294*	.341**	.231*	1										
	Sig.	.010	.002	.039											
	N	76	84	80	88										
RLPD1	r	.704**	.428**	.443**	.092	1									
	Sig.	.000	.000	.000	.407										
	N	75	79	77	83	83									
RLPD2	r	.559**	.301**	.364**	.142	.545**	1								
	Sig.	.000	.009	.002	.216	.000									
	N	71	74	72	78	76	78								
RLPD3	r	.552**	.203	.344**	.067	.479**	.704**	1							
	Sig.	.000	.082	.003	.563	.000	.000								
	N	72	74	73	77	75	75	77							
RLPD4	r	.530**	.290**	.423**	.221*	.373**	.346**	.494**	1						
	Sig.	.000	.008	.000	.041	.001	.002	.000							
	N	75	83	78	86	82	77	76	87						
RLPD5	r	.313**	.525**	.197	.356**	.306**	.287*	.188	.296**	1					
	Sig.	.006	.000	.082	.001	.005	.011	.102	.005						
	N	76	84	79	87	83	78	77	87	88					
ENV	r	.228*	.147	.128	.247*	.041	.174	.183	.260*	.271*	1				
	Sig.	.047	.186	.261	.022	.714	.128	.111	.016	.011					
	N	76	83	79	86	83	78	77	86	87	87				
PRO	r	.570**	.130	.352**	.320**	.417**	.398**	.401**	.437**	.113	.430**	1			
	Sig.	.000	.237	.001	.003	.000	.000	.000	.000	.299	.000				
	N	76	84	79	86	82	77	76	86	87	86	87			
SG	r	.377**	.132	.221	.296**	.079	.249*	.458**	.160	.024	.313**	.487**	1		
	Sig.	.001	.248	.055	.007	.486	.030	.000	.148	.828	.004	.000			
	N	73	79	76	83	80	76	75	83	83	83	82	83		
PR	r	.182	.260*	.090	.334**	.241*	.169	.133	.175	.440**	.348**	.458**	.318**	1	
	Sig.	.116	.017	.429	.002	.028	.138	.249	.105	.000	.001	.000	.003		
	N	76	84	79	87	83	78	77	87	88	87	87	83	88	
PW	r	.325**	.232*	.159	.203	.183	.315**	.338**	.360**	.103	.330**	.462**	.476**	.440**	1
	Sig.	.004	.037	.165	.063	.099	.005	.003	.001	.349	.002	.000	.000	.000	
	N	75	81	78	85	82	78	77	84	85	85	84	83	85	85

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Note: Abbreviations for the dimensions are as follow; Design for Disassembly (**DfD**); Design for Environment (**DfE**); Design for Recycling (**DfR**); Resource Commitment (**RC**); Repair (**RLPD1**); Recondition (**RLPD2**); Remanufacture (**RLPD3**); Recycling (**RLPD4**); Disposal (**RLPD5**); Regulatory Pressure (**PR**); Ownership Pressure (**PW**)

APPENDIX F1 Multiple Regression Analysis of Green Product Design and Resource Commitment on Repair

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.080[a]	.006	-.036	1.07235	.006	.153	3	71	.928	
2	.745[b]	.555	.508	.73913	.548	20.612	4	67	.000	2.074

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Design for Recycling, Resource Commitment, Design for Environment, Design for Disassembly
c. Dependent Variable: Repair

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.527	3	.176	.153	.928[a]
	Residual	81.645	71	1.150		
	Total	82.172	74			
2	Regression	45.569	7	6.510	11.916	.000[b]
	Residual	36.603	67	.546		
	Total	82.172	74			

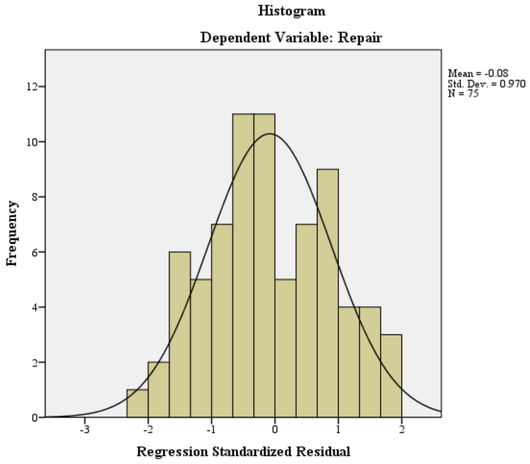
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Design for Recycling, Resource Commitment, Design for Environment, Design for Disassembly
c. Dependent Variable: Repair

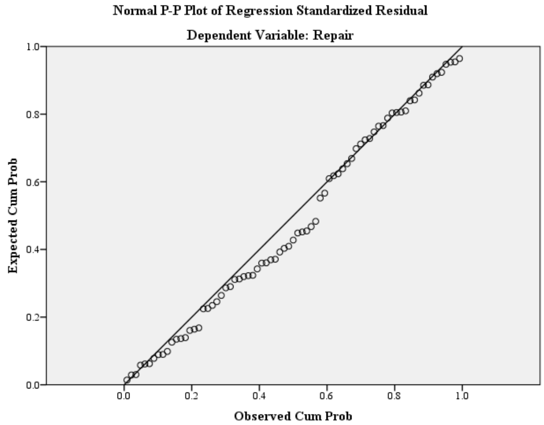
Coefficients[a]

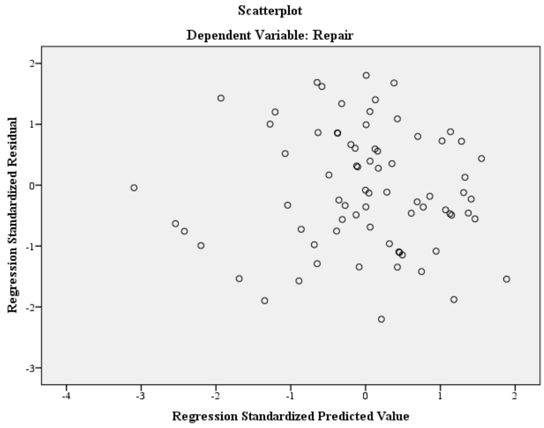
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.494	.370		9.450	.000		
	Small Firms	-.005	.446	-.002	-.011	.991	.415	2.409
	Medium Firms	.068	.440	.029	.155	.877	.403	2.483
	Large Firms	-.136	.422	-.063	-.323	.748	.370	2.706
2	(Constant)	1.204	.580		2.077	.042		
	Small Firms	-.313	.324	-.129	-.964	.339	.373	2.679
	Medium Firms	-.114	.319	-.048	-.357	.723	.365	2.737
	Large Firms	-.438	.301	-.202	-1.457	.150	.346	2.893
	Design for Disassembly	.740	.115	.712	6.454	.000	.547	1.829
	Design for Environment	.217	.126	.169	1.726	.089	.697	1.435
	Design for Recycling	-.030	.096	-.034	-.314	.754	.573	1.746
	Resource Commitment	-.165	.105	-.148	-1.574	.120	.749	1.335

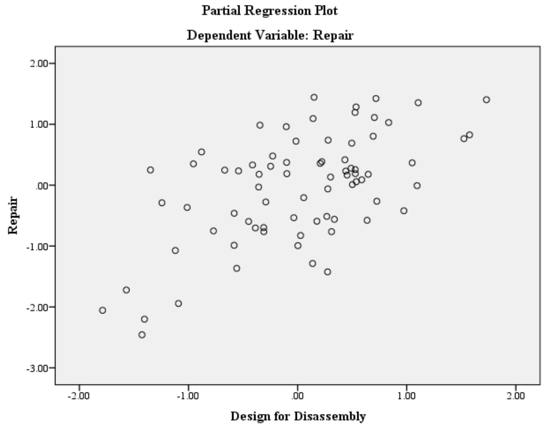
a. Dependent Variable: Repair

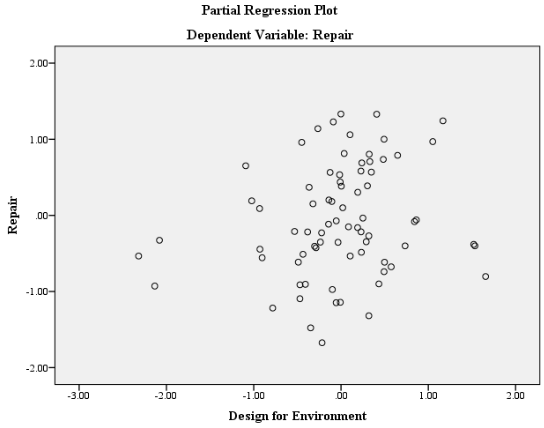
Chart

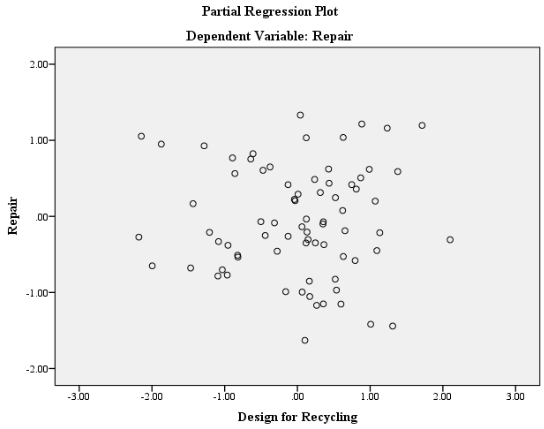

Histogram
Dependent Variable: Repair
Mean = -0.08
Std. Dev. = 0.970
N = 75
Frequency
Regression Standardized Residual

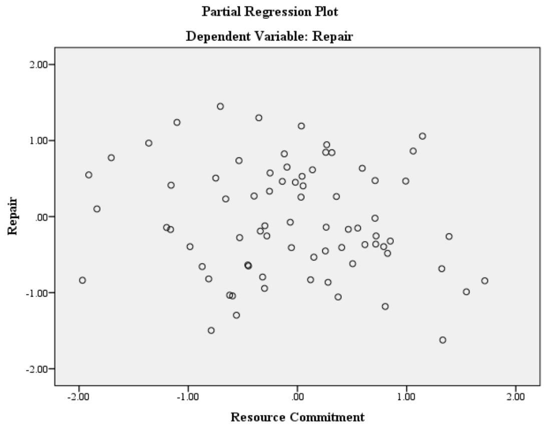

Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Repair
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: Repair
Regression Standardized Residual
Regression Standardized Predicted Value


Partial Regression Plot
Dependent Variable: Repair
Repair
Design for Disassembly


Partial Regression Plot
Dependent Variable: Repair
Repair
Design for Environment


Partial Regression Plot
Dependent Variable: Repair
Repair
Design for Recycling


Partial Regression Plot
Dependent Variable: Repair
Repair
Resource Commitment

APPENDIX F2 Multiple Regression Analysis of Green Product Design and Resource Commitment on Recondition

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.265[a]	.070	.029	1.17619	.070	1.686	3	67	.178	
2	.656[b]	.430	.367	.94952	.360	9.952	4	63	.000	1.926

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Design for Recycling, Resource Commitment, Design for Environment, Design for Disassembly
c. Dependent Variable: Recondition

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.996	3	2.332	1.686	.178[a]
	Residual	92.689	67	1.383		
	Total	99.685	70			
2	Regression	42.885	7	6.126	6.795	.000[b]
	Residual	56.800	63	.902		
	Total	99.685	70			

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Design for Recycling, Resource Commitment, Design for Environment, Design for Disassembly
c. Dependent Variable: Recondition

Coefficients[a]

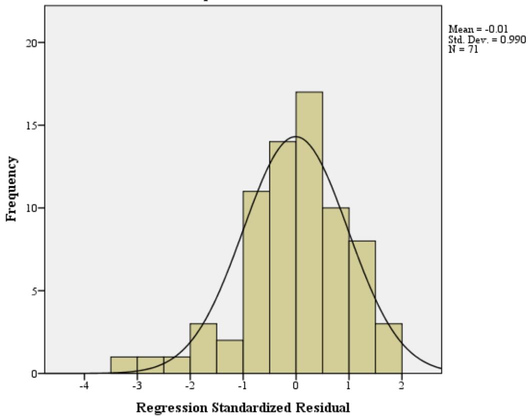
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.262	.417		7.823	.000		
	Small Firms	-.828	.503	-.301	-1.646	.104	.415	2.409
	Medium Firms	-.143	.496	-.054	-.288	.774	.403	2.483
	Large Firms	-.663	.476	-.270	-1.393	.168	.370	2.706
2	(Constant)	1.282	.766		1.675	.099		
	Small Firms	-1.107	.428	-.402	-2.585	.012	.373	2.679
	Medium Firms	-.304	.421	-.114	-.722	.473	.365	2.737
	Large Firms	-.975	.397	-.397	-2.455	.017	.346	2.893
	Design for Disassembly	.720	.151	.612	4.757	.000	.547	1.829
	Design for Environment	.049	.166	.034	.295	.769	.697	1.435
	Design for Recycling	-.017	.127	-.017	-.134	.894	.573	1.746
	Resource Commitment	-.054	.139	-.043	-.393	.696	.749	1.335

a. Dependent Variable: Recondition

Charts

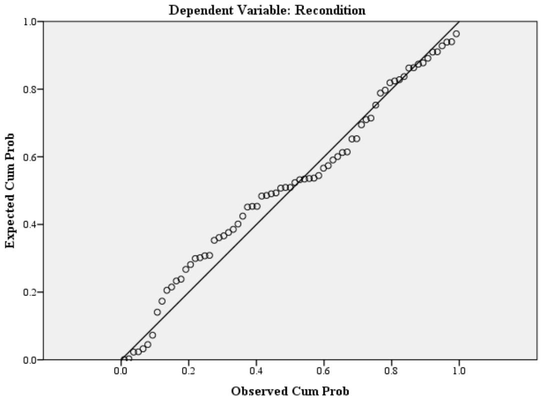
Histogram

Dependent Variable: Recondition



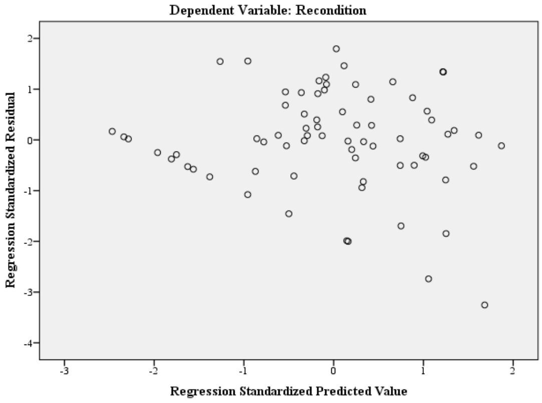
Normal P-P Plot of Regression Standardized Residual

