University of Strathclyde

Customers' switching behaviour towards remanufactured auto-products, with particular reference to the automotive industry in Thailand

by

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Declaration of Authenticity and Author's Rights

‘This thesis is the result of the author’s original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.’

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Signed: Bancha Dokmai

Date: 4 July 2021

Abstract

The automotive industry is a major manufacturing sector in the economy of Thailand. However, industrialisation in Thailand, largely based on the traditional 'take-make-dispose' linear economy model, has not only placed increased pressure on the resource base of the economy, but it has also resulted in increased dependency of the industrial sector on large and foreign enterprises and in environmental pollution due to end-of-life vehicles. Dependence of industry and the economy at large on the linear economy model has been at the heart of structural unsustainability underlying the Thai economy. Environmental pollution is also a cause for concern. Hence the case for transition to a circular economy.

Transition of the auto-sector in Thailand to the CE model is not without barriers that arise in the market. These become apparent when considering the range of factors associated with prevailing consumption and production behaviours that influence the transition process. In this study, the factors that influence the behaviours of customers and producers of automotive products are investigated.

This study on the switching behaviour of customers is based on the 'Push-Pull-Mooring' (PPM) theory of migration; and for investigation of the survey data, the structural equation model (SEM) is adopted. The findings of the demand-side study of the automotive remanufacturing market show that the decision of customers to switch to remanufactured products is significantly related to the special benefits and environmental benefits deriving from the use of these auto products, consumers' attitudes towards such products, and the risk of obsolescence that would be attach to remanufactured auto-products. Particularly, the suspicious attitude of customers towards the so-called 'like-new' remanufactured products were found to have a significant direct and indirect influence on their switching intentions. Meanwhile, the findings of the supply-side study indicate that the factors influencing auto-manufacturers to induce remanufacturing auto-businesses in Thailand are product maturity, financial costs, lack of skilled labour and technical aspects.

A sustainable business model (SBM) for remanufacturing and 'circular' practices in the Thai automotive industry is developed as a policy and decision framework based on the empirical findings of the study. The SBM is developed as a practical business model for remanufacturers to launch 'circular' businesses in the auto sector in Thailand.

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Finally, the usual disclaimer is in order – while acknowledging all the above and more, I remain responsible for any errors of omission or commission that may occur in this thesis.

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Chapter 1

Introduction

1.1 Introduction

This chapter introduces the landscape of the research, which explores evidence about the significance of flexibility in the switching behaviour of customers and how this bears on the course of transition to a circular economy (CE). As such, the study addresses the demand side of the issue of transition to a CE. The market could facilitate or inhibit transition to a circular economy depending on the disposition of customers not simply to short term changes in market behaviour relating to the price and quality competitiveness of products, but more importantly to long term shifts of market trajectories driven by consumer preferences and sustainability objectives. Nevertheless, producers and industry players on the supply side as well as the government also have important roles to play in the transition to a CE, which need to be considered.

The remainder of this chapter is in five parts. The first part sets the background to the study by looking into the wider context of the research question. This covers specification of the research problem as a response to the knowledge gap in the literature. This is followed by brief sections on the aim and objectives of the research, scope of the study, significance of the study and structure of the study.

1.1 Background of the study: Global sustainability issues and the need for transition to circular economy

The current global crisis - arguably precipitated by unsustainable economic, social and environmental conditions - is a reflection of the persistence of linear economic system based on the 'make-use-dispose' principle of production and consumption activities. The potential problem of its inherent unsustainability, notwithstanding that the system has been at the heart of modern economic growth since the industrial revolution (Sariatli, 2017).

The system of linear economy has largely thrived on the extraction and use of virgin natural resources, including material and energy resources. The industrial practice has invariably been for raw materials to be processed into final products, which after use, are disposed of, with no systemic plan for end-of-life parts to feed into inner-loop 'circular' activities, like reuse, repair, reconditioning and remanufacturing.

Linear economy-based activities have thrived in the face of rapid global population growth that has over the years increased demand pressure on finite resources. Depletion of material and non-renewable energy resources has the effect of ratcheting up raw material prices in the global market, which in turn would impose a constraint on productivity and economic growth, on climate change and environmental sustainability. Commodity prices have been on an upward trend, particularly since 1999. The increasing trend of material prices causes producers to bear higher production costs. Also, mining sites for extracting virgin raw materials have been depleted over the years. This means extraction is not easy to access any more. At the same time, global competition has increased, making it difficult for producers to increase their product prices or transfer their increasing production costs to their customers. This has the effect of squeezing down profits, and eventually narrowing down the scope for economic growth (Ellen MacArthur Foundation, 2012).

The scale of the problem is apparent in the observation that the EU's import of raw materials constitutes more than half of all the resources it consumes (Ellen MacArthur Foundation, 2012). In the linear economy framework, there is a limit beyond which unsustainable economic growth translates into unsustainable social and environmental conditions. This, however, presumes the relative absence of innovation and technological progress which holds true, but largely in the case of developing countries. Technological progress has the effect of pushing out the limits of growth in the linear economy context, albeit without necessarily redressing the social and environmental impacts of economic growth.

Social unsustainability, reflected by the level of inequality between and within countries, has increased since the Second World War (Piketty, 2014). According to the United Nations (UN), during the period 1990-2016, global inequality, measured by the Gini coefficient of concentration, has grown in 49 of the 119 UN member countries (41.2 per cent of the number of UN member countries). The 49 countries include the world's most populous countries, China and India in particular (UN, 2020, pp.26-27). This means 71 per cent of the global population lives in countries where income inequalities appear pronounced (UN, 2020, pp.26-27).

Linear economy activities precipitate solid and liquid waste, and so cause environmental pollution; and the use of fossil fuel as source of energy contributes to the problem of climate change through CO_2 emissions. Environmental unsustainability in turn feeds back into the system causing economic and social unsustainability. Global climate change increases the frequency of flood and storm events, and raises sea levels. These, in turn, threaten the integrity of infrastructure networks that are particularly necessary for local jobs and for the livelihoods of communities of millions of people, especially those who are in absolute poverty (IPCC, 2018). The 2011 flood disaster in Thailand, the worst flood in the modern history of Thailand, affected more than 13 million people and 680 deaths, and caused damage to the tune of 46.5 billion US dollars. Thailand's GDP growth for the fourth quarter of 2011, when the flood took place, was reported to have dropped by 8.9 per cent (Poapongsakorn & Meethom, 2012, pp.247-248). One of the economic sectors hard hit by the flood was the automotive industry, which accounted for 4.7 per cent of its global vehicle output for that year (BBC News, 2011). In the US, Hurricane Sandy caused about 71 billion US dollar worth of damage in 2012, while Hurricane Harvey caused 125 billion US dollar worth of damage in 2017 (USGCRP, 2018).

The rapid industrialisation of the emerging economies has added to the ever growing demand pressure on the finite stock of energy and material resources. Responding to this growing demand within the linear economy framework is not, however, without implications for environmental sustainability (Dobbs et al., 2011; OECD, 2019).

The global problem of environmental unsustainability is seen to be at the heart of the global crisis reflected in the increasing frequency of floods, storms, and in the severe damage wreaked to economies by these events, thus increasing the vulnerability of people, particularly in poor countries. The World Bank traces the problem of global economic, social and environmental vulnerability to the world-wide growth of activities based on the linear economic system to address the needs of the rapidly growing global population. Accordingly, the Bank warns: “If we don't change our economic behaviours immediately, climate change could push 100 million more people into poverty by 2030” (World Bank, 2015).

Many, like the Ellen MacArthur Foundation (2012, 2013, 2015b), would argue the way forward for global economic, social and environmental sustainability is to transition to a circular economy (CE). CE is an economic system which restores and/or regenerates end-of-use (EoU) or end-of-life (EoL) products and services back to economic life for as long as possible. As such, the CE system aims to ‘design out’ waste from production and consumption activities and to build economic, ecological, and social capital into the system. This means that CE will ensure keeping the maximum value and utility and minimising negative impacts of valuable material resources, including components, for as long as possible through the return, reuse, and recovery scheme (Ellen MacArthur Foundation, 2012, 2013b, 2015b). Thus, resource efficiency is enhanced, and the use of virgin material resources is decreased or made unnecessary (Guldmann, 2016).

Transition from a linear to a circular economy involves a process of structural economic transformation based on some basic principles that are concordant with the principles of ecological economics (Temesgen et al., 2019). There are four issues associated with the transition process: limitless vs finite resources; production inputs vs stakeholders; individual rational economic thinking vs systemic thinking; and competition vs cooperation.

Limitless vs finite resources: While the linear economic model implicitly assumes, if by default, infinitely elastic or limitless supply of non-renewable resources, a circular economy is based on the realisation that supply of virgin energy and material resources is finite (Costanza et al., 2015; Murray, Skene, & Haynes, 2017; Temesgen et al., 2019). The aim of CE is, therefore, to ‘design out’ waste and preserve the value of resources at their maximum level of utility through engagement in circular activities (or inner-loop activities), including reuse, repair, and remanufacturing that make use of embedded energy and material resources from discarded products (Ellen MacArthur Foundation, 2012).

Production inputs vs stakeholders: While the principles underlying the linear economy consider resources as production factor inputs, the principles underlying a circular economy, which relate to ecological economics, recognise resources and non-human co-inhabitants on Planet Earth as stakeholders functioning, as if in coordination, in a systemic framework. As a result, not only economic growth but also its social and environmental impacts and the ecosystem at large are included in the analysis of the CE business model (Temesgen et al., 2019). Moreover, beyond the energy and material resources (or primary factor inputs), resource management is a major concern in the circular economy paradigm. This would allow the choice of better-performing materials, technologies and processes (Ellen MacArthur Foundation, SUN, & McKinsey, 2015).

Individual rational economic thinking vs systemic thinking: While decision-makers in linear economy focus on personal utility maximising and individual organizational profit maximising behaviours, the focus of decision-making in the CE paradigm is on improvements in the quality of life of all its stakeholders. The former is the product of linear thinking, and the latter of systemic thinking. Profit maximisation, which is promoted in the linear economy business model, is sustained through production efficiency based on economies-of-scale and economies-of-speed of the production process to reduce production costs (Guldmann, 2016). In addition, the linear industrial system encourages 'cradle-to-grave' material-flows to minimise costs of resource-flow management (Ellen MacArthur Foundation, 2012).

On the other hand, systemic effectiveness, attributed to the CE business model, transforms products and related material flows in ways that would enhance the sustainability of eco-systems and prospects for future economic expansion without creating waste and negative external costs. The 'closed-loop' cycle, which is at the heart of the CE system, is based on the notion of 'cradle-to-cradle' material-cycles in which all materials would be considered valuable resources as components and parts (Ellen MacArthur Foundation, 2012). In other words, eco-effectiveness of the CE business model focuses not only on the production phase, but also on other phases of the product life cycle. This would make the CE network system complex, but resilient, unlike the linear system, which is based on the 'cradle-to-grave' cycle (Guldmann, 2016).

Competition vs cooperation: Activities in the linear economy system involve self-interested competition to determine rational economic interactions between economic agents. On the other hand, the CE business model encourages cooperation in economic and social interactions to ensure the evolutionary survival of Planet Earth (Temesgen et al., 2019). In the CE system, the working principle for stakeholders is ‘succeed together or fail alone’ (Rayne, 2017). CE supports that even under market competition, there is scope for cooperation, partnerships and networks among stakeholders. This would enable them to deploy their combined competency, strengths, and market access, thus reflecting the effectiveness of partnerships underpinning CE activities (Jansson et al., 2017; Rayne, 2017).

In all, CE is an economic system that attempts to conceptualise the integration of economic activities and ecosystem wellbeing. As a system, it aims to achieve the decoupling of economic growth from natural resource depletion and environmental degradation in a sustainable way. Transition from a linear to a circular economy is complex as it calls for the transformation of fundamental economic structures with sustainability at the heart of the system.