Dependent Variable: Recondition



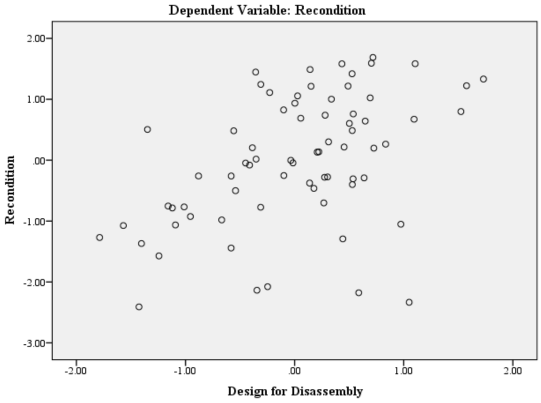
Scatterplot

Dependent Variable: Recondition



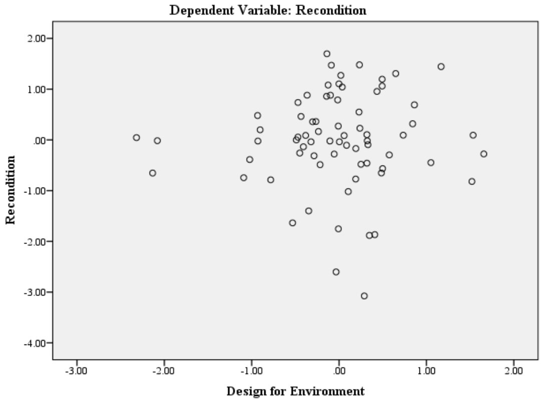
Partial Regression Plot

Dependent Variable: Recondition



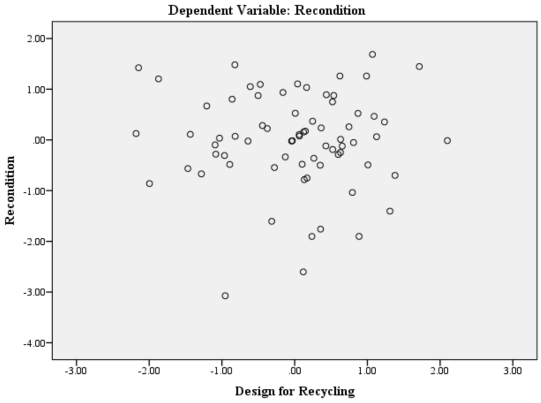
Partial Regression Plot

Dependent Variable: Recondition



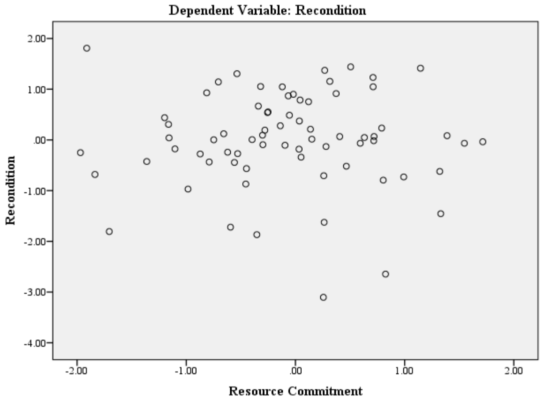
Partial Regression Plot

Dependent Variable: Recondition



Partial Regression Plot

Dependent Variable: Recondition



APPENDIX F3 Multiple Regression Analysis of Green Product Design and Resource Commitment on Remanufacture

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.261[a]	.068	.027	1.15095	.068	1.659	3	68	.184	
2	.646[b]	.417	.353	.93849	.349	9.568	4	64	.000	2.221

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Design for Recycling, Resource Commitment, Design for Environment, Design for Disassembly
c. Dependent Variable: Remanufacture

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.594	3	2.198	1.659	.184[a]
	Residual	90.078	68	1.325		
	Total	96.672	71			
2	Regression	40.303	7	5.758	6.537	.000[b]
	Residual	56.369	64	.881		
	Total	96.672	71			

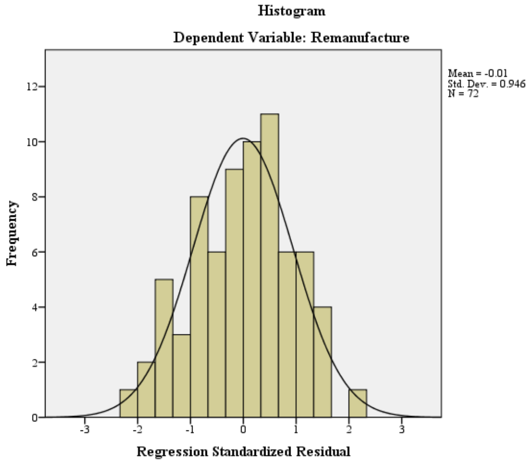
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Design for Recycling, Resource Commitment, Design for Environment, Design for Disassembly
c. Dependent Variable: Remanufacture

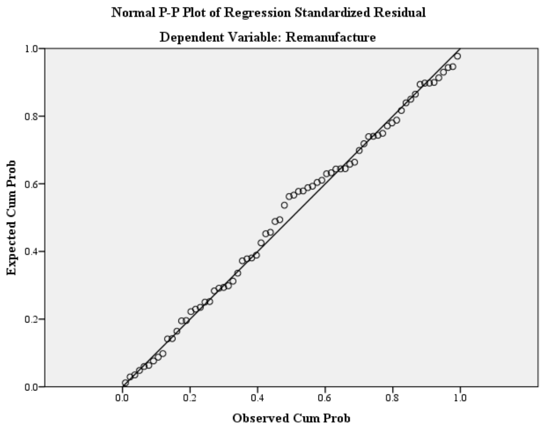
Coefficients[a]

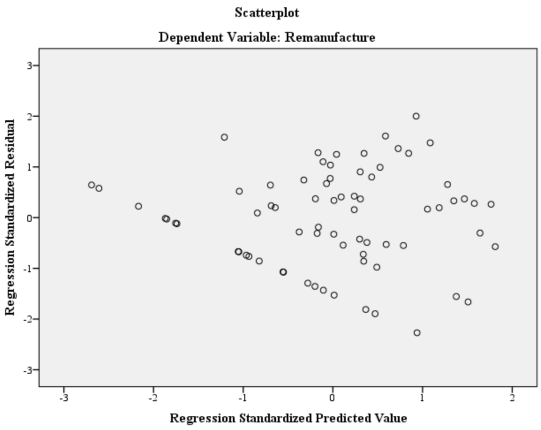
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.520	.405		6.221	.000		
	Small Firms	-.345	.489	-.128	-.707	.482	.415	2.409
	Medium Firms	.373	.482	.143	.774	.441	.403	2.483
	Large Firms	-.304	.463	-.126	-.657	.514	.370	2.706
2	(Constant)	1.128	.751		1.501	.138		
	Small Firms	-.701	.420	-.260	-1.667	.100	.373	2.679
	Medium Firms	.133	.413	.051	.323	.748	.365	2.737
	Large Firms	-.654	.390	-.272	-1.676	.099	.346	2.893
	Design for Disassembly	.741	.149	.644	4.987	.000	.547	1.829
	Design for Environment	-.078	.163	-.055	-.478	.634	.697	1.435
	Design for Recycling	-.013	.125	-.013	-.101	.920	.573	1.746
	Resource Commitment	-.084	.136	-.068	-.615	.541	.749	1.335

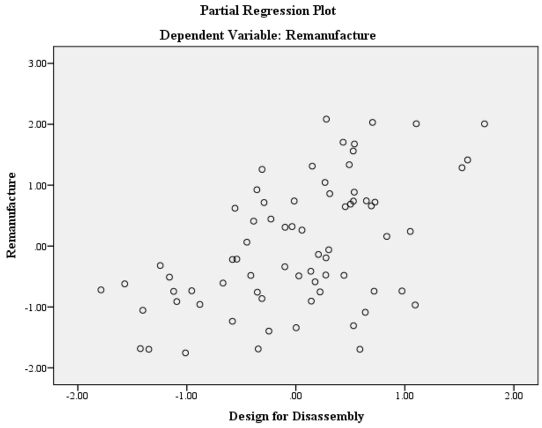
a. Dependent Variable: Remanufacture

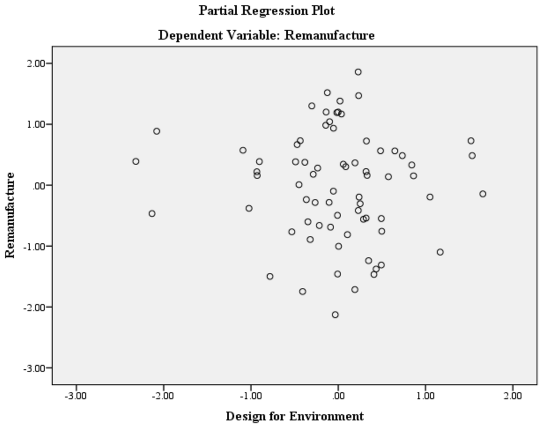
Charts

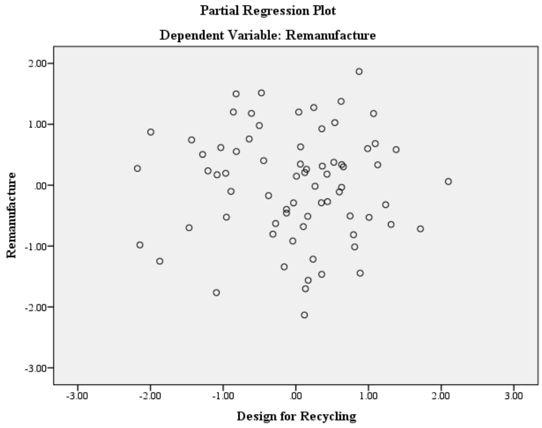

Histogram
Dependent Variable: Remanufacture
Mean = -0.01
Std. Dev. = 0.946
N = 72
Frequency
Regression Standardized Residual

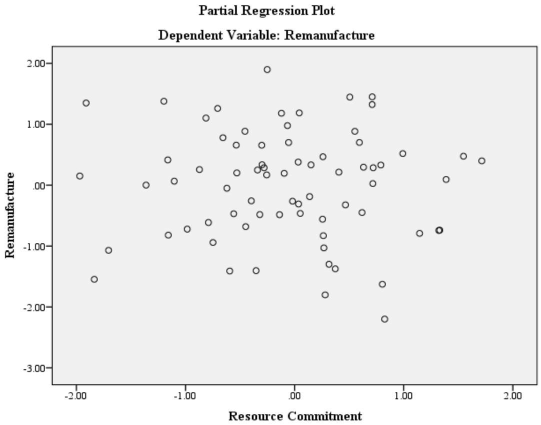

Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Remanufacture
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: Remanufacture
Regression Standardized Residual
Regression Standardized Predicted Value


Partial Regression Plot
Dependent Variable: Remanufacture
Remanufacture
Design for Disassembly


Partial Regression Plot
Dependent Variable: Remanufacture
Remanufacture
Design for Environment


Partial Regression Plot
Dependent Variable: Remanufacture
Remanufacture
Design for Recycling


Partial Regression Plot
Dependent Variable: Remanufacture
Remanufacture
Resource Commitment

APPENDIX F4 Multiple Regression Analysis of Green Product Design and Resource Commitment on Recycle

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.139[a]	.019	-.022	1.05200	.019	.463	3	71	.709	
2	.569[b]	.324	.254	.89890	.305	7.561	4	67	.000	2.260

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Design for Recycling, Resource Commitment, Design for Environment, Design for Disassembly
c. Dependent Variable: Recycle

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.539	3	.513	.463	.709[a]
	Residual	78.576	71	1.107		
	Total	80.114	74			
2	Regression	25.977	7	3.711	4.593	.000[b]
	Residual	54.138	67	.808		
	Total	80.114	74			