1.2 Knowledge gap and the case for this research

Thailand now ranks as one of the top twenty automotive producers in the world. The automotive sector constitutes a major component of the manufacturing industry in Thailand. It contributes ten per cent to manufacturing GDP. A major feature of the Thai manufacturing industry is that its growth and development trajectory has been based on the traditional and widely used linear ‘extract-make-use-dispose’ model of industrialisation. There is, however, growing recognition that this model of industrialisation would in the long run make the growth trajectory of the manufacturing industry environmentally, economically and socially unsustainable.

Based on the linear business model, the automotive sector in Thailand has thrived on the attraction of direct foreign investment from large multinational automotive companies. Thailand’s success in attracting multinationals has not, however, been without problems. Especially, the high dependency on the large multinationals (MNCs) has widened the income disparity between the large MNCs and the small and medium automotive companies in Thailand. Also, the ever-increasing volume of 'end-of-life' (EoL) vehicles are disposed without provisions and mechanisms for the reclamation of resources from EoL vehicles. These unsustainable problems in the automotive industry in Thailand need a solution that is capable of ensuring the growth of the sector on a sustainable basis without wreaking havoc to the environment.

As mentioned above, transition to a circular economy, the system which effectively decouples economic growth from natural resource depletion in a sustainable way, is broadly proposed as the way forward. The CE system is acclaimed to be potentially capable of promoting economic expansion and resilience, enhancing prospects for environmental sustainability, and creating job opportunities and skill development through localisation of SMEs. Moreover, CE in the re-manufacturing form offers a business model for product life-extension and with the potential for disrupting incumbent technologies by "doing more and better with less", as would be expected in the case of the global automotive sector.

However, although the application of the concept of circular economy, in general, and remanufacturing, in particular, appears to have taken hold in developed countries, this is not the case in developing countries, where, significantly enough, its relevance is compelling. While the literature on circular economy is replete with knowledge about the technical aspects of product recovery under developed country circumstances, knowledge that would guide decision-making processes for transition to a circular economy and management of 'circular' businesses is limited. This study is an attempt to contribute to the wider effort of bridging this knowledge gap by looking into the demand side of the transition to a circular economy, particularly the factors that are crucial for transition to CE at micro, sectoral and macro levels in the context of a middle-income country – that is, Thailand.

Broadly, research in the field of circular economy is addressed to tackling problems on three fronts - issues relating to reverse-logistic management or closed-loop supply-chain management; operational recovery, and product market development (Guide & Van Wassenhove, 2009). The stream of literature on market development is essentially about problems relating to customer behaviour and product valuation. Study of this would require interdisciplinary integration of operations management with economic and marketing issues (Guide & Van

Wassenhove, 2009). One study (Kirchherr & van Santen, 2019) surveys 160 articles relating to the CE field published between 2006 to 2019. Almost two-thirds of the authors are from the natural sciences, while only 37 per cent of the authors are from the social sciences (Kirchherr & van Santen, 2019).

With respect to the geographical focus of the studies, 95 per cent of the articles address CE issues relating to developed nations, while only 5 per cent relate to the circumstances of developing nations. According to Kirchherr & van Santen, (2019), the majority of the small proportion of articles addressing CE in the context of developing counties are based on research on China.

With respect to the usefulness of the findings of the research articles on CE issues surveyed by Kirchherr & van Santen (2019), the majority of the articles (81 per cent) would qualify as pure academic exercises, while 28 per cent could be of value to policy makers and 20 per cent to businesses.

Among the articles addressing the market development aspect of CE, most are focused on supply side issues addressing the readiness of businesses to engage in circular economy activities (Abbey, Meloy, Guide, & Atalay, 2015). Research concern about the role of customers in the transition to circular economy based on the closed-loop supply-chain system has, however, been limited to the last two decades, thus showing that to date, research outputs on this issue have been few and far between (Guide & Li, 2010).

In fact, customers' attitude towards CE products plays a critical role in the success of transition to CE (Hazen, Mollenkopf, & Wang, 2017; Matsumoto, Chinen, & Endo, 2017). If the market is prejudiced against CE products on grounds of quality or price attractiveness, the transition process at macro and micro levels can be bottlenecked. There is evidence to show that many customers have not yet accepted CE products in remanufactured form as an alternative to new ones (Abbey et al., 2015; Dokmai, 2018; Hazen, Boone, Wang, & Khor, 2017; Hazen, Mollenkopf, et al., 2017).

1.3 Aim and Objectives of the Research

In light of the above, the aim of this study is to investigate customers' willingness to switch their preference from new manufactured automotive products to 'like new' remanufactured alternatives. Understanding the behaviour of customers and their readiness to switch their preference is crucial on the pathway of CE development, since the role of customers in CE systems is not only as customers but also as suppliers. As customers, they would decide to purchase CE or remanufactured products to support the CE system or to prefer newly manufactured ones, which would reduce the scope for the growth of the CE system. As suppliers, they would decide either to dispose of their 'end-of-use' or 'end-of-life' products to break the circularity of the system, or else to reinsert their 'end-of-use' or 'end-of-life' products or core materials into the supply chain, thus contributing to the functioning of the CE system for as long as possible. Eventually, the success of the customer-based circular economy as a system would depend on whether and how customers encourage new models of sustainable business. This relates to their behaviour towards remanufactured products and their willingness to return or reinsert their products into the reverse supply chain system.

These difficulties surrounding transition to CE can be detected from changes in the behaviour of customers in the event of the introduction of CE or remanufactured products. The focus in this study is on remanufactured products in the context of the automotive industry, because remanufacturing is the most suited CE mode for the automotive industry. This will be discussed in detail in Chapter Two.

In view of the above, the following research question is proposed for empirical investigation: what are the factors that bear on consumers in the automotive sector to switch from linear to circular business models? Or, what does it take for automotive customers to be favourably disposed to remanufactured CE products?

This study has the objectives of identifying and empirically investigating the factors that bear on customers' preference in the course of transition to a circular economy in the automotive sector in Thailand. The investigation is conducted through tests of the following set of hypotheses expressing changes in customer behaviour in terms of ‘push’, ‘pull’ and ‘mooring’ or moderating factors drawn from the ‘push–pull–mooring’ (PPM) theory of migration (Bogue, 1969, 1977; Lee, 1966; Moon, 1995), which is discussed fully in the next chapter.

Hypothesis 1: Push factors positively affect the switching intention of auto consumers/users to select remanufactured products.

Hypothesis 2: Pull factors positively affect the switching intention of consumers to select remanufactured products.

Hypothesis 3: The direct effects of ‘mooring factors’ would be expected to negatively affect the switching intention of consumers to select remanufactured products.

Hypothesis 4: Moderating or indirect effects of ‘mooring factors’ have the effect of mitigating the influence of ‘push’ and ‘pull’ factors on the switching intention of consumers to select remanufactured products.

The conceptual underpinnings of the above hypotheses are fully discussed in the methodology chapter (Chapter 3), and the empirical tests of the hypotheses are conducted in Chapter 5.

The PPM theory can effectively analyse the complicated interrelationships between independent variables affecting the decision of customers to switch their preference in favour of remanufactured parts and components. The empirical tests are conducted within the PPM framework using the structural equation model (SEM), which is considered to be suitable for analysing the complexities involved in the PPM migration model.

Furthermore, producers and the government are also significant players in transitioning the automotive industry in Thailand to a CE remanufacturing model. As a result, the behaviours of the automotive producers in Thailand need to be considered. This leads to an objective of this research to investigate determinants influencing behaviours of automotive producers in Thailand to initiate a auto-remanufacturing business model.

Finally, policymakers in Thailand are essential when the transition to CE is pursued as a national policy agenda. Policy and regulation can influence behaviours on both sides of the market in favour of remanufacturing. Some policy recommendations based on the research findings will be suggested as the last objective of this study.

1.4 Scope of the Study

Owing to time and resource constraints, this research is limited in scope. First of all, it is focused on the case of the automotive sector in Thailand. The automotive industry is one of the most strategic manufacturing industries not only in Thailand, but also globally.

As a strategic industry, the automotive industry is widely networked with many economic activities in Thailand's economy, as shown in Figure 1.1. This includes supporting organisations such as associations, institutes, education, training, and research and development (R&D) organisations; supporting industries such as machinery, mould and die, and service industries including logistic, dealers, leasing and finance, after-sale service, maintenance, and insurance. These activities together contribute to more than ten per cent of the total annual GDP of Thailand (Thailand Automotive Institute: TAI, 2014).

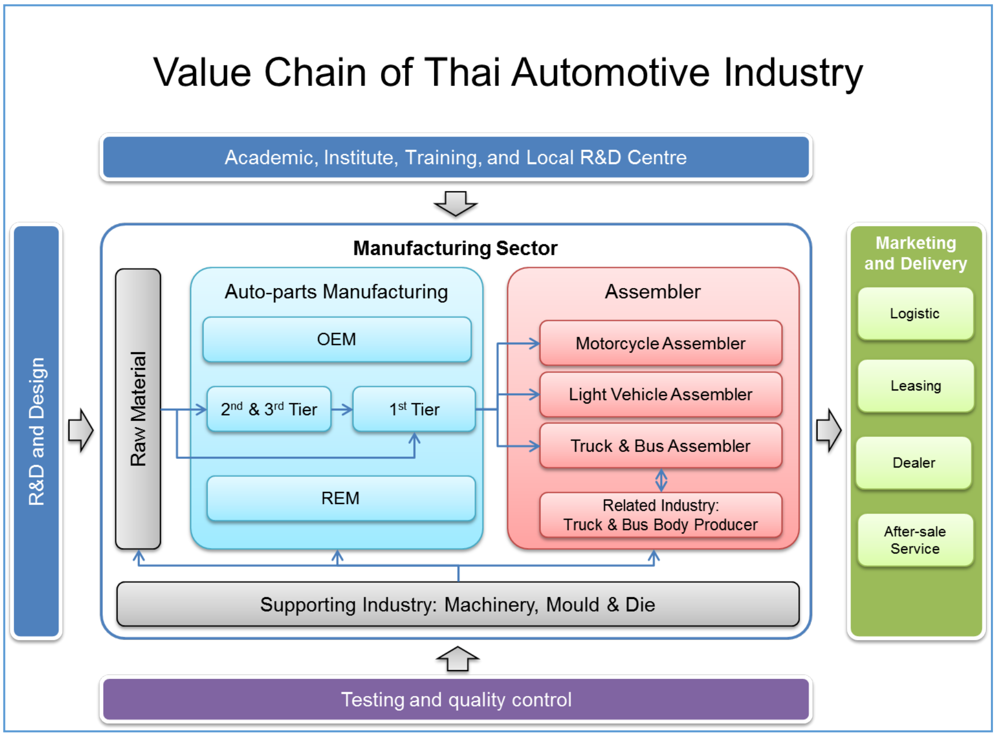

Figure 1.1 Value Chain of the Automotive Industry in Thailand (Thailand Automotive Institute: TAI, 2014)

Furthermore, the automotive industry in Thailand is one of the major motor-vehicle producers in the world. Thailand's motor-vehicle production ranked eleventh in the world production league table in 2018 and 2019. It has been ranked as the highest producer in the Southeast Asia region during the 2010s (International Organization of Motor Vehicle Manufacturers: OICA, 2020).

Another reason for the choice of the automotive sector is that the industry scopes the potential for CE activities, especially remanufacturing, which, as shown in Figure 2.1, is the only CE activity that can satisfy the characteristics of inner-loop activities (high ability to maintain resources' embedded values), and has the restorative ability to as good as new conditions (Ijomah, Childe, & Mcmahon, 2004).

The automotive products considered in this research are defined in generic terms. That is, automotive products can refer to automotive vehicles and/or automotive parts that have to be remanufactured at least 85 per cent by weight. On grounds that there is no 'end-of-life' vehicles directive (ELV Directive) in Thailand, the research adopts the ELV Directive of the European Union (EU). The EU Directive addresses ELVs covering vehicles and components. The directive requires manufacturers or importers to reach the target of new vehicle reusability and/or recyclability of at least 85 per cent by average weight of each ELV (European Parliament and Council, 2000).