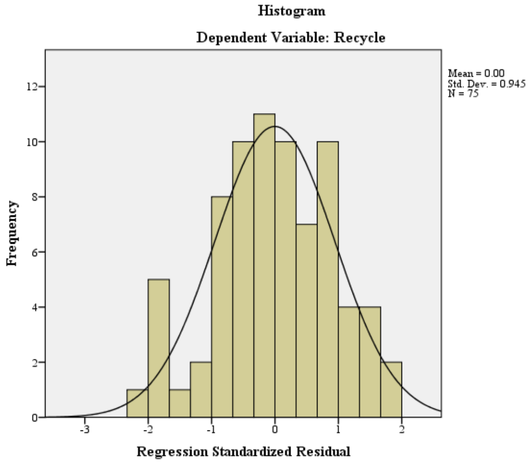
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Design for Recycling, Resource Commitment, Design for Environment, Design for Disassembly
c. Dependent Variable: Recycle

Coefficients[a]

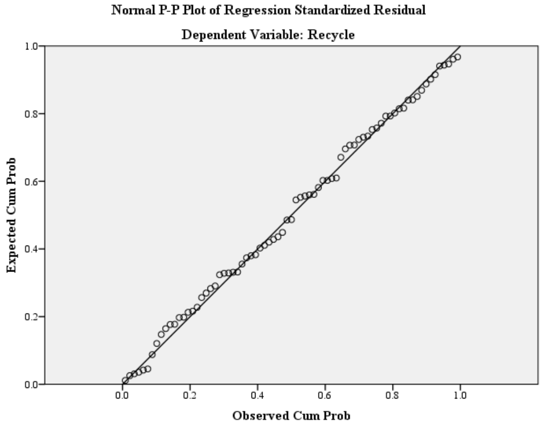
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.387	.363		6.581	.000		
	Small Firms	.489	.438	.204	1.118	.267	.415	2.409
	Medium Firms	.380	.432	.163	.881	.381	.403	2.483
	Large Firms	.268	.414	.125	.648	.519	.370	2.706
2	(Constant)	.140	.705		.199	.843		
	Small Firms	.456	.394	.190	1.156	.252	.373	2.679
	Medium Firms	.436	.387	.187	1.125	.265	.365	2.737
	Large Firms	.150	.366	.070	.409	.684	.346	2.893
	Design for Disassembly	.410	.139	.399	2.940	.004	.547	1.829
	Design for Environment	.046	.153	.036	.301	.764	.697	1.435
	Design for Recycling	.114	.117	.129	.972	.335	.573	1.746
	Resource Commitment	.133	.128	.121	1.042	.301	.749	1.335

a. Dependent Variable: Recycle

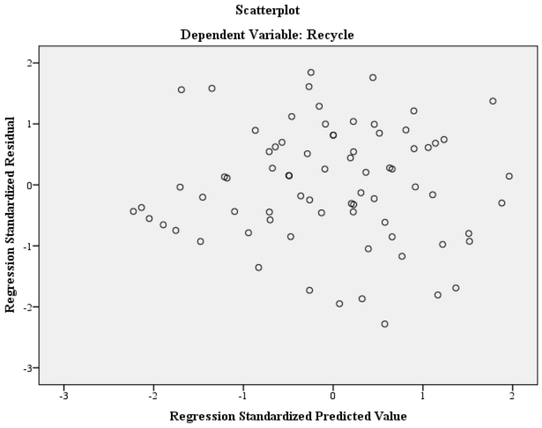
Charts



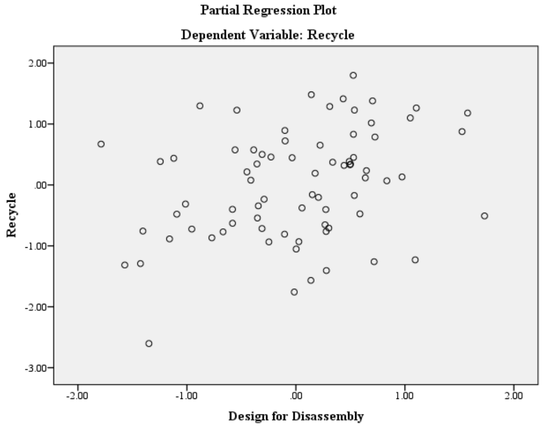
Histogram
Dependent Variable: Recycle
Mean = 0.00
Std. Dev. = 0.945
N = 75
Frequency
Regression Standardized Residual



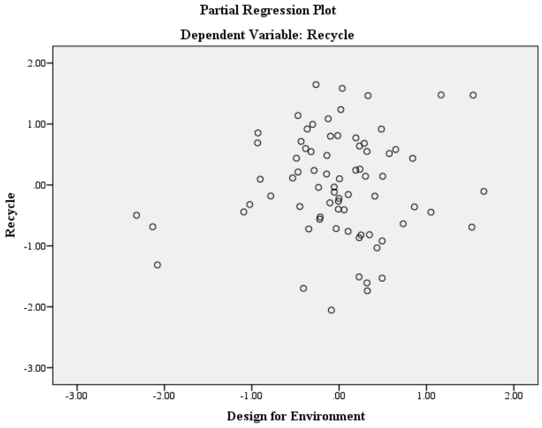
Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Recycle
Expected Cum Prob
Observed Cum Prob



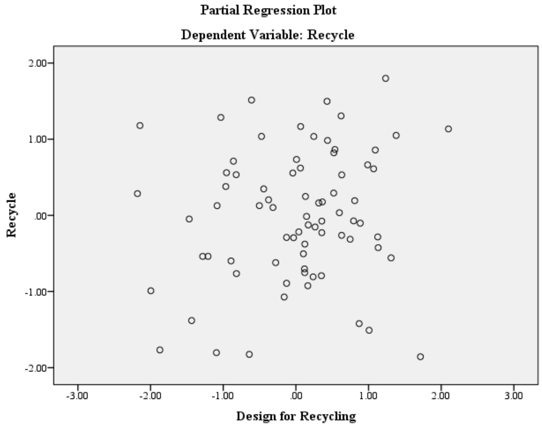
Scatterplot
Dependent Variable: Recycle
Regression Standardized Residual
Regression Standardized Predicted Value



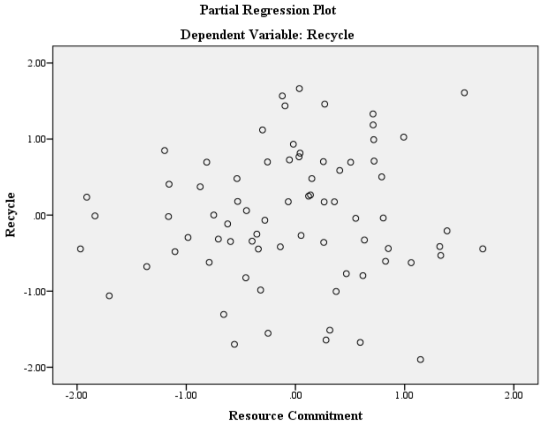
Partial Regression Plot
Dependent Variable: Recycle
Recycle
Design for Disassembly



Partial Regression Plot
Dependent Variable: Recycle
Recycle
Design for Environment



Partial Regression Plot
Dependent Variable: Recycle
Recycle
Design for Recycling



Partial Regression Plot
Dependent Variable: Recycle
Recycle
Resource Commitment

APPENDIX F5 Multiple Regression Analysis of Green Product Design and Resource Commitment on Disposal

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.186[a]	.035	-.006	1.01561	.035	.863	3	72	.465	
2	.570[b]	.325	.255	.87393	.290	7.309	4	68	.000	1.713

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Design for Recycling, Resource Commitment, Design for Environment, Design for Disassembly
c. Dependent Variable: Disposal

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.669	3	.890	.863	.465[a]
	Residual	74.265	72	1.031		
	Total	76.934	75			
2	Regression	24.999	7	3.571	4.676	.000[b]
	Residual	51.936	68	.764		
	Total	76.934	75			

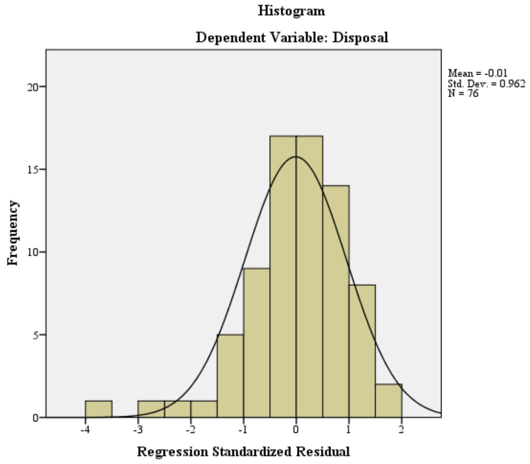
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Design for Recycling, Resource Commitment, Design for Environment, Design for Disassembly
c. Dependent Variable: Disposal

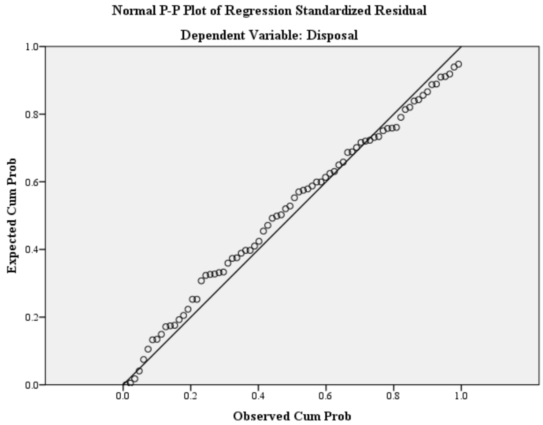
Coefficients[a]

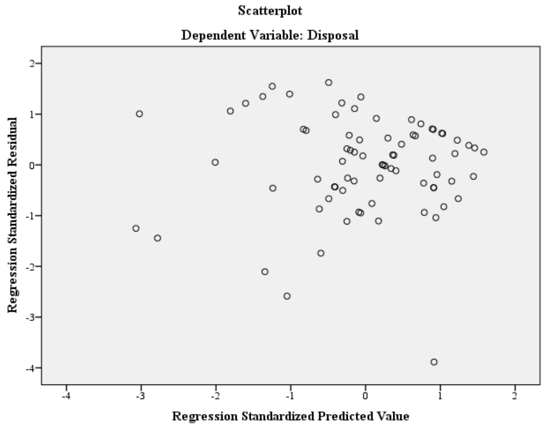
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	4.156	.348		11.948	.000		
	Small Firms	-.499	.420	-.214	-1.189	.239	.415	2.409
	Medium Firms	-.436	.414	-.192	-1.052	.296	.403	2.483
	Large Firms	-.132	.397	-.063	-.332	.741	.370	2.706
2	(Constant)	.995	.681		1.461	.149		
	Small Firms	-.192	.381	-.082	-.503	.617	.373	2.679
	Medium Firms	-.089	.374	-.039	-.239	.812	.365	2.737
	Large Firms	-.075	.353	-.036	-.214	.832	.346	2.893
	Design for Disassembly	.126	.135	.126	.936	.353	.547	1.829
	Design for Environment	.554	.147	.448	3.755	.000	.697	1.435
	Design for Recycling	-.094	.113	-.110	-.833	.407	.573	1.746
	Resource Commitment	.189	.123	.177	1.534	.130	.749	1.335

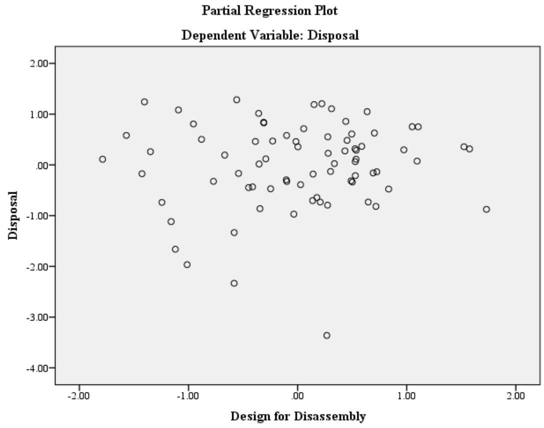
a. Dependent Variable: Disposal

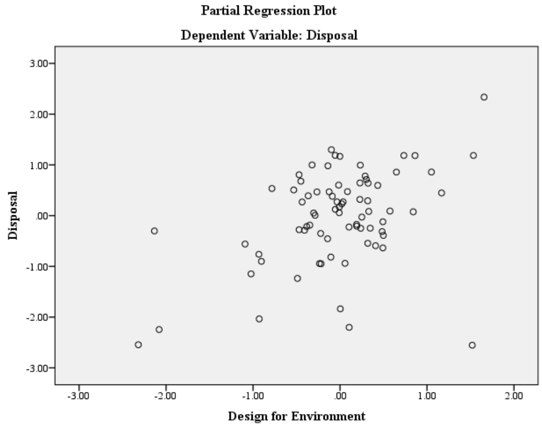
Charts

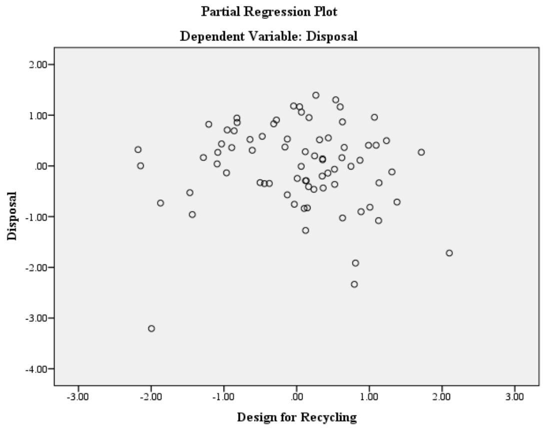

Histogram
Dependent Variable: Disposal
Mean = -0.01
Std. Dev. = 0.962
N = 76
Frequency
Regression Standardized Residual

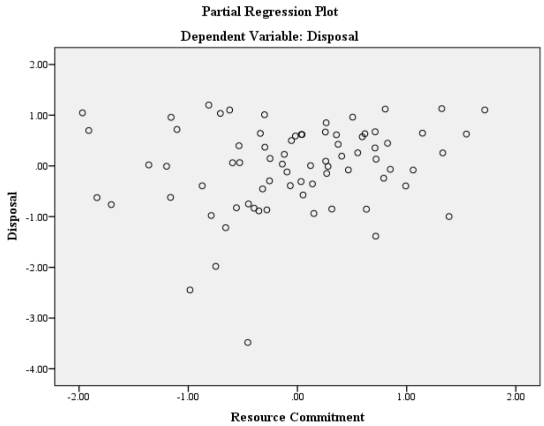

Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Disposal
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: Disposal
Regression Standardized Residual
Regression Standardized Predicted Value


Partial Regression Plot
Dependent Variable: Disposal
Disposal
Design for Disassembly


Partial Regression Plot
Dependent Variable: Disposal
Disposal
Design for Environment


Partial Regression Plot
Dependent Variable: Disposal
Disposal
Design for Recycling


Partial Regression Plot
Dependent Variable: Disposal
Disposal
Resource Commitment

APPENDIX F6 Multiple Regression Analysis of Reverse Logistics Product Disposition on Environment Outcome

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.095[a]	.009	-.033	.81278	.009	.218	3	71	.884	
2	.374[b]	.140	.036	.78526	.131	2.013	5	66	.088	2.251

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Dependent Variable: Environmental Outcome

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.431	3	.144	.218	.884[a]
	Residual	46.903	71	.661		
	Total	47.335	74			
2	Regression	6.637	8	.830	1.345	.237[b]
	Residual	40.698	66	.617		
	Total	47.335	74			

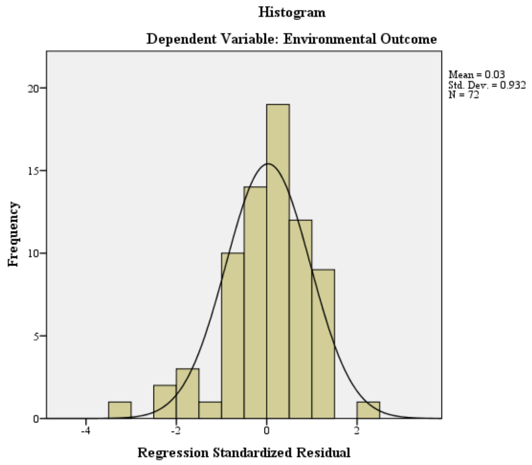
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Dependent Variable: Environmental Outcome

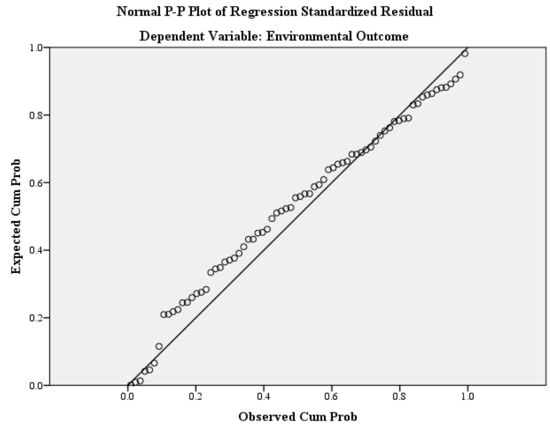
Coefficients[a]

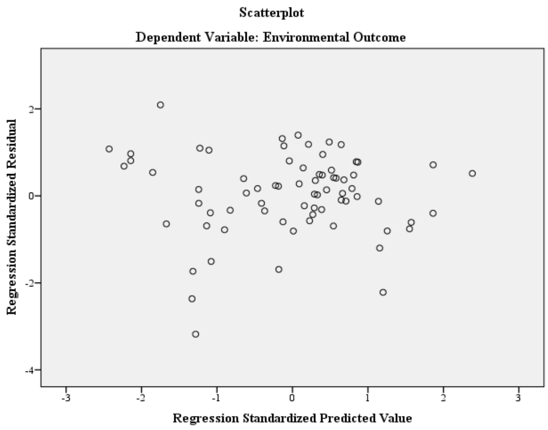
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.959	.280		14.128	.000		
	Small Firms	-.160	.338	-.087	-.473	.638	.415	2.409
	Medium Firms	-.143	.334	-.080	-.430	.669	.403	2.483
	Large Firms	.000	.320	.000	.001	.999	.370	2.706
2	(Constant)	3.036	.510		5.956	.000		
	Small Firms	-.082	.347	-.044	-.236	.814	.369	2.714
	Medium Firms	-.131	.331	-.073	-.396	.693	.382	2.619
	Large Firms	.020	.318	.012	.064	.949	.350	2.855
	Repair	-.138	.109	-.182	-1.271	.208	.634	1.577
	Recondition	.063	.118	.093	.529	.598	.418	2.395
	Remanufacture	.055	.123	.080	.447	.656	.408	2.454
	Recycle	.154	.108	.200	1.425	.159	.658	1.520
	Disposal	.167	.101	.212	1.660	.102	.799	1.252

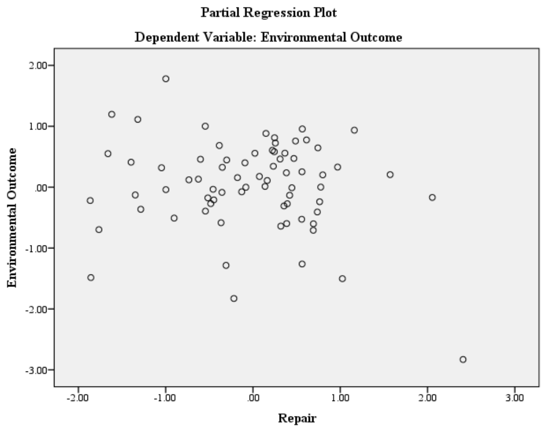
a. Dependent Variable: Environmental Outcome

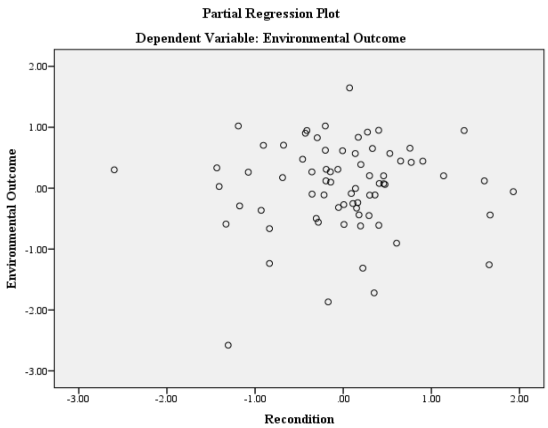
Charts

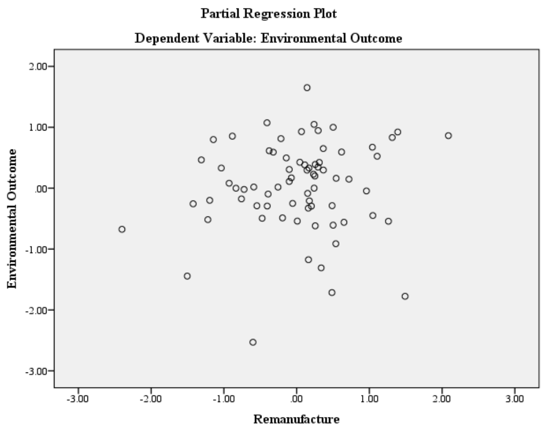

Histogram
Dependent Variable: Environmental Outcome
Mean = 0.03
Std. Dev. = 0.932
N = 72
Frequency
Regression Standardized Residual

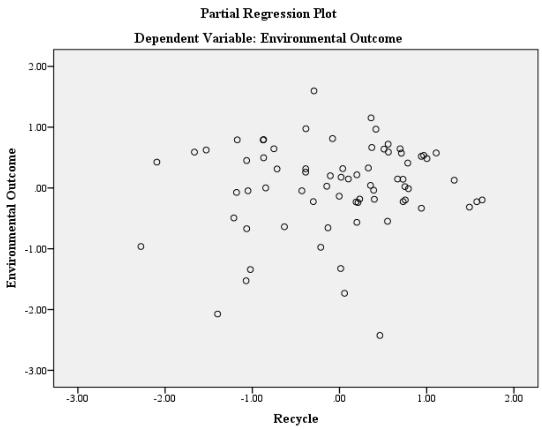

Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Environmental Outcome
Expected Cum Prob
Observed Cum Prob

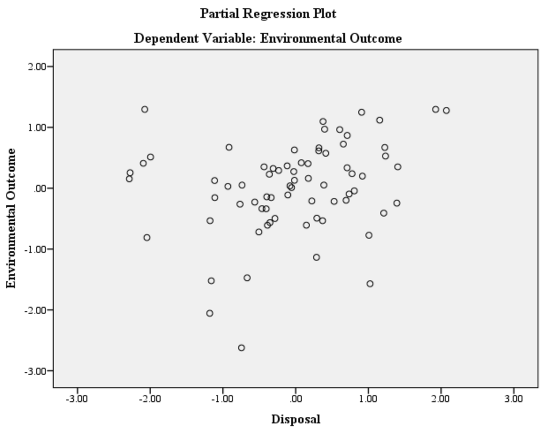

Scatterplot
Dependent Variable: Environmental Outcome
Regression Standardized Residual
Regression Standardized Predicted Value


Partial Regression Plot
Dependent Variable: Environmental Outcome
Environmental Outcome
Repair


Partial Regression Plot
Dependent Variable: Environmental Outcome
Environmental Outcome
Recondition


Partial Regression Plot
Dependent Variable: Environmental Outcome
Environmental Outcome
Remanufacture


Partial Regression Plot
Dependent Variable: Environmental Outcome
Environmental Outcome
Recycle


Partial Regression Plot
Dependent Variable: Environmental Outcome
Environmental Outcome
Disposal

APPENDIX F7 Multiple Regression Analysis of Reverse Logistics Product Disposition on Profitability

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.177[a]	.031	-.010	.94814	.031	.767	3	71	.516	
2	.596[b]	.355	.277	.80241	.324	6.627	5	66	.000	1.926

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Dependent Variable: Profitability

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.069	3	.690	.767	.516[a]
	Residual	63.827	71	.899		
	Total	65.897	74			
2	Regression	23.402	8	2.925	4.543	.000[b]
	Residual	42.495	66	.644		
	Total	65.897	74			

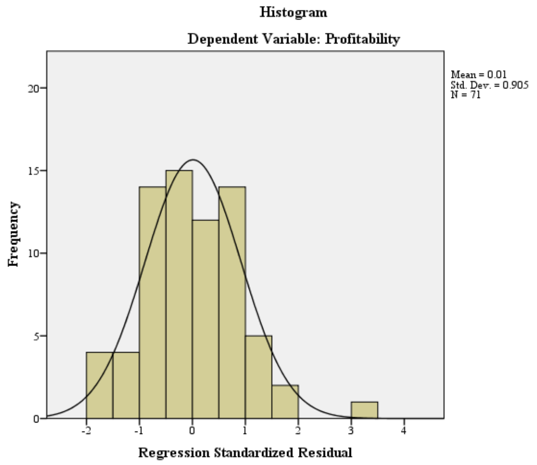
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Dependent Variable: Profitability

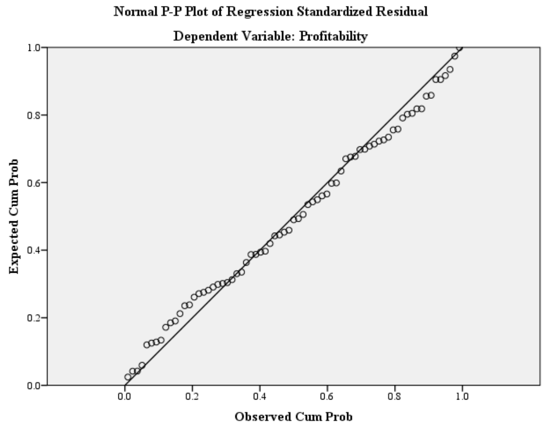
Coefficients[a]