Although the scope of the empirical analysis of this study is limited to the experiences of the automotive industry in Thailand, the results of the analysis can be expected to have generalizable significance that would make them applicable as lessons of experience elsewhere across industrial sectors and across countries.

1.5 Significance of the Study

The results of this study are expected to have significance for further research, for industrial practice and for policy decisions.

In terms of research, this study contributes to the body of knowledge on the problematics of transition to a circular economy – particularly from the vantage point of customer behaviour - in the automotive industry in Thailand. This is significant insofar as not much serious work has been done to date in this area. How sensitive are customers or users of automotive products and components to the sustainability agenda widely promoted at national and global levels? To address this question, the study provides a new approach to analyse the complex behaviour of individual consumers towards remanufactured products by introducing the ‘push-pull-mooring’ (PPM) theory of migration. Although the theory was initiated in the human geography literature, the theory has portable value as it could be applied to analyse the switching behaviour of customers, given alternative products. Moreover, it provides the framework for analysing relationships not only between dependent and independent variables, but also the interrelationships between the independent variables affecting the dependent variable, i.e. switching behaviour of customers in the CE auto-market. These complex relationships about the switching behaviour of customers are investigated using the structural equation model (SEM). The study does not, however, stake out any claim to be final in the approach it adopts for addressing the research problem, including the analytical methodology, and the adequacy and robustness of the data used for empirical analysis, nor in the conclusiveness of the results of the survey data-based empirical analysis.

With respect to the significance of the research for industrial practice, it is important that those in the management of businesses in the automotive sector are aware of existing evidence about the factors influencing customers’ behaviour that bear on their decisions to switch their preferences in favour of remanufactured products. Businesses can focus decisions on specific factors through, for example, promotional programmes, to influence changes in the behaviour of customers. However, if after major business initiatives customers are not convinced about the sustainability agenda, and the prevailing market trend is not found to be favourable towards remanufactured products, businesses would be reluctant to shift production modes towards remanufacturing practices, unless there is macro policy intervention that would help change the business climate in a way that would make remanufactured products attractive to customers. Market conditions are crucial for businesses to draw up strategies that would enhance their financial benefits.

The study also has significance for policy where sustainability and corporate social responsibility (CSR) and transition to a circular economy are pursued as policy agenda. Policy can influence the switching behaviour of customers in favour of remanufacturing by creating awareness about the usefulness and advantages of remanufactured products, which are often unfairly stigmatised by customers, and by changing relative prices in favour of remanufactured products through the implementation of tax and subsidy programmes.

1.6 Structure of the thesis

The thesis is organised in seven chapters. Following this introductory chapter, Chapter 2 will look into issues in the transition to a circular economy through remanufacturing in the automotive sector from the vantage point of the switching behaviour of customers. The chapter will address the relevant literature and the conceptual framework of the study. The methodology will be discussed in the Chapter 3. Chapter 4 will set the context to the study by shedding light on the state of the automotive sector in Thailand and its readiness for transition to a circular economy through remanufacturing. An empirical analysis to investigate the factors influencing automotive producers to develop remanufacturing auto-businesses in Thailand is presented. The secondary data for the supply-side analysis were facilitated by Chaowanapong et al. (2017). The supply-side results are also discussed in this chapter. In Chapter 5, the empirical analysis of factors influencing the switching behaviour of auto-customers in favour of remanufactured auto-products is conducted and the results of the analysis discussed. In Chapter 6, the implications of the results are presented. Chapter 7 is the conclusion in which the results of the study are summarised, and the implications of the study for future research and policy are discussed in the light of the limitations of the study.

Chapter 2

Issues in transition to circular economy through remanufacturing: the literature and conceptual and empirical frameworks of the study

2.1 Introduction

This chapter aims to review the literature on the circular economy (CE). It is organised in ten parts. The second part, following this brief introduction, addresses CE as a system. The key stakeholders in a CE transition are listed in the third part. Then, externalities and public goods of market failures are explained as crucial barriers to CE development in the fourth part. The fact that a transition to a CE does not have only benefits; trade-offs or risks of improper transition to a CE are discussed in the fifth part.

The sixth part discusses “remanufacturing” as a “circular option”. The seventh part focuses on the key factors influencing the transition to circular remanufacturing by reviewing the theoretical, conceptual and empirical framework for switching customers' behaviour towards circular options. Factors influencing the decisions of producers to develop remanufacturing businesses are listed and discussed by reviewing the relevant literature in the eighth part. The ninth part presents a Sustainable Business Model (SBM). The tenth part presents brief conclusions of the chapter.

2.2 Circular economy (CE) as a system

Circular Economy (CE) is an economic system that utilises resources to their maximum value and minimises negative environmental impacts of valuable material resources for as long as possible through repair, reuse, remanufacturing and recycling. These activities on the 'inner loops'[1] of the circular economy model are based on the principle of 'designing out' waste from the system of production and decoupling economic growth from the finite supply of material and energy resources (Ellen MacArthur Foundation, 2012, 2013b, 2015b). Thus, while efficiency in resource use is enhanced, the need for the use of virgin material resources is decreased through the implementation of circular economy projects (Guldmann, 2016).

In contrast, the traditional linear economic model is based on the 'make-use-dispose' principle of transforming resources into products (Ellen MacArthur Foundation, 2013b). Historically, this system of 'linear production' has led to the problems of resource depletion and environmental pollution.

Transition from the well-established linear economic system to a circular economy regime is a complex process, but would have the effect of enhancing the long-term resilience of economies, reducing, if not eliminating, the scope for waste; and bringing forth a wide range of economic, social and environmental benefits. For example, in some developed countries, implementation of the CE model has propelled economic growth by creating high-skilled labour jobs; encouraged the development of knowledge and innovation-based economies (Stahel, 2017); generated local businesses; and reduced demand for finite or non-renewable resources, and the emission of greenhouse gases (GHGs) (Ellen MacArthur Foundation, 2012, 2014b; Ellen MacArthur Foundation, SUN, & McKinsey, 2015; Stahel, 2010).

2.2.1 Circular Economy and Economic Expansion

Transition to CE is sought to leverage economic expansion through creativity and innovation. For example, in the case of the EU, the Ellen MacArthur Foundation, Sun, and McKinsey (2015) estimated that under the CE model, European gross domestic products (GDP) can grow by up to 11, and 27 per cent by 2030 and 2050, respectively. On the other hand, under the current linear model of development in Europe, economic expansion of up to 4 per cent and 15 per cent is expected by 2030 and

[1] The inner loops or the tighter loops refer to circular activities that involve less change to end-of-life products when put into economic use in activities, including reuse, refurbishment and remanufacturing. What makes inner loop activities significant is the potential they offer producers to extract from the end-of-life products embedded material, labour and energy resources, which would otherwise be disposed as waste (Ellen MacArthur Foundation, 2012, p.30).

2050, respectively (Ellen MacArthur Foundation, SUN and McKinsey, 2015). Transition to CE would bring forth rapid economic growth largely because of the shift towards outputs involving circular activities and the use of inputs with lower costs of production (Ellen MacArthur Foundation, 2015b). Moreover, it is presumed that circular activities, like repair, refurbishing and remanufacturing, would lead to more job creation than would be the case with their linear counterparts (Parker et al., 2015). This is because linear-manufacturers require fewer high-skilled workers compared to circular activities (Parker et al., 2015, p.46). Circular activities are generally labour-intensive in character and require high-skilled labour to remanufacture high-quality products. As a result, these circular activities directly contribute the creation high-wage skilled jobs (Ellen MacArthur Foundation, SUN and McKinsey, 2015).

Another advantage of CE over its linear counterpart is its ability to decrease production costs by enabling productive use of 'second life' inputs deriving from 'end-of-life' products, and reducing the need for new resource inputs. Because of the lower production costs, the prices of circular remanufactured products are between 40-80 per cent lower than newly manufactured alternative products (Stahel, 2017). This indirectly increases spending of households, which in turn leads to more employment across sectors and to economic expansion.

2.2.2 Circular Economy and Enhancement of Knowledge & Innovation

Underlying the process of transition to CE are advancements in knowledge production and the application of this to design development and innovative activities (Stahel, 2017; 2016). In the circular economy model, the application of innovative ideas aimed at promoting the cause of 'designing out waste' would be expected to extend the service life of resources, and decrease the volume of resource consumption and waste. Creativity and innovation are central to circular activities to reuse, fix, refurbish, re-manufacture and re-purpose materials, components and products.

Innovative activities are important for improving components and materials that enhance production and existing resources. Digital technology and innovation strengthen reverse logistic networks for circular systems. Moreover, they reinforce communications between stakeholders in circular systems, including circular suppliers and producers, and customers, interacting via online platforms.

2.2.3 Circular Economy and Environmental Sustainability

Transition to circular economy is sought not only for the prospect it offers for economic expansion, but also for environmental sustainability since 'circular' activities bring forth the potential for the reduction of consumption of material and energy resources and carbon dioxide emission. Ellen MacArthur Foundation et al. (2015) found that CE could save primary components from households' consumption of durable goods (Ellen MacArthur Foundation et al., 2015). In this respect, it is important to note that given the average of business-as-usual consumption in Europe, household consumption constitutes 80 per cent of resource consumption, and 60 per cent of households' spending. However, research by the Ellen MacArthur Foundation et al. (2015) identified that CE could reduce primary material consumption by 32 per cent and 53 per cent of business as usual consumption by 2030, and 2050, respectively. In addition, resource savings of up to 60-80 per cent could be achieved for mobility by 2050 as a result of transition to circular economy (Ellen MacArthur Foundation et al., 2015). Moreover, it was found that implementation of CE could result in the reduction of carbon-dioxide emission by 48 per cent and 83 per cent of carbon-dioxide discharge by 2030 and 2050, respectively, compared with business-as-usual levels in 2015.

2.2.4 Circular Economy and Decentralisation/Localisation and Local SMEs

Transition to CE creates opportunities for localisation of economic activities and investment in small and medium enterprises (SMEs) (Clift & Allwood, 2011; Ellen MacArthur Foundation, 2015b; Lacy & Rutqvist, 2015). Circular activities, especially reverse logistics, encourage changes in industrial structure to be localised, making it expedient for circular producers to easily track the markets for their products and end-of-life products for their throughputs. Thus, localisation allows circular businesses to be closer to their customers and their assets. In addition, local reverse logistics create local jobs and entrepreneurs and promotes the emergence of service-based small and medium enterprises distributed across regions.

In the circular economy business model, production based on local SMEs operating as repair service networks distributed across regions is considered to be more effective than the large volumes produced within large enterprises in terms of revenue generation and employment generation. Moreover, the business model creates opportunities for product-life extension and waste reduction (Lacy & Rutqvist, 2015). For instance, the US industry of electronics and computer fixing services generated value-added to the tune of 20 billion US dollars in 2014; and in 2011, the US market for remanufactured products generated more than 43 billion US dollars and created more than 180,000 jobs. Also, the worldwide market of automotive maintenance and repair service was more than 305 billion US dollars in 2015 (Lacy & Rutqvist, 2015).

2.3 The key stakeholders in the generation of the circular economy

There are several players that are required in the transition to a more circular economy, each one as vital as the others. The CE transition cannot be achieved by certain echelons of society alone, all relevant stakeholders must contribute in order to obtain sustainable results. The key stakeholders in the transition to a CE are consumers, industry players, and the government.

2.3.1 Consumers

Consumers make their everyday consumption choices based on their efforts to reduce, select and consume products and services, as well as their willingness to dispose or separate and return their end-of-use/end-of-life products. Their consumption behaviours affect the CE strategies because their choices and behaviours can promote or impede the CE. Their decisions determine whether products and services are consumed and provided through circular economic processes (Triodos Research, 2017).