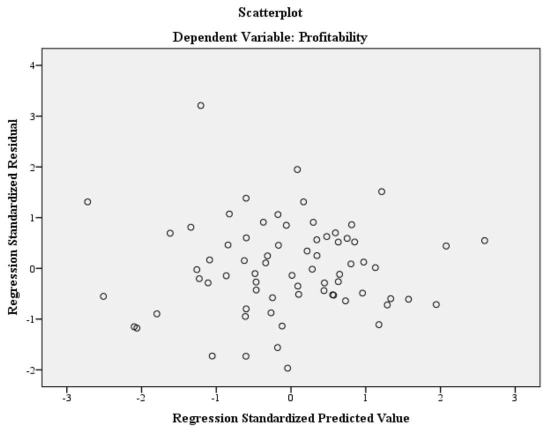
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.754	.327		8.424	.000		
	Small Firms	.320	.394	.147	.811	.420	.415	2.409
	Medium Firms	.274	.389	.130	.705	.483	.403	2.483
	Large Firms	.531	.373	.273	1.422	.159	.370	2.706
2	(Constant)	1.261	.521		2.421	.018		
	Small Firms	.297	.354	.137	.839	.404	.369	2.714
	Medium Firms	.112	.338	.053	.330	.743	.382	2.619
	Large Firms	.604	.324	.311	1.860	.067	.350	2.855
	Repair	.194	.111	.217	1.747	.085	.634	1.577
	Recondition	.167	.121	.211	1.377	.173	.418	2.395
	Remanufacture	.065	.125	.081	.522	.604	.408	2.454
	Recycle	.254	.111	.280	2.295	.025	.658	1.520
	Disposal	-.120	.103	-.129	-1.166	.248	.799	1.252

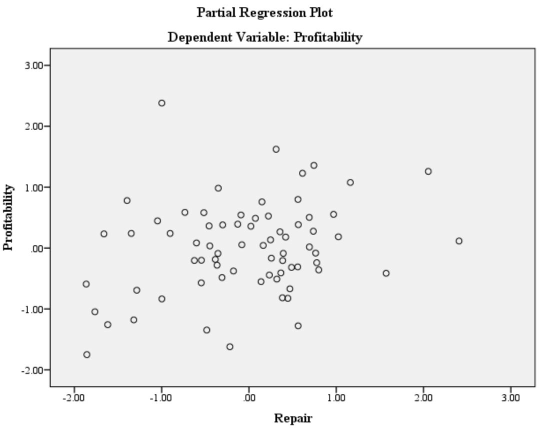
a. Dependent Variable: Profitability

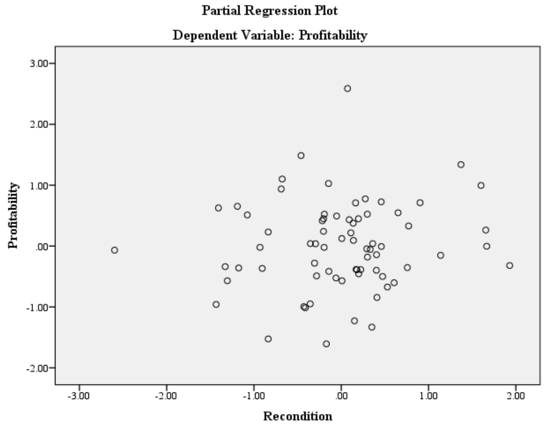
Charts

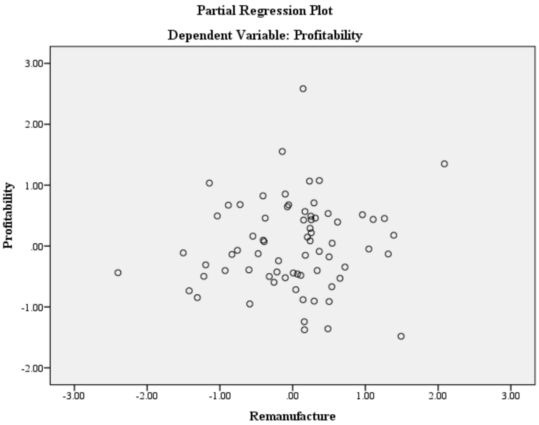

Histogram
Dependent Variable: Profitability
Mean = 0.01
Std. Dev. = 0.905
N = 71
Frequency
Regression Standardized Residual

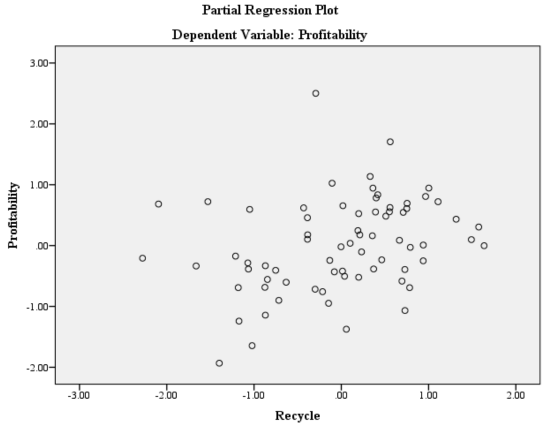

Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Profitability
Expected Cum Prob
Observed Cum Prob

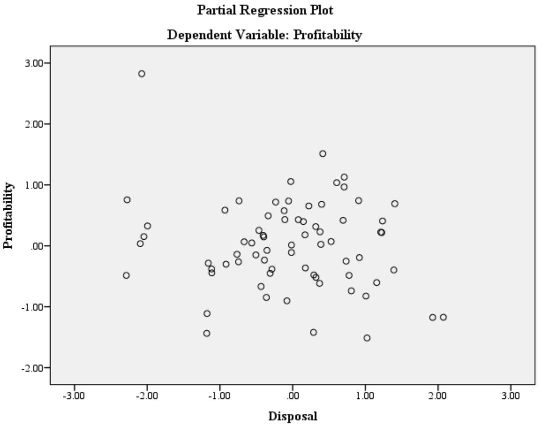

Scatterplot
Dependent Variable: Profitability
Regression Standardized Residual
Regression Standardized Predicted Value


Partial Regression Plot
Dependent Variable: Profitability
Profitability
Repair


Partial Regression Plot
Dependent Variable: Profitability
Profitability
Recondition


Partial Regression Plot
Dependent Variable: Profitability
Profitability
Remanufacture


Partial Regression Plot
Dependent Variable: Profitability
Profitability
Recycle


Partial Regression Plot
Dependent Variable: Profitability
Profitability
Disposal

APPENDIX F8 Multiple Regression Analysis of Reverse Logistics Product Disposition on Sales Growth

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.284[a]	.081	.042	1.04820	.081	2.084	3	71	.110	
2	.585[b]	.342	.262	.91973	.261	5.244	5	66	.000	2.023

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Dependent Variable: Sales Growth

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.868	3	2.289	2.084	.110[a]
	Residual	78.009	71	1.099		
	Total	84.877	74			
2	Regression	29.047	8	3.631	4.292	.000[b]
	Residual	55.830	66	.846		
	Total	84.877	74			

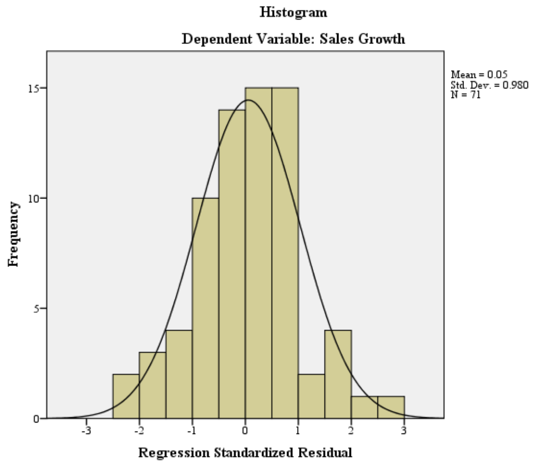
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Dependent Variable: Sales Growth

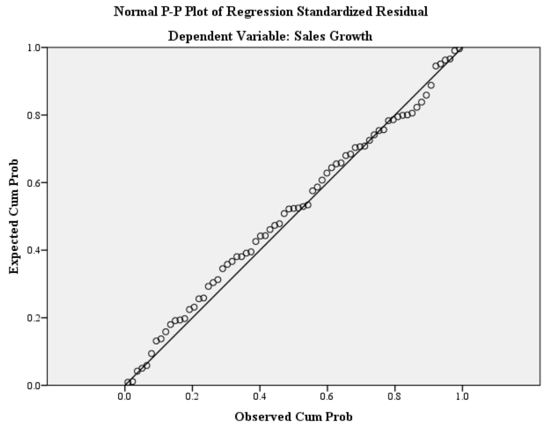
Coefficients[a]

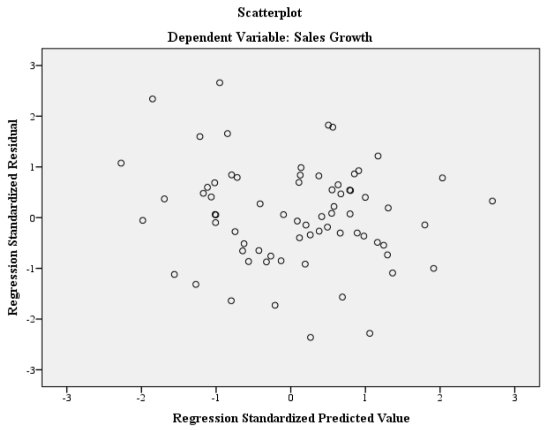
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.715	.361		7.512	.000		
	Small Firms	-.101	.436	-.041	-.231	.818	.415	2.409
	Medium Firms	.301	.430	.125	.699	.487	.403	2.483
	Large Firms	.637	.413	.289	1.543	.127	.370	2.706
2	(Constant)	2.268	.597		3.799	.000		
	Small Firms	.062	.406	.025	.152	.880	.369	2.714
	Medium Firms	.079	.388	.033	.203	.840	.382	2.619
	Large Firms	.773	.372	.351	2.079	.042	.350	2.855
	Repair	-.137	.127	-.135	-1.075	.286	.634	1.577
	Recondition	-.052	.139	-.058	-.373	.710	.418	2.395
	Remanufacture	.594	.144	.647	4.140	.000	.408	2.454
	Recycle	-.064	.127	-.062	-.502	.617	.658	1.520
	Disposal	-.061	.118	-.057	-.513	.609	.799	1.252

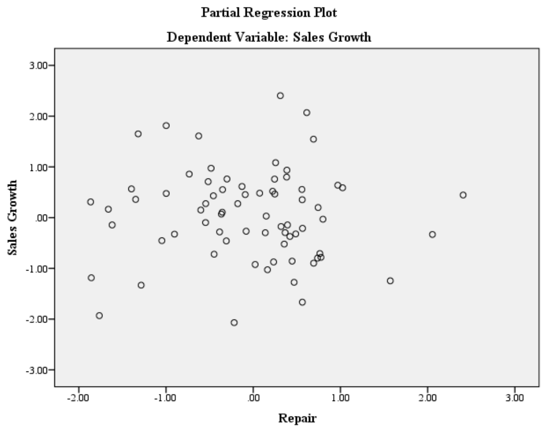
a. Dependent Variable: Sales Growth

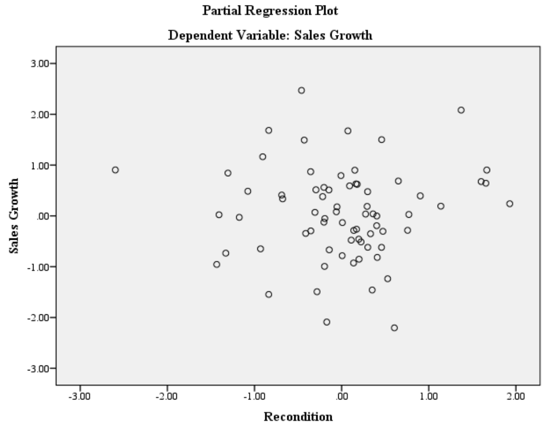
Charts

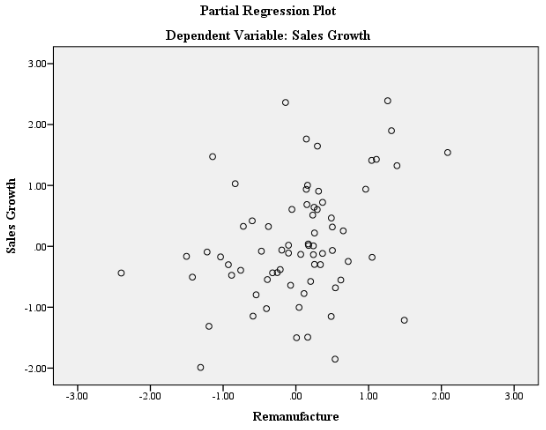

Histogram
Dependent Variable: Sales Growth
Mean = 0.05
Std. Dev. = 0.980
N = 71
Frequency
Regression Standardized Residual

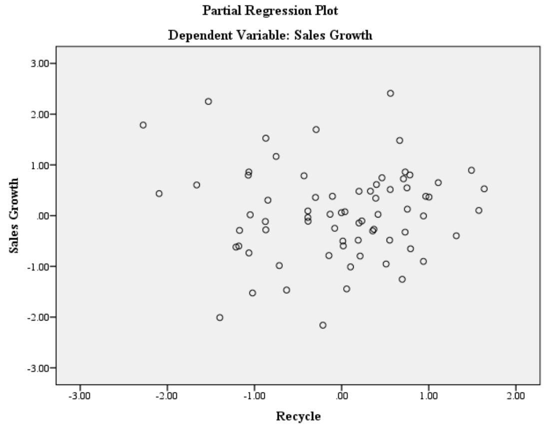

Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Sales Growth
Expected Cum Prob
Observed Cum Prob