Consumers' perceptions determine whether the CE will be a success. They depend on consumers' efforts to shift their market demand in the ways to support a CE (Jakhar et al., 2019). To generate a CE transition, consumers should stop supporting linear economic trends, such as short-lived fashions, rapid replacement, purchasing products that they do not really need and dispose end-of-use products that are still usable. Furthermore, they need to change their behaviours to encourage CE principles, such as reduce, reuse and repair. This change presents a grand challenge in a society that is used to consumerism. However, there is a trend that the ownership behaviours of Millennials fundamentally differ from prior generations. For example, Millennials are less likely to own vehicles and travel less in personal cars than previous generations (Knittel & Murphy, 2019). This is a good prospect for CE development.

Moreover, new initiatives to promote CE development are emerging. Service-innovation business models such as repairing, remanufacturing, and sharing are growing. These create alternative choices to replacing broken or obsolescent consumer products. This gaining momentum in the consumer mindset will hopefully stimulate industrial players to distinguish themselves and change their manufacturing behaviours to support the generation of a CE (Sheikh, 2021).

Finally, consumers have a role in accelerating the adoption of circular principles. Support and recognition from public peers to share CE stories is a key function in making this transition (Azaria, 2015).

2.3.2 Industry Players

Businesses, also, have a crucial role in stepping up their efforts in changing business models towards more eco-friendly designs and promoting the reuse of products for generating a CE transition.

In the process of CE generation, while consumers have a responsibility to change market demand into a CE path, businesses have a role to change market supply to CE promotion. The CE is not only good for society and the planet, but it is also an excellent opportunity for businesses, particularly in the long run. Industrial players who adapt to a CE model will ensure the availability of the resources and materials they need in their supply chain system in the future. The CE can increase their sustainability.

Industrial players initiate CE development by designing their products so that they can easily be dismantled, repaired, and assembled, instead of being made from parts and components that have short-life utilisation and are unavailable in long term. Also, the businesses create new business models that are suitable in serving the CE market-demand trend.

For example, to support the new demand trend of the Millennials, CE businesses will offer products based on performance instead of ownership where consumers pay for the products' utilisation and performance instead of to own them. Then, they can repair, refurbish or remanufacture when the end of life of the product is near or when the consumer's situation changes and they require a different product without requiring use of finite natural resources.

However, an industrial player cannot generate the CE market alone. All sizes of businesses have a role to play, including entrepreneurs, multi-national corporations (MNCs) and small and medium enterprises (SMEs).

Entrepreneur businesses are excellent initiators to reinvent new business models (Azaria, 2015). They create a practical circular business model, in reality from the bottom-up perspective. They often disrupt their entering market. The role of entrepreneur businesses is essential as an initiator in the early stage of a CE transition. Then, their successful innovating CE business models will be shared as a proven track record of growth.

At the other end of the spectrum, MNCs have a role in catalysing a CE transition into a large scale change (Azaria, 2015). This is because MNCs have decades of experience, complicated supply-chains, and processes. So, they can keep pace and scale up the circular innovations (Sheikh, 2021). For example, Dell utilises its global market leader position to determine infrastructure, standards, and policies in the global IT market and so contribute to a move toward a circular economy. A MNC can effectively change its supply chain to provide packaging made of certified closed-loop recycled plastics that minimise their impact on the environment (Azaria, 2015).

Finally, SMEs will play a role in connecting the gap between niche and mass markets as distributing channels in the extensive adoption of circular principles by facilitating reach and agility. SMEs will distribute entrepreneurs' initiations into actions through MNCs' networks in many areas (Sheikh, 2021).

All in all, entrepreneurs create disruptive solutions in terms of new CE business models to solve unsustainability in linear economic markets. However, they lack capital, resources, or networks to develop their CE initiations at a large scale.

Cooperation with MNCs will empower stakeholders, including many SMEs in the market and across the value chain to create new eco-systems and positive incentives that drive CE generation.

2.3.3 Government

Policymakers have a key role to provide efforts on a legislative and administrative level to establish a regulatory framework that is stable, ambitious, and economically viable for CE stakeholders. Also, the government is responsible for monitoring and capturing CE opportunities (Ellen MacArthur Foundation, 2015a). The governmental stakeholder includes all levels of the public sphere, such as the government, policy-makers, city councils or charities (Azaria, 2015). There are two policymaking strategies that can accelerate promotion of the CE transition by the government: to fix market failures and to stimulate CE market activities (Ellen MacArthur Foundation, 2012).

The first strategy is to revise market and regulatory failures. Four significant market failures impeding CE development are (i) excessive negative externalities; (ii) under-provision of public goods and free rider problems; (iii) insufficient market competition; and (iv) asymmetric information and lemon market problems. The government has to enable the right market conditions to appropriately set directions for a CE transition to reach market scale.

Another strategy for policymakers is to motivate CE market activities. In fact, the second strategy has complementary actions. Policymakers should set their appropriate directions about where to place their priorities and to provide inspiration. Policy actions include actions such as setting directions, plans and targets, initiating collaboration platforms, providing capital support to CE enterprises, and encouraging public procurement.

2.3.4 Cooperation is the answer

All stakeholders and their cooperation are essential in determining whether the CE generation is a success. Neither consumers, manufacturers, nor government can create a CE alone. all stakeholders in society have their own important role to play in the CE development pathway. That is, industrial players need to change business models so that they are appropriate for their specific consumers' preferences and the culture of the society as well as for CE. The government needs to provide suitable frameworks to control the regulatory environments. While consumers need to shift their mindset to encourage the CE emerging market.

2.4 Externalities as a barrier to a circular economy transition

Externalities are one of the most significant difficulties in CE development. An externality is a phenomenon where an action taken by either a producer or a consumer totally or partly affects other producers or consumers but is not accounted for by the market price (Pindyck & Rubinfeld, 2001). Externalities can be divided into positive and negative externalities. A positive externality is an effect where the action of a party benefits another party, while a negative one is an effect where the action of a party imposes costs on another party (Pindyck & Rubinfeld, 2001).

Externalities lead to market failures in economic principles. A market failure is an economic situation where a free or unregulated competitive market (or invisible hand) is inefficient in providing socially optimal outcomes. That is, if externalities are in place, the prices of products or services cannot reflect their optimal social value. The prices fail to provide suitable signals to producers and consumers. Thus, manufacturers may produce too little (because of positive externalities) or too much (because of negative externalities), so that the market outcome is not optimal.

Policy interventions are essential to managing collective activities among stakeholders to provide an optimal level of CE investment for sustainable development. Otherwise, there will be insufficient CE investment.

2.4.1 Positive externality and public goods

Positive externalities are production choices that have a positive effect on an unrelated third-party or society. For instance, an enterprise invests in a new production value-chain to run its business based on a CE model. As a result, the enterprise reduces its demand for virgin resources and energy and decreases its environmental footprints, including greenhouse gas emissions. The society also gains ecological benefits from the decreasing ecological footprints by the enterprise's action and investment.

However, only the enterprise has to bear the investment costs without additional outputs or incomes. Furthermore, society and third-parties who can also enjoy the environmental benefits by the enterprise's action considers a clean environment to be a universal right that should be provided for free of charge (Velthuijsen et al., 2019). They do not pay or share any of the costs to the enterprise because of the effect of public goods.

As a result, the enterprise lacks an incentive to initiate the CE investment. It, in turn, leads any companies to invest less in cleaner initiations than the level that the companies are willing to invest from a welfare economics point of view.

Public goods, in economics, are a good or service made available to every person of society, including access to clean air and drinking water. Public goods have two significant characteristics: non-exclusive [2] and non-rivalry [3] (Kotchen, 2012). Public goods are defined as the opposite of private goods in that they are both rivalry and excludable. For example the value of, a sandwich can be diminished after someone has eaten it and it can be excludable to all individuals who are not willing to pay for it.

Public goods can suffer from the problem of 'free riding'. That is, individuals can enjoy the benefits of non-rivalry and non-excludable public goods provided by others but have little incentive to provide the public goods voluntarily (Kotchen, 2012).

Applying the same example, society and third party enjoy a cleaner environment by the enterprise's CE investment. Still, the investment does not happen at the expense of this third party. This is because it is impossible to exclude one person from enjoying a better environment by the enterprise's action (non-exclusive). Furthermore, the cleaner environment does not reduce its quality when one person

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[2] Non-exclusive refers to a situation where people cannot be prevented from enjoying the same commodity or service.

[3] Non-rivalry refers to a situation where one person's enjoyment of a commodity or service does not reduce the ability of others to enjoy the same one.

enjoys the cleaner environment (non-rivalry). As a result, the society and third party will generally be unwilling to pay for the better environment. This, in turn, leads to a non-incentive for the enterprise to provide the better environment and CE investment. The CE investment will, therefore, be less than the socially optimal level (Velthuijsen et al., 2019).

2.4.2 Negative externalities

Negative externalities, in contrast to positive externalities, are external costs that occur when economic activity negatively affects an unrelated third party or society (Velthuijsen et al., 2019). For example, production costs for any products and services are incurred by the producer and these can be divided into private costs and external costs. The producers bear the private costs, but they can pass on the external costs to society or another party. For example, pollution is a negative externality. Because the producers are not directly affected by the external costs of their production decisions about whether or not to pollute, the producers have an incentive to produce more products and waste than the optimal level.

2.4.3 The effects of Externalities and public goods on a CE transition

CE development is a public good. A CE can enhance resource efficiency by maximising material circulation and utilisation and minimising wastes and losses (Ellen MacArthur Foundation, 2012). The CE aims to improve sustainable wealth and well-being by reducing dependency on natural resources within the limitation of the world’s capacity (Van Ewijk, 2018). Thus, the efficiency enhancement of resource utilisation by the CE can improve the environment to avoid degradation, depletion, or collapse. Ecosystems can be prolonged to serve society with food and nutrition, clean air and drinkable water, aesthetic and recreational pleasures and assimilate air emissions and pollutions (Van Ewijk, 2018). A better ecosystem due to the impact of the positive externality of a CE transition is a pure public good in economics. Therefore, the transition to a CE model is a public good.

Ultimately free market dynamics is likely to make environmental degradation more complicated because of externalities. Firstly, the unsustainability difficulties due to the traditional linear economy tend to be more severe. By the effects of negative externalities, private producers have an incentive to produce and discharge more pollution than the optimal level of social and environmental absorption. Furthermore, a cleaner environment and pollution abatement tend to be underprovided by the effects of positive externalities and public goods (Velthuijsen et al., 2019). As a result of public goods and free-rider problems, society and third-party consumers are generally unwilling to pay for public goods. Thus, private firms have no incentive to initiate sustainable development through investment for a CE transition.

In the linear industrialisation model, a free market is not fully transparent. The market prices cannot reflect actual total benefits (private benefits and positive external benefits) and the actual total costs (private costs and external costs). As a result, commercial actors in the market have not enough incentives to provide more investments for environmental safeguards, but they have incentives to discharge more pollution (Kotchen, 2012). In a circular economy, however, prices reflect actual costs and benefits. This includes the costs of negative externalities in a transparent market. Companies get accurate price signals to decide on their optimal production choices, which will not create the negative side-effects of escalating climate change and depleting natural resources (Kotchen, 2012).

Undoubtedly, if remaining with the linear industrialisation model, CE development as a public good tends to be generally underprovided by the effect of positive externalities, while global pollution trends to be overprovided by the effect of negative externalities. A market intervention of public policy is needed to control collective actions of various stakeholders in order to initiate an optimal CE development.

2.4.4 Policy market intervention

Government leadership is essential to initially encourage transition to work together with the private actors to set up a fully transparent market providing ecological abatement and safeguards in order to initiate a transition to a CE model for sustainable development.

To promote the transition to a CE, the government can implement policies and regulation to internalise the positive and negative externalities (Velthuijsen et al., 2019). Governments need to solve the externality problems by intervening in the market in the presence of market failures. If governments are able to set a price on pollution and reward and stimulate incentives with a positive environmental outcome, profit maximisation could be aligned with the broader welfare goals of society

The government can set the accurate price of pollution to decrease negative externalities, reducing waste and pollution. The government also provides incentives to increase positive externalities, creating more effective safeguards for a clean environment as public goods (CE initiative included).

2.5 Trade-offs in a transition to a circular economy

A strong criticism of the CE is that it is often presented without due recognition of the risks and trade-offs of particular approaches. In certain circumstances, circular approaches may be more energy-intensive or costlier than the alternatives. Or they may introduce one type of system-level thinking while missing others. Open dialogue, better evidence and more collaborative approaches can help to mitigate these concerns (Preston & Lehne, 2017b). This part will introduce some trade-offs in the early development stages of sustainability-oriented initiatives.

2.5.1 Trade-offs and challenges

On the one hand, the CE could solve the dilemma of global unsustainability by decoupling economic growth from environmental degradation while supporting social well-being at the same time. The CE encourages economic growth by enhancing resource productivity, initiating employment and reducing the risk of exposure to volatility in raw materials prices. Meanwhile, CE strategies could decrease social and environmental pressures from unmanaged waste, such as health and pollution effects in terms of lives saved.

On the other hand, the transition to a CE could causes some trade-offs that need careful and systemic management, especially trade-offs that affect development in developing countries. A trade-off is a situation that is characterised by conflicts between some desired objectives, i.e. where all criteria are impossible to satisfy simultaneously (Kravchenko et al., 2021, p.1). If trade-offs are not realised, there is a risk to accept a CE initiative that leads to higher impacts or sub-optimisations (Kravchenko et al., 2021). In fact, all trade-offs must be avoided to limit backward steps or impede enhancement in any category of basic requirements for progress towards sustainability. All categories of basic requirements should have a positive balance of benefits instead of sacrifices unless all other options are worse.

Trade-offs complicate the CE decision process. Trade-offs to sustainability in CE transitions can occur in several ways (Byggeth & Hochschorner, 2006). Trade-offs or conflicts are between sustainability-related and other criteria, for instance, sustainability issues versus products' quality and advance technological production selection issues. Trade-offs are also between sustainability thresholds, such as cost reduction in the economic aspect versus selecting a non-toxic material in the environmental part. Finally, trade-offs or conflicts within the exact sustainability dimensions, including choosing a more lightweight, durable material, which may not be recyclable. These cause difficulties in either comparing or prioritising the key triple sustainability dimensions or some criteria at the expense of others (Kravchenko et al., 2021).

In some project-based CE transitions, stakeholders can weigh clear trade-offs between benefits and drawbacks or opportunity costs of CE approaches. For example, it appears that consideration of resource-efficiency improvements in an end-of-used vehicle by repairing needs to be weighed against utility improvement of advanced mobility technology delivered by purchasing a new one (Cooper & Gutowski, 2017). Also, project effectiveness or trade-offs of waste-to-energy initiatives depend on the materials selection, the implications of incineration practices and emissions, and what opportunities exist as an alternative to combustion (Lonca, Muggéo, Imbeault-Tétreault, Bernard, & Margni, 2018). Without the trade-off recognition, initiatives may be more energy-intensive or costlier than alternatives.

However, many CE transition projects, particularly at the macro level, partially concern only some well-known issues to economic and industrial development. Still, a far broader concern of governance and market interventions is needed to enhance productivity or reduce opportunity losses (Kravchenko et al., 2021). The risk is controversial when the CE concept is dismissed as naive and that its benefits are likely to be missed (Preston & Lehne, 2017a, p.14). For example, to protect domestic textile manufacturing as their industrial strategies, certain countries in East Africa considered banning end-of-use textiles imports. Nevertheless, their people regularly consume the reused apparels and work in processing scrap textiles (TradeMark East Africa, 2017).

2.5.2 Examples

The effectiveness of the enhancement of resource utilisation in the process of economic-model transition from a linear traditional economy to a circular economy could result in trade-offs to sustainability. To understand the trade-off between the CE initiatives and sustainable development, here are some examples of trade-offs that might arise in a circular economy transition to sustainability based on some Sustainable Development Goals (SDGs).

Food and nutrition security: When transitioning to a circular economy for food and nutrition security, closed-loop agriculture systems encourage decentralised, self-sufficient and local food networks. This improves food and nutrition security from risks of supply shocks and price changes in global supply chains (FAO, 2017). However, the closed-loop agriculture systems may disrupt existing trade between rural and urban communities, threatening the resilience of rural livelihoods (Preston, Lehne, & Wellesley, 2019).

Water security: There is also an example of a transition to a circular economy for clean water security. Closed-loop agriculture systems are an example of the circular economy since they reuse and recycle wastewater from other sectors and the desalination of salt water could improve the efficiency of water-use, enhance water security and increase the global availability of clean water (Lahiry, 2017). However, the significant trade-off in CE activity is that the process of wastewater recycling and desalination of salt water is extremely energy-intensive, creating a highly concentrated brine waste product which is often discharged back into the oceans (Preston et al., 2019).

Energy security: Transitioning to a circular economy from a linear economic model is also a good strategy to enhance energy security. Inner loops of circular activities, improving global energy-use efficiency, can decrease demand for energy inputs. This could lead to lower costs of energy access and higher security of global energy stocks. However, there is a risk of a 'rebound effect', where increased energy efficiency causing lower costs of energy inputs is offset by increasing energy consumption (Preston et al., 2019).

Also, local waste-to-energy initiatives can reduce dependence on large grids in external markets for energy inputs. This could increase local energy security and decrease risks of climate impact exposures. However, there may be a trade-off in that local companies will adopt harmful activities and sub-standardised incineration practices. This potentially causes local environmental and human health risks. There may also be a drawing on waste streams for the waste-to-energy process instead of them being better-suited to reutilise in second-life products (Preston & Lehne, 2017a).

Income security: On the understand that CE activities are more labour-intensive and resource-efficient than linear economic practices, the CE tends to generate more local opportunities for providing employment and value creation. As a result, a CE transition could decrease exposure to resource supply shocks and other economic shocks. Diversifying production in CE systems is one way to improve resilience in economic systems over the longer term. However, the CE transition may imply significant shifts in industrial paradigms and economic structures. Trade-offs may arise in that the transition could create green employment and value creation in the new CE economic system. Still, there are risks to jobs among those trapped in resource-intensive economies of the industrialisation paradigm, such as those employed in resource extraction and primary processing (Preston & Lehne, 2017a).

International trade-offs of a CE transition: As the CE focuses on resource-use efficiency improvements by reusing, remanufacturing, and recycling resources, the demand for raw materials and primary resources will potentially drop. As a result, counties that highly rely on such exports tend to more vulnerable to economic downturns because of this demand reduction (de Jong, van der Gaast, Kraak, Bergema, & Usanov, 2016).

According to the EU action plan for the CE (European Commission: EC, 2015), the CE policy agenda of the EU reflects a desire to limit imports of raw materials, to develop high-quality jobs and encourage innovation. However, the transition to a circular economy in the EU is likely to affect global trade flows, and may lead to worsening incomes in some least developed countries (Preston & Lehne, 2017a).

The EU contributed 12.3 per cent of the global import of raw materials as the second-largest importer, following China. If the EU transitions to a circular economy, it may disrupt the existing global trade of raw materials. As a result, this may threaten the resilience of livelihoods in export countries, especially in developing countries that rely on the export of raw materials (Preston et al., 2019).

For example, raw-material exports of some least-developed countries in sub-Saharan African contribute up to 35 per cent of their total GDP. Sierra Leone and Mauritania are heavily dependent on the export of iron-ore, which accounted to more than one-third (34.36 per cent) and one-quarter (25.39 per cent) of their GDP respectively. In the same manner, raw-material export dependency are more than one-fifth of GDP for Suriname (23.01 per cent), Mali (22.31 per cent), Guyana (22.22 per cent), Liberia (20.42 per cent) and Zambia (20.23 per cent). Guinea and Liberia are heavily dependent on the export to the EU for gold and bauxite, as well as iron-ore, which accounted for 8.05, and 7.97 per cent of their total GDP in 2014, respectively (de Jong et al., 2016).

Moreover, export taxes are a significant source of fiscal revenues for some countries. A wide-EU transition to a CE could result in a direct loss of 1.6, 1.4 and 1.2 per cent of their fiscal revenues of Mozambique, Namibia and the Republic of the Congo, respectively. Furthermore, Iceland is likely to lose most in public revenue, as 3.2 per cent of its fiscal revenues could be affected since its export taxes contributed to 29.4 per cent of its GDP (de Jong et al., 2016).

2.5.3 How circular is 'circular'?

All in all, trade-offs are complicated situations that cause conflicts among desired results meaning that all criteria cannot be satisfied at the same time. A CE transition, focusing on resource preservation and waste elimination, is often named as an initiative to enhance sustainability (Ellen MacArthur Foundation, 2012). However, trade-offs to sustainability can arise in the transition to a CE (Kravchenko et al., 2021). This challenges the decision process of policymakers and practitioners when transitioning to a CE. Benefits and costs of CE initiatives should be assessed, compared and prioritised in any significant criteria of inclusive sustainability and its relevant issues.

However, the difficulty should not be an excuse for inaction. It is possible to move forward on CE initiatives with confidence in the outcomes. To address these issues of trade-offs, cooperation between interdisciplinary academics, societal stakeholders' participation, industry practitioners, businesses and governmental agencies with influence on broader socio-economic systems and global value chains are essential to avoid or at least to mitigate effects of the potential trade-offs (Schroeder, Dewick, Kusi-Sarpong, & Hofstetter, 2018). Also, a combination of past experience, some basic historical data and new technologies that enable real-time monitoring so that changes can be easily implemented (Preston & Lehne, 2017a).

2.6 Remanufacturing as a circular option

Re-manufacturing occurs as one of the inner loop activities in the CE scheme as represented in Figure 2.1. It short-circuits the need for recycling, which is a high-cost and centralised process. The re-manufacturing process involves used products to be totally disassembled, recovered, rebuilt, re-assembled and their quality tested to match that of newly manufactured products (Ellen MacArthur Foundation, 2012; King, Burgess, Ijomah, & Mcmahon, 2006). Remanufactured products can be 'like-new' or even better in performance than new manufactured products. Remanufactured products are thus supported by quality warranty that would make them attractive to customers. Re-manufactured products are not new-manufactured products. They are, however, often referred to as 'like new'. But they face the problem of market recognition as in the case of reused, repaired, and reconditioned products (King et al., 2006). This problem arises from the lack of awareness about the nature of remanufactured products.

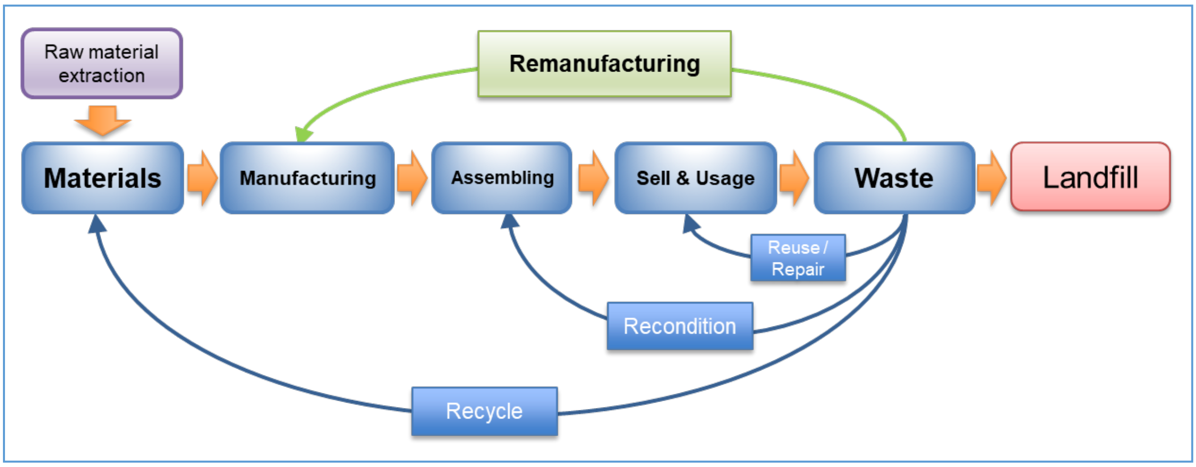

Figure 2.1 Circular Economic activities (Parker et al., 2015, p.11)

2.6.1 The Remanufacturing Disrupting the Challenges of the Automotive Industry

Another feature of remanufacturing is its favourable environmental impact. By "doing more with less", re-manufacturing plays a role as a driver of eco-innovation (Weiland, Kripli, Vandenberg, Steinhilper, & Freiberger, 2008). Re-manufacturing holds important embedded resources, such as materials, energy and labour that have been used to make the cores for their first-life (King et al., 2006). As such, remanufacturing based on resource efficiency and low carbon emission is adopted in a wide spectrum of industrial activities, including, for example, those in the aerospace, automotive, and electrical and electronic manufacturing sectors (Parker et al., 2015).