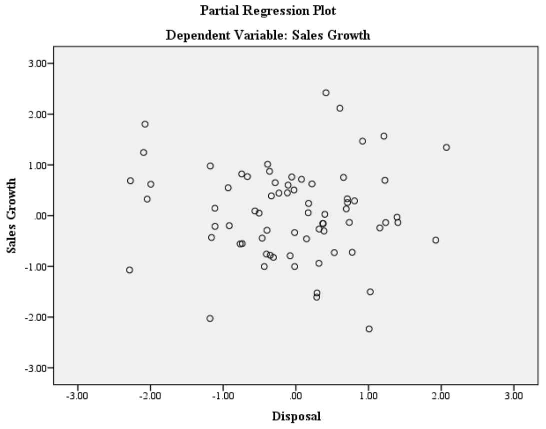

Scatterplot
Dependent Variable: Sales Growth
Regression Standardized Residual
Regression Standardized Predicted Value


Partial Regression Plot
Dependent Variable: Sales Growth
Sales Growth
Repair


Partial Regression Plot
Dependent Variable: Sales Growth
Sales Growth
Recondition


Partial Regression Plot
Dependent Variable: Sales Growth
Sales Growth
Remanufacture


Partial Regression Plot
Dependent Variable: Sales Growth
Sales Growth
Recycle


Partial Regression Plot
Dependent Variable: Sales Growth
Sales Growth
Disposal

APPENDIX G1 Hierarchical Regression Analysis of Regulatory Pressure on the Relationship between Reverse Logistics Product Disposition and Environmental Outcome

Predictor : Reverse Logistics Product Disposition
Outcome : Environmental Outcome
Moderator : Regulatory Pressure

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.095[a]	.009	-.033	.81278	.009	.218	3	71	.884	
2	.374[b]	.140	.036	.78526	.131	2.013	5	66	.088	
3	.453[c]	.206	.096	.76061	.065	5.347	1	65	.024	
4	.629[d]	.396	.255	.69028	.190	3.784	5	60	.005	1.909

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Regulatory P.
d. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Regulatory P., RemanuxRegu, DispxRegu, RecycxRregu, RepairxRegu, ReconxRegu
e. Dependent Variable: Environmental Outcome

ANOVA[e]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.431	3	.144	.218	.884[a]
	Residual	46.903	71	.661		
	Total	47.335	74			
2	Regression	6.637	8	.830	1.345	.237[b]
	Residual	40.698	66	.617		
	Total	47.335	74			
3	Regression	9.730	9	1.081	1.869	.073[c]
	Residual	37.604	65	.579		
	Total	47.335	74			
4	Regression	18.745	14	1.339	2.810	.003[d]
	Residual	28.590	60	.476		
	Total	47.335	74			

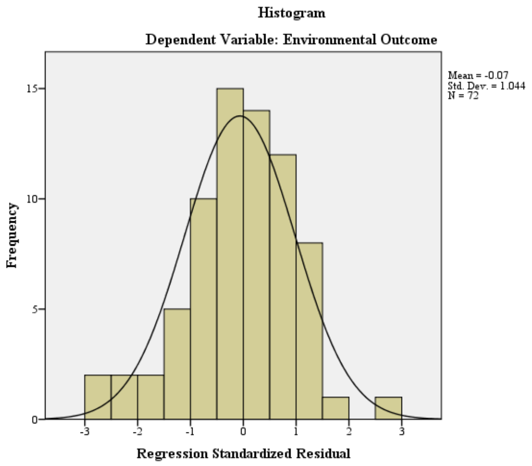
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Regulatory P.
d. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Regulatory P., RemanuxRegu, DispxRegu, RecycxRregu, RepairxRegu, ReconxRegu
e. Dependent Variable: Environmental Outcome

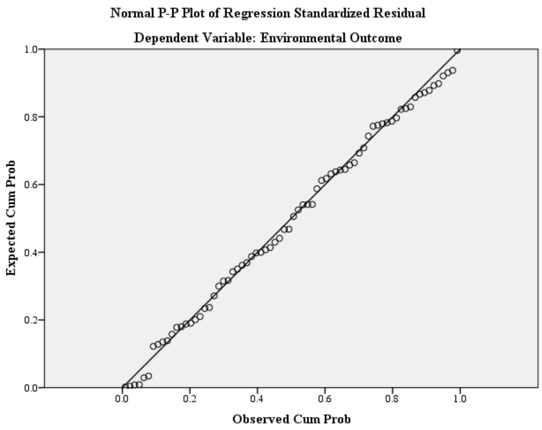
Coefficients[a]

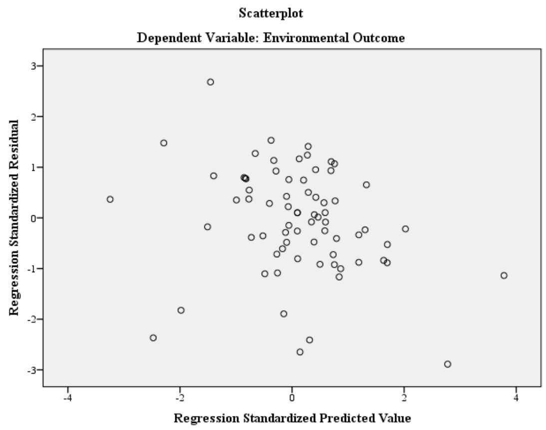
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.959	.280		14.128	.000
	Small Firms	-.160	.338	-.087	-.473	.638
	Medium Firms	-.143	.334	-.080	-.430	.669
	Large Firms	.000	.320	.000	.001	.999
2	(Constant)	3.036	.510		5.956	.000
	Small Firms	-.082	.347	-.044	-.236	.814
	Medium Firms	-.131	.331	-.073	-.396	.693
	Large Firms	.020	.318	.012	.064	.949
	Repair	-.138	.109	-.182	-1.271	.208
	Recondition	.063	.118	.093	.529	.598
	Remanufacture	.055	.123	.080	.447	.656
	Recycle	.154	.108	.200	1.425	.159
	Disposal	.167	.101	.212	1.660	.102
3	(Constant)	2.199	.612		3.592	.001
	Small Firms	.115	.346	.063	.333	.740
	Medium Firms	-.017	.324	-.009	-.052	.959
	Large Firms	.063	.308	.038	.204	.839
	Repair	-.175	.107	-.230	-1.640	.106
	Recondition	.078	.115	.116	.677	.501
	Remanufacture	.054	.119	.078	.451	.654
	Recycle	.137	.105	.178	1.302	.197
	Disposal	.087	.104	.110	.836	.406
	Regulatory P.	.313	.135	.302	2.312	.024
4	(Constant)	.356	1.864		.191	.849
	Small Firms	.363	.357	.197	1.016	.314
	Medium Firms	.415	.331	.232	1.256	.214
	Large Firms	.388	.314	.236	1.236	.221
	Repair	2.479	.747	3.266	3.317	.002
	Recondition	-2.220	1.067	-3.313	-2.081	.042
	Remanufacture	.193	.678	.282	.285	.777
	Recycle	-.653	.681	-.850	-.959	.342
	Disposal	.364	.592	.461	.615	.541
	Regulatory P.	.676	.475	.652	1.424	.160
	RepairxRegu	-.690	.191	-4.754	-3.606	.001
	ReconxRegu	.630	.280	4.423	2.245	.028
	RemanuxRegu	-.057	.177	-.378	-.322	.749
	RecycxRregu	.189	.170	1.131	1.114	.270
	DispxRegu	-.055	.152	-.375	-.359	.721

a. Dependent Variable: Environmental Outcome

Charts


Histogram
Dependent Variable: Environmental Outcome
Mean = -0.07
Std. Dev. = 1.044
N = 72
Frequency
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Environmental Outcome
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: Environmental Outcome
Regression Standardized Residual
Regression Standardized Predicted Value

APPENDIX G2 Hierarchical Regression Analysis of Regulatory Pressure on the Relationship between Reverse Logistics Product Disposition and Profitability

Predictor : Reverse Logistics Product Disposition
Outcome : Profitability
Moderator : Regulatory Pressure

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.177[a]	.031	-.010	.94814	.031	.767	3	71	.516	
2	.596[b]	.355	.277	.80241	.324	6.627	5	66	.000	
3	.721[c]	.520	.453	.69778	.165	22.277	1	65	.000	
4	.794[d]	.630	.543	.63761	.110	3.569	5	60	.007	1.724

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Regulatory P.
d. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Regulatory P., RemanuxRegu, DispxRegu, RecycxRregu, RepairxRegu, ReconxRegu
e. Dependent Variable: Profitability

ANOVA[e]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.069	3	.690	.767	.516[a]
	Residual	63.827	71	.899		
	Total	65.897	74			
2	Regression	23.402	8	2.925	4.543	.000[b]
	Residual	42.495	66	.644		
	Total	65.897	74			
3	Regression	34.249	9	3.805	7.816	.000[c]
	Residual	31.648	65	.487		
	Total	65.897	74			
4	Regression	41.504	14	2.965	7.292	.000[d]
	Residual	24.393	60	.407		
	Total	65.897	74			

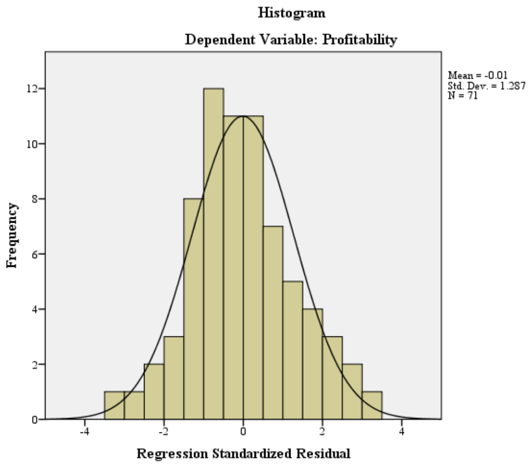
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Regulatory P.
d. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Regulatory P., RemanuxRegu, DispxRegu, RecycxRregu, RepairxRegu, ReconxRegu
e. Dependent Variable: Profitability

Coefficients[a]

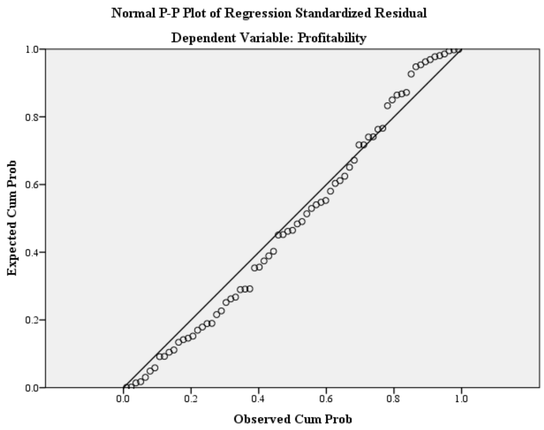
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.754	.327		8.424	.000
	Small Firms	.320	.394	.147	.811	.420
	Medium Firms	.274	.389	.130	.705	.483
	Large Firms	.531	.373	.273	1.422	.159
2	(Constant)	1.261	.521		2.421	.018
	Small Firms	.297	.354	.137	.839	.404
	Medium Firms	.112	.338	.053	.330	.743
	Large Firms	.604	.324	.311	1.860	.067
	Repair	.194	.111	.217	1.747	.085
	Recondition	.167	.121	.211	1.377	.173
	Remanufacture	.065	.125	.081	.522	.604
	Recycle	.254	.111	.280	2.295	.025
	Disposal	-.120	.103	-.129	-1.166	.248
3	(Constant)	-.306	.562		-.545	.588
	Small Firms	.666	.318	.306	2.097	.040
	Medium Firms	.326	.298	.154	1.094	.278
	Large Firms	.683	.283	.352	2.417	.018
	Repair	.126	.098	.141	1.289	.202
	Recondition	.195	.105	.247	1.850	.069
	Remanufacture	.063	.109	.078	.579	.565
	Recycle	.221	.096	.244	2.296	.025
	Disposal	-.271	.095	-.291	-2.851	.006
	Regulatory P.	.586	.124	.479	4.720	.000
4	(Constant)	-2.075	1.722		-1.205	.233
	Small Firms	1.263	.330	.580	3.827	.000
	Medium Firms	.813	.306	.384	2.659	.010
	Large Firms	1.204	.290	.620	4.150	.000
	Repair	1.863	.690	2.080	2.699	.009
	Recondition	-3.785	.986	-4.786	-3.840	.000
	Remanufacture	1.784	.627	2.206	2.847	.006
	Recycle	-.891	.629	-.983	-1.416	.162
	Disposal	1.274	.547	1.368	2.332	.023
	Regulatory P.	.952	.439	.777	2.170	.034
	RepairxRegu	-.463	.177	-2.702	-2.618	.011
	ReconxRegu	1.054	.259	6.276	4.069	.000
	RemanuxRegu	-.464	.164	-2.610	-2.839	.006
	RecycxRregu	.271	.157	1.373	1.728	.089
	DispxRegu	-.384	.141	-2.234	-2.730	.008

a. Dependent Variable: Profitability

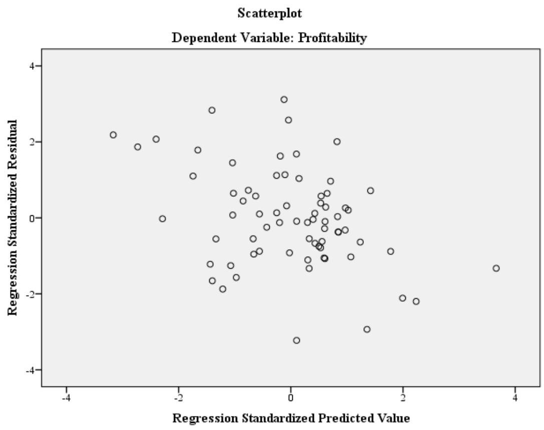
Charts



Histogram
Dependent Variable: Profitability
Mean = -0.01
Std. Dev. = 1.287
N = 71
Frequency
Regression Standardized Residual



Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Profitability
Expected Cum Prob
Observed Cum Prob



Scatterplot
Dependent Variable: Profitability
Regression Standardized Residual
Regression Standardized Predicted Value

APPENDIX G3 Hierarchical Regression Analysis of Regulatory Pressure on the Relationship between Reverse Logistics Product Disposition and Sales Growth

Predictor : Reverse Logistics Product Disposition
Outcome : Sales Growth
Moderator : Regulatory Pressure

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.284[a]	.081	.042	1.04820	.081	2.084	3	71	.110	
2	.585[b]	.342	.262	.91973	.261	5.244	5	66	.000	
3	.654[c]	.428	.349	.86432	.086	9.734	1	65	.003	
4	.782[d]	.611	.521	.74141	.184	5.668	5	60	.000	1.983

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Regulatory P.
d. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Regulatory P., RemanuxRegu, DispxRegu, RecycxRregu, RepairxRegu, ReconxRegu
e. Dependent Variable: Sales Growth

ANOVA[e]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.868	3	2.289	2.084	.110[a]
	Residual	78.009	71	1.099		
	Total	84.877	74			
2	Regression	29.047	8	3.631	4.292	.000[b]
	Residual	55.830	66	.846		
	Total	84.877	74			
3	Regression	36.319	9	4.035	5.402	.000[c]
	Residual	48.558	65	.747		
	Total	84.877	74			
4	Regression	51.896	14	3.707	6.744	.000[d]
	Residual	32.981	60	.550		
	Total	84.877	74			

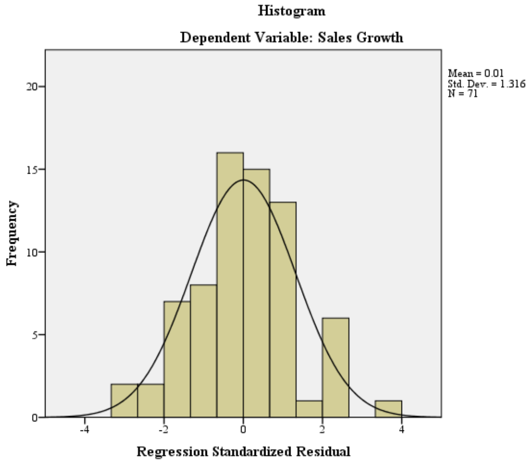
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Regulatory P.
d. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Regulatory P., RemanuxRegu, DispxRegu, RecycxRregu, RepairxRegu, ReconxRegu
e. Dependent Variable: Sales Growth

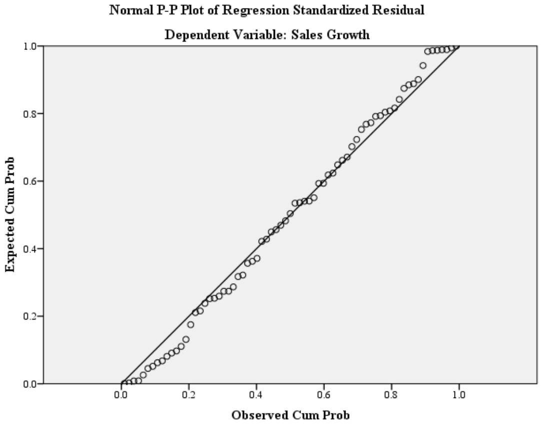
Coefficients[a]

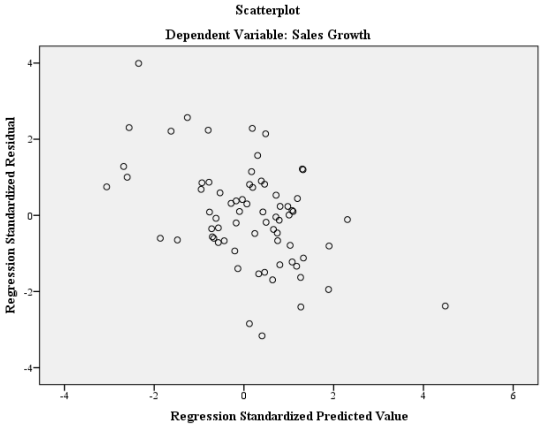
Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2.715	.361		7.512	.000
	Small Firms	-.101	.436	-.041	-.231	.818
	Medium Firms	.301	.430	.125	.699	.487
	Large Firms	.637	.413	.289	1.543	.127
2	(Constant)	2.268	.597		3.799	.000
	Small Firms	.062	.406	.025	.152	.880
	Medium Firms	.079	.388	.033	.203	.840
	Large Firms	.773	.372	.351	2.079	.042
	Repair	-.137	.127	-.135	-1.075	.286
	Recondition	-.052	.139	-.058	-.373	.710
	Remanufacture	.594	.144	.647	4.140	.000
	Recycle	-.064	.127	-.062	-.502	.617
	Disposal	-.061	.118	-.057	-.513	.609
3	(Constant)	.985	.696		1.416	.162
	Small Firms	.364	.394	.147	.924	.359
	Medium Firms	.254	.369	.106	.689	.494
	Large Firms	.838	.350	.380	2.394	.020
	Repair	-.193	.121	-.190	-1.592	.116
	Recondition	-.029	.131	-.032	-.219	.828
	Remanufacture	.592	.135	.645	4.391	.000
	Recycle	-.090	.119	-.088	-.755	.453
	Disposal	-.184	.118	-.174	-1.564	.123
	Regulatory P.	.480	.154	.345	3.120	.003
4	(Constant)	-.835	2.002		-.417	.678
	Small Firms	-.387	.384	-.157	-1.009	.317
	Medium Firms	-.291	.355	-.121	-.819	.416
	Large Firms	.211	.337	.096	.625	.534
	Repair	-.355	.803	-.349	-.442	.660
	Recondition	4.388	1.146	4.889	3.828	.000
	Remanufacture	-2.721	.729	-2.965	-3.734	.000
	Recycle	1.691	.732	1.643	2.310	.024
	Disposal	-1.779	.635	-1.682	-2.800	.007
	Regulatory P.	1.048	.510	.754	2.054	.044
	RepairxRegu	.072	.206	.372	.352	.726
	ReconxRegu	-1.154	.301	-6.055	-3.832	.000
	RemanuxRegu	.882	.190	4.366	4.635	.000
	RecycxRregu	-.458	.182	-2.046	-2.514	.015
	DispxRegu	.391	.163	2.006	2.393	.020

a. Dependent Variable: Sales Growth

Charts


Histogram
Dependent Variable: Sales Growth
Mean = 0.01
Std. Dev. = 1.316
N = 71
Frequency
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Sales Growth
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: Sales Growth
Regression Standardized Residual
Regression Standardized Predicted Value

APPENDIX G4 Hierarchical Regression Analysis of Ownership Pressure on the Relationship between Reverse Logistics Product Disposition and Environmental Outcome

Predictor : Reverse Logistics Product Disposition
Outcome : Environmental Outcome
Moderator : Ownership Pressure

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.095[a]	.009	-.033	.81278	.009	.218	3	71	.884	
2	.374[b]	.140	.036	.78526	.131	2.013	5	66	.088	
3	.445[c]	.198	.087	.76409	.058	4.708	1	65	.034	
4	.597[d]	.357	.207	.71224	.159	2.962	5	60	.019	2.088

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Ownership P.
d. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Ownership P., ReconxOwner, RecycxOwner, RepairxOwner, DispxOwner, RemanuxOwner
e. Dependent Variable: Environmental Outcome

ANOVA[e]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.431	3	.144	.218	.884[a]
	Residual	46.903	71	.661		
	Total	47.335	74			
2	Regression	6.637	8	.830	1.345	.237[b]
	Residual	40.698	66	.617		
	Total	47.335	74			
3	Regression	9.385	9	1.043	1.786	.088[c]
	Residual	37.949	65	.584		
	Total	47.335	74			
4	Regression	16.898	14	1.207	2.379	.010[d]
	Residual	30.437	60	.507		
	Total	47.335	74			

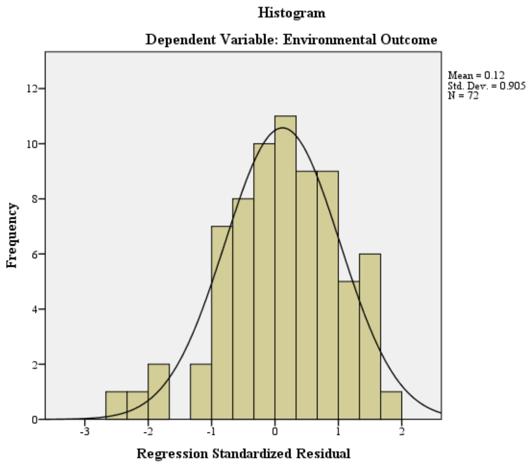
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Ownership P.
d. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Ownership P., ReconxOwner, RecycxOwner, RepairxOwner, DispxOwner, RemanuxOwner
e. Dependent Variable: Environmental Outcome

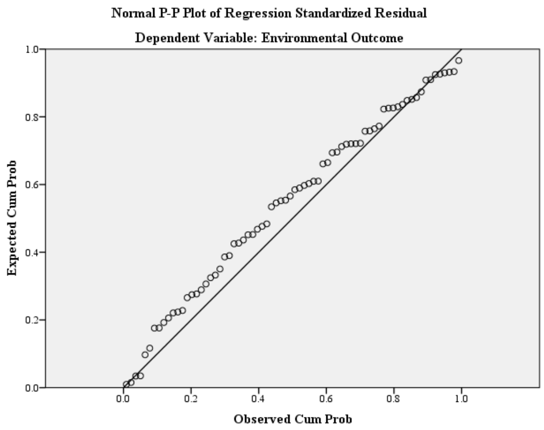
Coefficients[a]

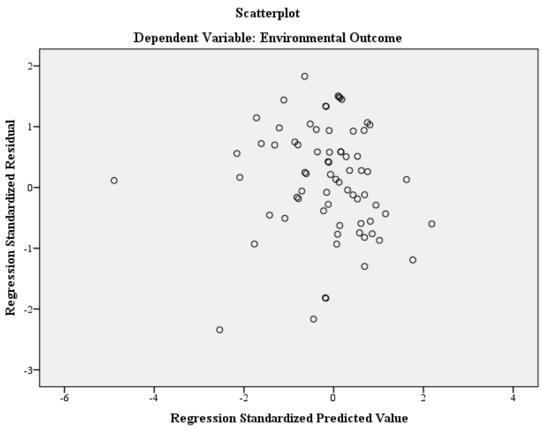
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.959	.280		14.128	.000
	Small Firms	-.160	.338	-.087	-.473	.638
	Medium Firms	-.143	.334	-.080	-.430	.669
	Large Firms	.000	.320	.000	.001	.999
2	(Constant)	3.036	.510		5.956	.000
	Small Firms	-.082	.347	-.044	-.236	.814
	Medium Firms	-.131	.331	-.073	-.396	.693
	Large Firms	.020	.318	.012	.064	.949
	Repair	-.138	.109	-.182	-1.271	.208
	Recondition	.063	.118	.093	.529	.598
	Remanufacture	.055	.123	.080	.447	.656
	Recycle	.154	.108	.200	1.425	.159
	Disposal	.167	.101	.212	1.660	.102
3	(Constant)	2.610	.533		4.893	.000
	Small Firms	-.062	.337	-.033	-.183	.856
	Medium Firms	-.188	.323	-.105	-.581	.563
	Large Firms	-.054	.311	-.033	-.174	.862
	Repair	-.129	.106	-.170	-1.219	.227
	Recondition	.029	.116	.043	.249	.804
	Remanufacture	.039	.119	.057	.329	.743
	Recycle	.093	.109	.121	.852	.398
	Disposal	.179	.098	.227	1.822	.073
	Ownership P.	.228	.105	.272	2.170	.034
4	(Constant)	1.200	1.555		.772	.443
	Small Firms	-.114	.345	-.062	-.329	.743
	Medium Firms	-.474	.316	-.265	-1.499	.139
	Large Firms	-.146	.303	-.089	-.484	.630
	Repair	-.426	.261	-.561	-1.635	.107
	Recondition	1.431	.489	2.135	2.927	.005
	Remanufacture	-1.429	.499	-2.085	-2.861	.006
	Recycle	.566	.319	.736	1.776	.081
	Disposal	.475	.335	.601	1.416	.162
	Ownership P.	.762	.480	.908	1.587	.118
	RepairxOwner	.108	.095	.656	1.142	.258
	ReconxOwner	-.450	.151	-2.809	-2.976	.004
	RemanuxOwner	.454	.151	2.821	3.015	.004
	RecycxOwner	-.148	.098	-.868	-1.507	.137
	DispxOwner	-.111	.106	-.726	-1.052	.297

a. Dependent Variable: Environmental Outcome

Charts


Histogram
Dependent Variable: Environmental Outcome
Mean = 0.12
Std. Dev. = 0.905
N = 72
Frequency
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Environmental Outcome
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: Environmental Outcome
Regression Standardized Residual
Regression Standardized Predicted Value