Remanufacturing also offers opportunities for economic expansion and for the creation of highly skilled jobs (Parker et al., 2015). In the automotive market of the EU, re-manufacturing activity is known to have contributed around 7.4 billion Euros in turnover as well as providing around 43,000 jobs in 2,363 firms across the EU countries (Parker et al., 2015). Renault, for example, is no stranger to the remanufacturing business as it has operated a remanufacturing factory in France since 1898. By prolonging the life of the automotive materials, the circular model underpinning remanufacturing helps to retain value, save energy and reduce waste. For instance, Renault's Choisy-le-Roi factory enables reduction by 80, 88, 92, and 70 per cent of energy, water, chemical products and waste, respectively, from the production of a remanufactured part in comparison with a new manufactured alternative (Ellen MacArthur Foundation, 2013a; European Automobile

Manufacturers' Association: ACEA, 2014). In addition, the plant is reported to have generated a turnover of 100 million Euros with 200,000 remanufactured components in 2012 (Ellen MacArthur Foundation, 2013a).

"Doing more with less", re-manufacturing can solve the availability pressure of spare-parts in the automotive after-market, especially in case of obsolete auto-product replacement (Automotive Parts Remanufacturers Association: APRA, 2015; Weiland et al., 2008). Automotive vehicles have continuously developed for a long time. The development has led to more complexity of production processes and more diversity of materials (Automotive Parts Remanufacturers Association: APRA, 2015). Producers have to ensure that their spare-parts are available in future decades after their original auto-products were manufactured. However, it is difficult to ensure availability of various materials for some specific processes, depending on the lifetime of the products. For instance, the lifetime of semiconductors is shorter than the lifetime of a motor-vehicle. So, the problem of material availability is more acute in the latter than in the former.

Manufacturing of new spare-parts in the future for supply the aftermarket is subject to the problem of significant growth of production costs. But there is evidence to show that the recycling option would do little to overcome this problem. Moreover, it should be noted that embedded values of auto-materials are lost in the recycling processes (Automotive Parts Remanufacturers Association: APRA, 2015). On the other hand, there is growing evidence to show that re-manufacturing is a better option on grounds of cost and affordability of products, quality of products and conservation of materials (Weiland et al., 2008). The advantage of re-manufacturing over recycling is that it provides the scope for "doing better with less" (Kemps & Vos, 2016). Re-manufacturing is the only close-looped business model that can – using emerging technologies, like digital technology - provide a chance for manufacturers, like auto-manufacturers, to revise and upgrade their reused auto-components in order to re-manufacture price- and quality-competitive auto-products.

2.6.2 Challenges of re-manufacturing within the automotive sector

Remanufacturing can be applied in a wide range of industrial sectors. Especially, it is attractive to industrial sectors that produce capital-intensive, and durable products with relatively long product life cycles (Parker et al., 2015, p.10).

Remanufacturing is appropriate when certain essential characteristics of products, core-components, and technology trends are met:

- The product is durable, high-value, factory-built and has reached end-of-use functionally and not by decomposition (All-Party Parliamentary Sustainable Resource Group, 2014; Matsumoto & Ijomah, 2013).
- The product has 'core-components' that can be used as key parts of the restored product. A core is the end-of-use/end-of-life product/material/ or part that is put through the remanufacturing process. The core for remanufacturing can be easily disassembled and can be restored to the original condition and performance. The restorable value-added in the core has high enough value for recovery incentives relative to its market value and original cost. Core-components are potentially available for continuous supply in the remanufacturing market (Matsumoto & Ijomah, 2013).
- The product and process technologies are stable or at least do not change quickly (All-Party Parliamentary Sustainable Resource Group, 2014; Matsumoto & Ijomah, 2013).
- Fashion or demand trends in the product do not change quickly (All-Party Parliamentary Sustainable Resource Group, 2014).

Remanufacturing can be applied in a wide range of industrial sectors. These include automotive, aerospace, electrical & electronic equipment, heavy duty and off road equipment, machinery, and medical devices (Parker et al., 2015). However, the automotive sector is by far the largest sector of the remanufacturing industry (Yuan et al., 2020). In principle, any automotive hard-parts for automobiles can be re-manufactured (Jörg, 2019).

Most of the automotive parts that automotive remanufacturers use as automotive replacement-parts are shown in Figure 2.2 (Matsumoto & Ijomah, 2013). There is wide variation and complexity in the remanufactured auto-products, ranging from remanufactured windshield-wiper-motor to a completed engine. However, only one tenth of spare parts in automotive after-market are remanufactured auto-parts. Furthermore, manufacturers of new-manufactured vehicles rarely use remanufactured parts (Optimate, 2013, p.15). Remanufacturing of passenger cars now only occur in the classic car segment of the automotive market (Optimate, 2013, p.17).

Air brakes	Differentials	Power window motors
Air conditioners	Electronic control modules	Rack and pinion
Alternators and parts	Engines and parts	Smog pumps
Antilock brake systems	Fan clutches	Starters
Brake shoes	Front wheel drive axles	Steering units
Brake cylinders	Fuel injectors	Torque converters
Calipers	Generators and parts	Turbo chargers
Carburetors	Master cylinders	Transmissions and parts
Clutches	Oil pumps	Water pumps
Constant velocity drive shafts	Power brake units	Wiper motors
Cruise controls	Power Steering gears	
Cylinder heads	Power steering pumps	

Figure 2.2 Targets for the remanufacturing of automotive parts (Matsumoto & Ijomah, 2013)

There is a significant room for growth in the auto-remanufacturing industry in view of the growing concern with sustainability. Growth in the remanufacturing of components means employment of less energy and material resources, and reduction in production costs. Engineers, product designers and planners on the supply side constantly enhance new-manufacturing techniques and product designs to optimize re-manufacturing and enhance the appeal of remanufactured products to potential customers (Jörg, 2019).

The auto-remanufacturing sector is not however without difficulties. The major impediments relate to perverse customer behaviour stigmatising remanufactured products as ‘second-hand’ and second rate. This prejudice against remanufactured products stems from lack of awareness of customers that remanufactured products can be as good and robust as ‘like new’ (Lund, 1984; Yuan et al., 2020).

Remanufacturing as the best practice of the Circular Economy

In terms of eco-friendliness, safety and availability of automotive products, remanufactured automotive parts are considered to have an edge over their newly manufactured counterparts (Automotive Parts Remanufacturers Association: APRA, 2015). Re-manufactured parts are different from reused and repaired automotive-units. Reused parts are unreconstructed parts of discarded automobiles. These are put on the market as intermediate inputs with little or no value-added to them. Repaired parts are parts with value-added to them as they are put through simple processes, often labour-intensive, to get them fixed and make them operational again. Remanufactured parts, on the other hand, are perfectly rebuilt through the re-assembly of components of completely disassembled auto-motives (Table 2.1). Remanufacturing of auto-parts is conducted with concern for quality and safety as warranty to safeguard consumers from the risk of potential problems of safety and functionality. That is why remanufactured products are considered to be as good as new products that are manufactured using primary materials. However, customers would often attach stigma to remanufactured products out of misconception, and this has the effect on remanufactured products being considered inferior to their manufactured counterparts in the eyes of customers. This will be investigated in the empirical part of this study.

Reconditioned parts are rebuilt from broken components after cleaning, inspecting, and replacing the components. Serviceable components are reused if the components are considered satisfactory to the re-manufacturers within their acceptable limits of tolerance. As a result, the quality of re-conditioned parts is related to the capacity of the re-conditioners which differs from one re-conditioned part to the other. Not surprisingly, many of these reconditioned parts are supplied with a limited warranty (James Berry, 2015). Thus, re-manufactured parts generally perform better than re-conditioned parts in terms of quality and involve low risk to customers in terms of durability and reliability (Table 2.1).

New-manufactured and recycled parts may be preferred for safety, quality and reliability; but there is evidence to suggest that they are less environmentally friendly and less price-competitive than the inner-loop remanufactured circular activities (Automotive Parts Remanufacturers Association: APRA, 2015; King et al., 2006) (see also Table 2.1).

Table 2.1 End-of-Life Activities of Automotive Parts

(Saavedra et al., 2013; Weiland et al., 2008)

Automotive Products	Disassembly Level	Raw Material	Availability	Systematic Final Test	Quality/Safety Risks	Environmental Friendliness
New Parts	not applicable	new materials	Yes	Yes	No	No
Reused Parts	No disassembly and re-assembly	used parts and components	not applicable	No	Yes	Yes
Repaired Parts	Partial disassembly and re-assembly	used parts and components	No	Partial	Partial	Yes
Re-conditioned or Refurbished Parts	Partial disassembly and re-assembly	used parts and components	Yes	Partial	Partial	Yes
Re-manufactured Parts	Completed disassembly and re-assembly	used parts and components	Yes	Yes	No	Yes
Recycling Parts	Completed disassembly and re-assembly	used materials	Yes	Yes	No	Partial

The remanufacturing process and challenges

Re-manufactured products are widely applied and contribute to the high growth potential of the automotive industry (Parker et al., 2015, p.62). Automotive remanufacturing is the biggest industry of the global remanufacturing industry (Kamper, Triebs, Hollah, & Lienemann, 2019; Yuan et al., 2020).

The key objective of remanufacturing is turns on achieving at least the same quality level, durability, safety, reliability and robustness of performance, and warranty as new-manufactured alternatives. The process of remanufacturing is similar to the processes involved in the assembly of new-manufacturing auto-products, with the exception that components of the remanufactured are re-processed in different ways. Indeed, many of the know-hows, skills and experiences, technologies, tools and equipment, as well as assembly sequences and quality assurance of new-manufacturing processes can be used in remanufacturing processes. The only exceptions exclusive to remanufacturing are the disassembly and cleaning processes. Remanufacturing needs new standards, new solutions and new technological know-hows on industrial levels to close the loop from an end-of-use stage to the stage where core-components are remanufactured (at least) 'like-new' product stage.

The re-manufacturing process can be divided mainly into seven steps as shown in Figure 2.3 (APDI, 2017; Atlantic Automotive Manufacturing, 2015; Automotive Parts Remanufacturers Association: APRA, 2015; Butzer, Schötz, & Steinhilper, 2016; Matsumoto & Ijomah, 2013; Sakao & Sundin, 2019; Zero Waste Scotland, 2014). These stages in the remanufacturing process are: (1) collection of cores or end-of-use products; (2) total disassembly of the cores; (3) thorough cleaning and surface processing of subparts; (4) component remanufacture and replenishment by new components; (5) product reassembly; (6) final testing; and (7) final complement.

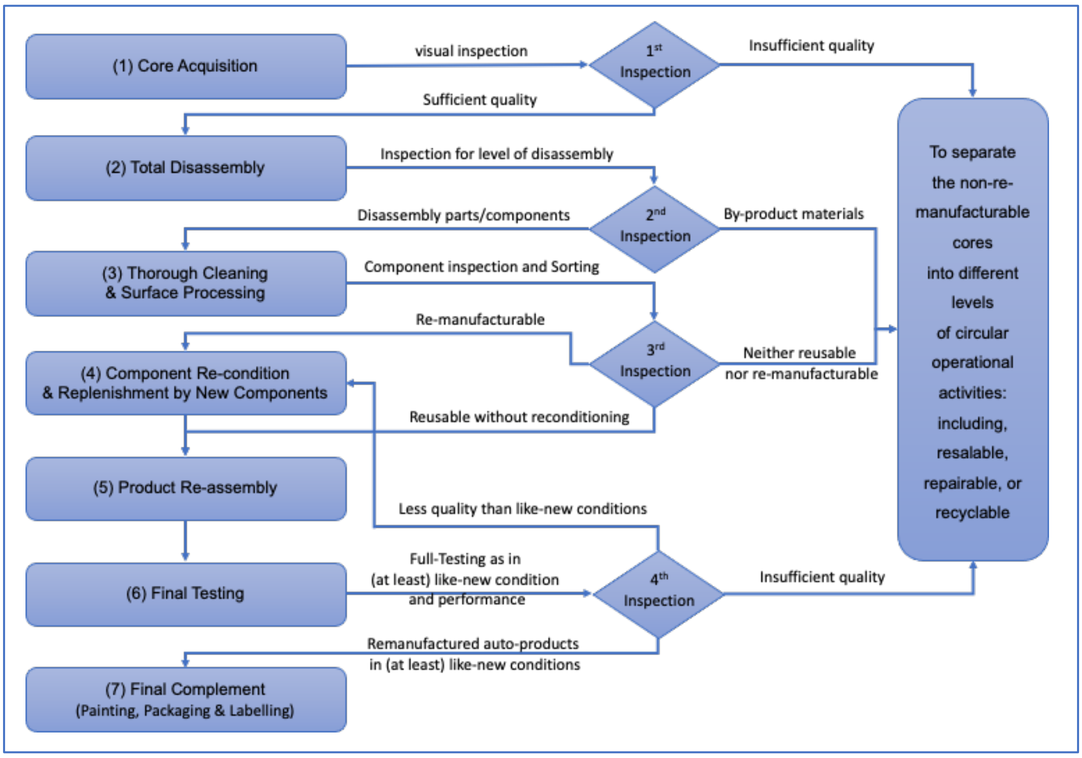

Figure 2.3 Seven major steps in the re-manufacturing of automotive products

Stage 1: *Core acquisition and inspection*

The first stage is "core acquisition and inspection". The re-manufacturing process begins with the collection of 'end-of-use' auto-parts or cores via their reverse-logistic channels. The success of this process depends on the information obtained from return forecasts which are based on designs of return strategies and the principle that remanufacturers should balance the volume of core collection and the quality level of the cores collected (Matsumoto & Umeda, 2011).

The surface appearance of the collected cores is inspected to check for their usefulness. At this stage the collected cores are sorted to ensure that the cores are not structurally damaged and deficient with missing key components as this would affect the physical integrity of the cores and their usefulness for re-manufacturing. Damaged cores are sifted out upon inspection. The difficulty envisaged at this stage is that the quality of many 'end-of-use' parts appear the same on the surface, although this may not be the case when the inside of the cores is considered. It is therefore important that the cores are carefully inspected by automotive technicians before passing to the next stage of the re-manufacturing process (Atlantic Automotive Manufacturing, 2015). The aim at this stage is not only inspect re-manufacturability of cores, but also to grade and separate the acquired cores into different levels for remanufacturing, for reconditioning, for repair, or for recycling (Matsumoto & Ijomah, 2013).

Visual inspection is important for adding values to the automotive remanufactured products. Insufficient inspection can cause incorrect quality-decisions and faulty screening of cores, which would be reflected in the quality of the products' to be remanufactured. According to Casper & Sundin (2018), the major challenge at this stage is how to handle the variety of automotive cores, given the diversity and complexity of the cores acquired. The variety issue (41%) is identified to have more critical effects on remanufacturing than the issues of uncertainty (28%); size (17%); and dynamics (14%) (Casper & Sundin, 2018, p.98).

Stage 2: *Total disassembly*

The second stage is "total disassembly and (the second) inspection". The cores that filtered to this stage are completely disassembled and separately inspected. The process begins with consideration of what parts are required for re-production. Then, some accepted cores are totally disassembled into components. The process of total disassembly of cores starts by removing the outside components of the cores. All insignificant components, hard fluid lines, and inside residual oils are removed. Then, all inside components are disassembled. After complete disassembly, all components of the cores are individually inspected. Extraction of all wearable components is needed before they are replaced with new components in the re-assembly stage. The disassembly process throws up a lot of by-product materials, including oils, paper, plastic, and scrap metals that are subsequently suitably separated and directed to the recycling process (Atlantic Automotive Manufacturing, 2015). The significant challenge at the stage is that many auto-parts are not designed for disassembly (Casper & Sundin, 2018).

Stage 3: *Thorough cleaning and surface processing*

Thorough cleaning, surface processing and (the third) inspection constitute the activities at the third stage. All parts and components are thoroughly cleansed to reach the standard appearance of new condition (Atlantic Automotive Manufacturing, 2015). Cleaning includes removing of old paints, rust, grease and oil. Many cleaning methods, techniques and equipment are used, such as brushing, hot water cleaning, steam cleaning, baking ovens, sandblasting, chemical detergent and ultrasonic cleaning chambers (Matsumoto & Ijomah, 2013).

The cleaning process in the auto-parts remanufacturing is a knowledge-intensive procedure (Matsumoto & Ijomah, 2013). According to the survey of Hammond et al. (1998), the cleaning process is the second most costly procedure of the auto-remanufacturing process(Hammond et al., 1998). The challenge at this stage is that the development of new technological solutions is needed in terms of equipment and knowledge. Technological solutions, including glass bead or steel shot blasting, are not only cleaning but also bringing back a shiny surface and hardening the cores' surface (Matsumoto & Ijomah, 2013). Knowledge to accurately diagnose the cores' contamination is, also, a major challenge. Remanufacturers do not often know the type and level of contamination before they receive the cores. Automotive cores are most often heavily contaminated with various contaminants, including oil, grease, rust, particles, oxide and other operational liquids. Therefore, the ability to diagnose contaminants and cleanse the cores of these depends on individual companies' skills, knowledge, experiences, proficiency and creativity (Casper & Sundin, 2018).

Then, the condition of the disassembled and cleaned parts and components is assessed for their re-manufacturability. The re-processed components by disassembly and cleaning are inspected and grouped in to three grades: reusable without reconditioning, re-manufacturable, and neither reusable nor re-manufacturable (Matsumoto & Ijomah, 2013).

Stage 4: *Component reconditioning and replenishment*

The fourth stage in the remanufacturing process covers "component re-conditioning/re-building, replenishment by new components and further inspection". At this stage, all components are reconditioned and/or rebuilt incorporating into them new elements in an effort to return them to their original condition as parts and components. Parts/components that cannot be brought back to the level of their original specification are replaced by new spare parts (Atlantic Automotive Manufacturing, 2015; Matsumoto & Ijomah, 2013). Alternatively, the components can be modified to have improved performance, functionality and/or durability to be better than their original condition. The reconditioned and modified components are sealed and then put through a make-over process involving polishing to improve their appearance. Finally, they are inspected to check that the seals on fluid-lines are leak-free (Atlantic Automotive Manufacturing, 2015).

Because the performance of remanufactured components can be improved at this stage, it is this stage of the re-manufacturing process that is associated with the highest added value. In the case of auto-products for which new-manufactured parts are no-longer available in the market, the situation offers an interesting business opportunity for remanufacturers to promote their remanufactured auto-products (Casper & Sundin, 2018, p.99).

The major challenges facing remanufacturers at this stage include: availability of core parts and new spare parts in the quality required, particularly in the case where no longer being manufactured; and accessibility to technology, know-how, data, information, product-design drawings for re-processing auto-components to 'like-new conditions', which is crucial, especially for independent manufacturers (IRs)[4]. Research and development for reverse engineering is also a challenge, particularly where products data and information from original equipment manufacturers (OEMs)[5]

[4] Independent Remanufacturers (IRs) or non-contract remanufactures are remanufacturers who remanufacture products with little or no contact with the OEM (Sundin et al., 2016, p.12).

[5] Original Equipment Manufacturers (OEMs) are new-product manufacturers who manufacture their own products. While Original Equipment Remanufactures (OERs) are remanufactures who remanufacture their own products. Hence, OEMs/OERs have all the data, information, product design, availability of correct spare parts and service knowledge that are needed for manufacturing/remanufacturing (Sundin et al., 2016, p.12).

are not available (Casper & Sundin, 2018). However, the process of reverse engineering is expensive, time-consuming, and often ineffective. Hence, in order to proceed with remanufacturing, cooperation between IRs and OEMs to bypass intellectual property rights (IPR) restrictions under OEMs' licence for contract remanufacturers (CRs)[6] is important for remanufacturers (Matsumoto & Ijomah, 2013).

Stage 5: *Product reassembly*

The fifth stage is "product re-assembly". The reconditioned parts and components are re-assembled at the same level of quality as new manufactured components. The challenge is that specialist craftsmen are needed to control the process with care and precision to assure that no defects occur. All parts and components are measured and arranged according to their original specifications, and inspected to checked for their adequacy in terms of quality and technical robustness to ensure if, upon remanufacturing, they would have the same appeal to consumers as their new manufactured counterparts. All parts are then re-assembled in line with the same detailed techniques and specific steps adopted the manufacturing of new products. This assures consistency and repeatability of production in re-manufacturing (Atlantic Automotive Manufacturing, 2015).

Stage 6: *Final testing*

The sixth stage is "final testing". All re-manufactured products have to pass the final standardised testing stage. This includes testing of seals to be leak-free; fluid flow controls; and pressure ranges as accepted by control standards of the specific auto-products. Furthermore, the testing data results are retained for every re-manufactured product, which can be checked and retracted for quality in case of warranty claims. This process ensures that the remanufactured products are given the same quality and warranty as a new unit (Atlantic Automotive Manufacturing, 2015).

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[6] Contract Remanufacturers (CRs) are remanufacturers who are contracted to remanufacture products on behalf of OEM (Sundin, Sakao, Lindahl, Kao, & Joungerious, 2016, p.12).

Stage 7: *Final complement*

The final stage is “final complement”. At this stage of the remanufacturing process, auto-products are checked for completeness including clearance of residual testing elements. Then, re-manufactured units are processed for surface painting; and inspected for quality and durability before packaged to be dispatched to the automotive market. Finally, all re-manufactured auto-products are labelled for disclosure by the remanufacturer (Atlantic Automotive Manufacturing, 2015).

2.6.3 The empirical basis: Remanufacturing experiences in different countries

Globally, remanufacturing contributes over 110 billion US dollars annually to business turnovers (Zero Waste Scotland, 2015). The automotive remanufacturing market is currently the largest remanufacturing industry across the world (Kamper et al., 2019). The automotive remanufacturing market is well-established and has been a growing one (U.S. International Trade Commission: USITC, 2012). According to the research firm, Research and Markets (2017), the remanufactured automotive market was valued at 33.16 billion US dollars in 2016 and is estimated to expand at a compound annual growth rate (CAGR) of 6.6 per cent during the period, 2017 – 2025. Furthermore, about 35 million units of remanufactured auto-products were sold in Europe in 2016 and this is expected to grow at the rate (CAGR) of 7.4 per cent to reach over 56 million units across Europe by the end of 2024 (Persistence Market Research, 2019).

The USA is the global largest producer, consumer, and exporter of remanufactured products (U.S. International Trade Commission: USITC, 2012). Figure 2.4 shows that North American region is the largest player in the global market for remanufactured auto-products. The region is expected to stay at the same pole position in 2022, although its market share is predicted to decrease. Europe was the second-largest market for global remanufactured auto-products in 2015; and its market share is expected to increase a bit by 2022. China's market for remanufactured auto-products is predicted to grow significantly with its market share doubling to 9 per cent by 2022 from the 2015 position (Kripli, 2016, p.12).