APPENDIX G5 Hierarchical Regression Analysis of Ownership Pressure on the Relationship between Reverse Logistics Product Disposition and Profitability

Predictor : Reverse Logistics Product Disposition
Outcome : Profitability
Moderator : Ownership Pressure

Model Summary[e]

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.177[a]	.031	-.010	.94814	.031	.767	3	71	.516	
2	.596[b]	.355	.277	.80241	.324	6.627	5	66	.000	
3	.650[c]	.423	.343	.76477	.068	7.657	1	65	.007	
4	.757[d]	.574	.474	.68420	.151	4.242	5	60	.002	1.796

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Ownership P.
d. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Ownership P., ReconxOwner, RecycxOwner, RepairxOwner, DispxOwner, RemanuxOwner
e. Dependent Variable: Profitability

ANOVA[e]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.069	3	.690	.767	.516[a]
	Residual	63.827	71	.899		
	Total	65.897	74			
2	Regression	23.402	8	2.925	4.543	.000[b]
	Residual	42.495	66	.644		
	Total	65.897	74			
3	Regression	27.880	9	3.098	5.297	.000[c]
	Residual	38.016	65	.585		
	Total	65.897	74			
4	Regression	37.809	14	2.701	5.769	.000[d]
	Residual	28.088	60	.468		
	Total	65.897	74			

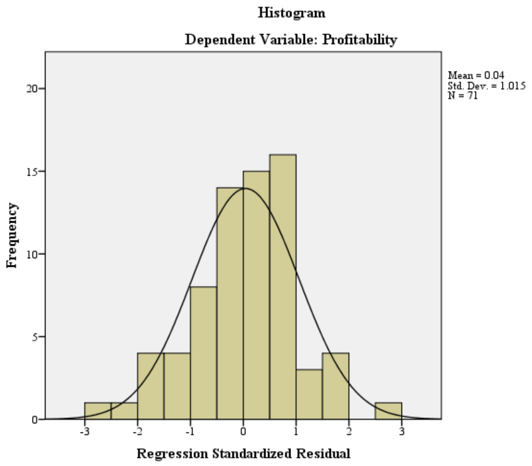
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Ownership P.
d. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Ownership P., ReconxOwner, RecycxOwner, RepairxOwner, DispxOwner, RemanuxOwner
e. Dependent Variable: Profitability

Coefficients[a]

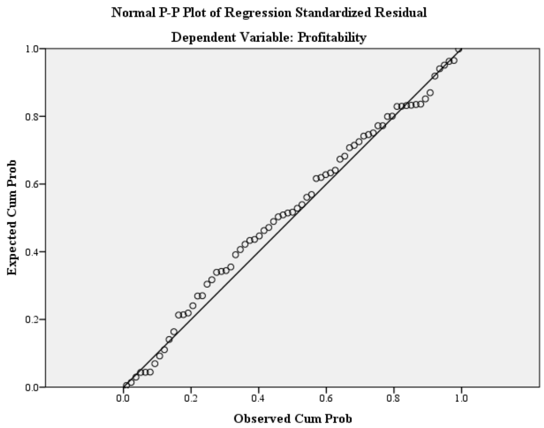
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.754	.327		8.424	.000
	Small Firms	.320	.394	.147	.811	.420
	Medium Firms	.274	.389	.130	.705	.483
	Large Firms	.531	.373	.273	1.422	.159
2	(Constant)	1.261	.521		2.421	.018
	Small Firms	.297	.354	.137	.839	.404
	Medium Firms	.112	.338	.053	.330	.743
	Large Firms	.604	.324	.311	1.860	.067
	Repair	.194	.111	.217	1.747	.085
	Recondition	.167	.121	.211	1.377	.173
	Remanufacture	.065	.125	.081	.522	.604
	Recycle	.254	.111	.280	2.295	.025
	Disposal	-.120	.103	-.129	-1.166	.248
3	(Constant)	.718	.534		1.344	.184
	Small Firms	.323	.338	.148	.956	.343
	Medium Firms	.039	.323	.019	.121	.904
	Large Firms	.508	.311	.262	1.634	.107
	Repair	.206	.106	.230	1.941	.057
	Recondition	.123	.116	.156	1.062	.292
	Remanufacture	.046	.120	.056	.381	.704
	Recycle	.175	.109	.193	1.608	.113
	Disposal	-.105	.098	-.113	-1.071	.288
	Ownership P.	.291	.105	.294	2.767	.007
4	(Constant)	.175	1.494		.117	.907
	Small Firms	.338	.332	.156	1.021	.311
	Medium Firms	-.262	.304	-.124	-.863	.391
	Large Firms	.356	.291	.183	1.225	.225
	Repair	.276	.250	.308	1.101	.275
	Recondition	1.333	.470	1.685	2.838	.006
	Remanufacture	-1.788	.480	-2.210	-3.726	.000
	Recycle	.355	.306	.391	1.158	.251
	Disposal	.165	.322	.177	.512	.611
	Ownership P.	.556	.461	.561	1.205	.233
	RepairxOwner	-.030	.091	-.151	-.324	.747
	ReconxOwner	-.377	.145	-1.997	-2.599	.012
	RemanuxOwner	.578	.145	3.040	3.991	.000
	RecycxOwner	-.055	.094	-.275	-.587	.560
	DispxOwner	-.102	.101	-.563	-1.003	.320

a. Dependent Variable: Profitability

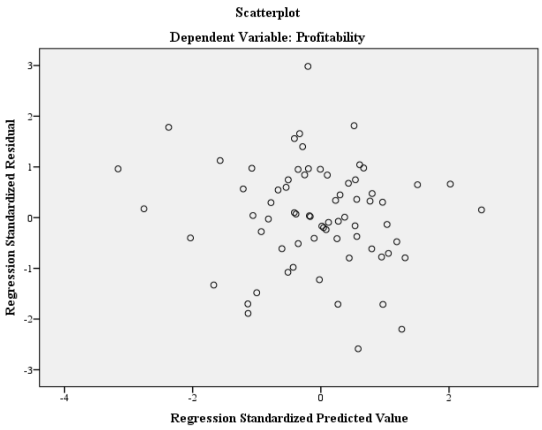
Charts



Histogram
Dependent Variable: Profitability
Mean = 0.04
Std. Dev. = 1.015
N = 71
Frequency
Regression Standardized Residual



Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Profitability
Expected Cum Prob
Observed Cum Prob



Scatterplot
Dependent Variable: Profitability
Regression Standardized Residual
Regression Standardized Predicted Value

APPENDIX G6 Hierarchical Regression Analysis of Ownership Pressure on the Relationship between Reverse Logistics Product Disposition and Sales Growth

Predictor : Reverse Logistics Product Disposition
Outcome : Sales Growth
Moderator : Ownership Pressure

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.284[a]	.081	.042	1.04820	.081	2.084	3	71	.110	
2	.585[b]	.342	.262	.91973	.261	5.244	5	66	.000	
3	.675[c]	.456	.381	.84271	.114	13.616	1	65	.000	
4	.740[d]	.548	.442	.79976	.092	2.434	5	60	.045	1.714

a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Ownership P.
d. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Ownership P., ReconxOwner, RecycxOwner, RepairxOwner, DispxOwner, RemanuxOwner
e. Dependent Variable: Sales Growth

ANOVA[e]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.868	3	2.289	2.084	.110[a]
	Residual	78.009	71	1.099		
	Total	84.877	74			
2	Regression	29.047	8	3.631	4.292	.000[b]
	Residual	55.830	66	.846		
	Total	84.877	74			
3	Regression	38.716	9	4.302	6.057	.000[c]
	Residual	46.161	65	.710		
	Total	84.877	74			
4	Regression	46.500	14	3.321	5.193	.000[d]
	Residual	38.377	60	.640		
	Total	84.877	74			

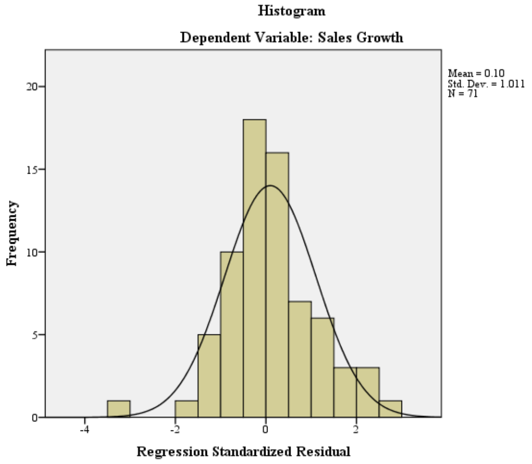
a. Predictors: (Constant), Large Firms, Small Firms, Medium Firms
b. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture
c. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Ownership P.
d. Predictors: (Constant), Large Firms, Small Firms, Medium Firms, Repair, Disposal, Recycle, Recondition, Remanufacture, Ownership P., ReconxOwner, RecycxOwner, RepairxOwner, DispxOwner, RemanuxOwner
e. Dependent Variable: Sales Growth

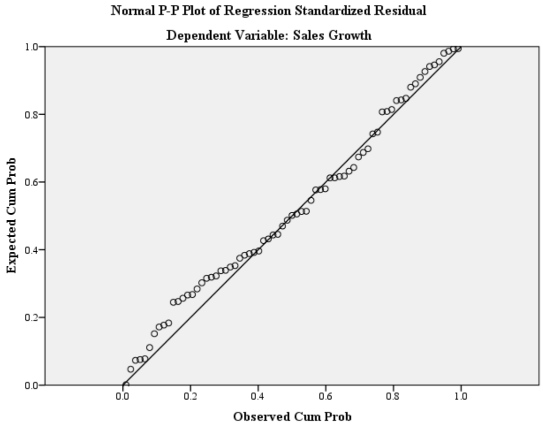
Coefficients[a]

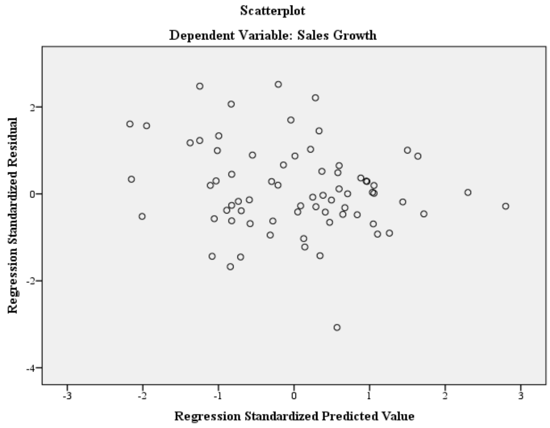
Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2.715	.361		7.512	.000
	Small Firms	-.101	.436	-.041	-.231	.818
	Medium Firms	.301	.430	.125	.699	.487
	Large Firms	.637	.413	.289	1.543	.127
2	(Constant)	2.268	.597		3.799	.000
	Small Firms	.062	.406	.025	.152	.880
	Medium Firms	.079	.388	.033	.203	.840
	Large Firms	.773	.372	.351	2.079	.042
	Repair	-.137	.127	-.135	-1.075	.286
	Recondition	-.052	.139	-.058	-.373	.710
	Remanufacture	.594	.144	.647	4.140	.000
	Recycle	-.064	.127	-.062	-.502	.617
	Disposal	-.061	.118	-.057	-.513	.609
3	(Constant)	1.469	.588		2.497	.015
	Small Firms	.099	.372	.040	.266	.791
	Medium Firms	-.028	.356	-.012	-.078	.938
	Large Firms	.633	.343	.287	1.847	.069
	Repair	-.120	.117	-.118	-1.026	.309
	Recondition	-.115	.128	-.128	-.898	.373
	Remanufacture	.565	.132	.616	4.290	.000
	Recycle	-.179	.120	-.173	-1.486	.142
	Disposal	-.039	.108	-.037	-.358	.721
	Ownership P.	.428	.116	.380	3.690	.000
4	(Constant)	-1.152	1.746		-.660	.512
	Small Firms	.119	.388	.048	.307	.760
	Medium Firms	-.229	.355	-.095	-.643	.523
	Large Firms	.550	.340	.250	1.620	.111
	Repair	.225	.293	.222	.770	.444
	Recondition	.837	.549	.932	1.524	.133
	Remanufacture	-.807	.561	-.879	-1.439	.155
	Recycle	.052	.358	.051	.146	.884
	Disposal	.398	.376	.376	1.057	.295
	Ownership P.	1.352	.539	1.203	2.508	.015
	RepairxOwner	-.137	.107	-.617	-1.280	.205
	ReconxOwner	-.300	.170	-1.402	-1.771	.082
	RemanuxOwner	.440	.169	2.041	2.602	.012
	RecycxOwner	-.067	.110	-.296	-.612	.543
	DispxOwner	-.142	.119	-.691	-1.195	.237

a. Dependent Variable: Sales Growth

Charts


Histogram
Dependent Variable: Sales Growth
Mean = 0.10
Std. Dev. = 1.011
N = 71
Frequency
20
15
10
5
0
-4
-2
0
2
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Sales Growth
Expected Cum Prob
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Observed Cum Prob


Scatterplot
Dependent Variable: Sales Growth
Regression Standardized Residual
2
0
-2
-4
-3
-2
-1
0
1
2
3
Regression Standardized Predicted Value