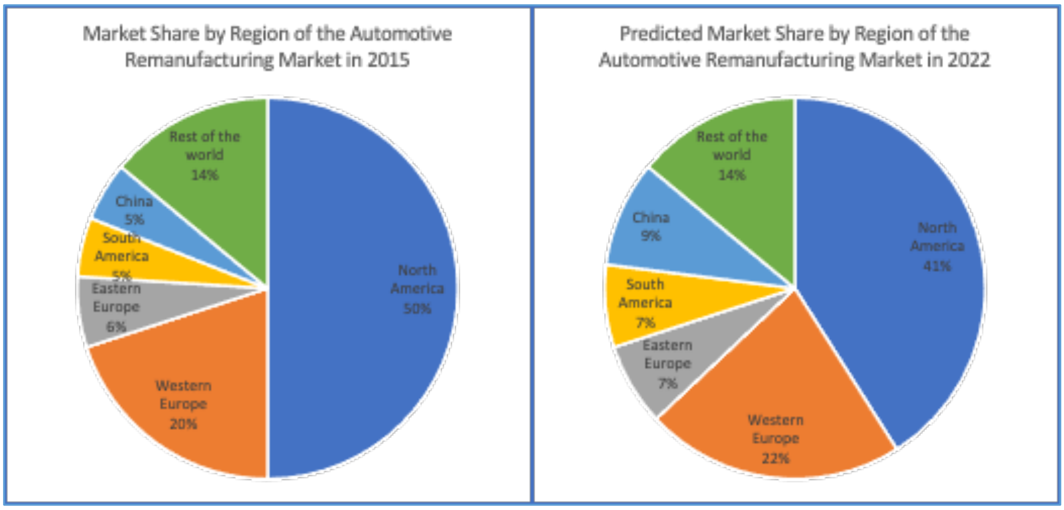

Figure 2.4 Global Market Share by Region of Automotive Remanufacturing Market in 2015 and 2022 (Kripli, 2016)

The market for remanufactured auto-products has also grown significantly in the last decade for the Asia Pacific region, especially for Japan and China (Zhang, Yang, & Chen, 2017). Thus, the major players in the global market for remanufactured automotive products are: USA, EU, Japan and China. Following is a cursory review of auto-remanufacturing experiences in these countries.

A. Remanufacturing experience in the USA

Remanufacturing is well established in the USA. It is named the world's greatest producer, consumer, and exporter of remanufactured products (U.S. International Trade Commission: USITC, 2012). More than 6,000 remanufacturing firms are located across all 50 states of the country, which are engaged in the remanufacturing in 113 product areas (Lund & Hauser, 2010). The US annual remanufacturing market is currently about 53 billion US Dollars (Gao & Wang, 2017). Around 180,000 people were employed in remanufacturing industry in 2012 (Zlamparet et al., 2017). Auto-products are one of the major product areas of remanufacturing in the USA (Zhang et al., 2017).

The entire remanufacturing system in the USA is based in the private sector (Lund & Hauser, 2010). Almost all remanufacturing firms in the USA are small and medium enterprises (SMEs), with more than 70 per cent of these being small enterprises, and about 25 per cent, medium enterprises (Lund & Hauser, 2010, p.4). Small firms tend to be located near their markets, while the larger firms tend to be located in areas where there are low capital costs and plentiful labour-forces (Lund & Hauser, 2010, p.3).

The domestic remanufacturing auto-market in the USA was 6.2 billion US dollars in 2011 (U.S. International Trade Commission: USITC, 2012). Remanufactured auto-products are common in the USA - up to 70 per cent of major replacement auto-parts in the USA are remanufactured, including engines, transmissions, starters and alternators (Matsumoto, Chinen, & Endo, 2017; Zhang et al., 2017). Most automotive remanufacturing businesses in the USA are outgrowths of the service operations of original equipment manufacturers (OEMs) and independent repair auto-firms (Lund, 1984).

A key facilitating factor driving the remanufacturing market in the USA is government support policy targeted at remanufacturing businesses (Zero Waste Scotland, 2015). Government procurement is also used as policy instrument for promoting remanufactured auto-products in the domestic US market. The US Federal legislation for procurement, enforced by the Federal Vehicle Repair Cost Savings Act in 2015, requires all vehicles in the Federal fleet (around 588,000 vehicles) to use, where possible, remanufactured products instead of new-manufactured auto-products (Zero Waste Scotland, 2015). This measure is excepted where remanufactured auto-products are more expensive, take longer lead time or are of lower performance than new-manufactured ones (Zero Waste Scotland, 2015). Overall, this public procurement policy has had the effect of increasing the demand for remanufactured auto-products and stimulating the domestic remanufacturing auto-industry.

Trade promotion policy encourages US remanufacturing exports to many countries in Europe, South America and Asia. For example, the US International Trade Commission (USITC) has helped to promote remanufactured products among America's trade partner countries through negotiations in Free trade Area (FTA) agreements, World Trade Organisation (WTO) and Asia-Pacific Economic Cooperation (APEC). US trade agreements have sought favourable terms on trade regulations containing articles on the definition of cores and remanufactured products in order to ease trade restrictions on remanufactured exports from the US. This has helped to increase export demand for remanufactured products from America

(Kojima, 2017). Activities focusing on issues of quality of cores and remanufactured products have been funded to have open access to markets in emerging economies. Moreover, the US government provides an Automotive Resource Guide for US exporters through the International Trade Administration (USITA). The guidebook provides foreign market intelligence over 40 countries around the world. The market information includes industry trends, competitors, trade restrictions and analytical data in the trade partner countries (Zero Waste Scotland, 2015).

As well as the Government, some organisations also promote and support remanufacturing in the USA (Zero Waste Scotland, 2015). These organisations include Automotive Parts Remanufacturers Association (APRA) and Motor & Equipment Remanufacturers Association (MERA). APRA facilitates auto-remanufacturers for technical services, legislative & legal advocacy, workshops and educational information and build-up the automotive remanufacturing community. MERA provides remanufacturing quality standards and certification. Also, the Remanufacturing Industries Council (RIC), which evolved from the Rochester Institute of Technology (RIT), is a centre of excellence for remanufacturing activities, in general.

B. Remanufacturing experience in Japan

The market for automotive remanufacturing has been evolving in Japan since the 1970s. In the 1970s, it was the repair industry that dominated the automotive market (Matsumoto, Chinen, & Endo, 2018). However, it was at this time that automotive remanufacturing businesses began mainly for export to the US, taking advantage of the cheap labour costs in Japan at the time compared to that in the US. The domestic demand for automotive remanufactured products in Japan was negligible in the 1970s, because Japanese consumers did not have favourable disposition towards remanufactured products (Matsumoto et al., 2018).

After September 1985, following the Plaza accord[7], and the increase of wage rates in many countries including Japan, the price competitiveness of Japanese

[7] The Plaza Accord or the Plaza Agreement is a 1985 agreement signed by the Group of Five (G5) nations: France, Germany, the US, the UK, and Japan. The agreement aims to correct trade imbalances

remanufactured auto-products dropped, and exports slowed down. This together with the unfavourable domestic demand for remanufactured products caused many automotive remanufacturing enterprises in Japan to close down business (Matsumoto et al., 2018).

The domestic demand for automotive remanufactured products in Japan started to grow only after the early 2000s. Key elements that led to growth in the domestic market for remanufactured auto-products include collaboration between original equipment manufacturers (OEMs) to increase the demand of remanufactured auto-products, to design auto-products for suitably remanufacturing and to get a high core return rate (Parker et al., 2015). Also, Japanese consumers' attitude remanufactured auto-products has changed via direct and indirect channels (Matsumoto et al., 2018).

Automotive OEMs play an important role in promoting remanufactured auto-products in Japan because of the reputation of their brands, their large network of dealers and their initiative to use remanufactured auto-parts in aftersales markets. For instance, Denso and Hitachi began to use remanufactured auto-parts for the domestic market since the early 2000s. As a result, awareness of remanufacturing among vehicle repair shops was enhanced, as was awareness of customers who would now recognize the ‘like new’ claim alluded to remanufactured auto-products. As a result of this change of attitude on the sides of both remanufacturers and customers, the demand of remanufactured auto-products is known to have increased rapidly (Matsumoto et al., 2018).

The commercial practices of automobile repair shops also had an important influence in shaping the Japanese market for remanufactured auto-products. They would directly offer the remanufactured auto-products to customers as an option to new manufactured auto-products, and also inform them about the general customer feedback they receive about real experiences regarding remanufactured auto-products (Matsumoto et al., 2018). More than a half (about 60 per cent) customers with experience of remanufactured auto-products in Japan are reported to have disclosed that their first awareness about and experiences with remanufactured auto-

between the U.S. and Japan by depreciating the US dollar relative to the Japanese yen. However, an unintended effect was that the agreement caused Japan less dependent on trade with the U.S.

products was because vehicle repair shops offered them the option at the point of service (General Insurance Association of Japan: GIAJ, 2014). Therefore, cooperation and knowledge of vehicle repair shops was a key channel in the promotion of automotive remanufactured products in Japan (Matsumoto et al., 2018).

Although the Japanese Government did not have policies to directly support demands of remanufactured auto-products as that of the US Government, Japanese environmental regulations had indirectly influenced growth of demand for remanufactured auto-products. Especially, the End-of-Life Vehicle (ELV) Recycling Act 2002, which came into force in 2005, was a turning point for Japanese circular operational activities in ELV recovery system. It has enhanced environmental consciousness of automotive OEMs and auto-customers. It is, also, the first step of some OEMs to use remanufactured auto-products in their aftersales services (Despeisse, Kishita, Nakano, & Barwood, 2015).

C. Remanufacturing experience in China

The gross domestic value of the remanufacturing market in China was around £15 billion (150 billion RMB) in 2015 (Yan Wang, 2016). The remanufacturing market in China is known to have developed rapidly over the last decade. According to the High-end Intelligent Remanufacturing Action Plan (2018–2020), it is expected to reach £20 billion (200 billion RMB) by 2020 (Yuan et al., 2020).

The automotive remanufacturing market in China was formally launched in 2008. Prior to this, automotive remanufacturing was prohibited in China because of road safety reasons, especially with important auto-parts such as engines, transmissions, gear and the vehicle frames. These auto-parts can cause a lot of waste and pollution when they are broken-down and re-melted in waste treatment processes (Zhang et al., 2011).

China has now become the largest global producer of and market for remanufactured automotive products. The number of passenger cars in China was more than 240 million vehicle-units in 2018. The number of ‘end-of-life vehicles’ (ELVs) was 9.1 million, but only 1.99 million ELVs were recycled. That is, the recycling rate of ELVs in China was around 22 per cent in 2018 (CII, 2019). Moreover, the number of ELVs in China is expected to be more than 10 million units by the end of 2020 (Yuan et al., 2020).

From the standpoint of environmental protection from the ELVs pollutions, the automotive remanufacturing stands as an emerging industry of strategic significance. Steady progress of the industry has been observed in recent years following policy guidance by the Government. Indeed, the automotive remanufacturing market in China has grown rapidly and standards were legally instituted to regulate specifications of remanufactured automotive parts. In 2009, more than 100,000 engines and 60,000 transmissions were remanufactured (Parker et al., 2015).

A series of policies were adopted to provide legal and institutional support to remanufacturing activities (Yuan et al., 2020). In 2008, China's National Development and Reform Commission (NDRC) and the Ministry of Industry and Information Technology (MIIT) established a pilot programme to allow and control automotive remanufacturing businesses in China (Zero Waste Scotland, 2015); and 14 pilot automotive remanufacturers were selected and authorised to run remanufacturing businesses (Zhang et al., 2011). In 2013, 28 remanufacturing enterprises were approved by NDRC in the second phase of the pilot project (Yuan et al., 2020).

China aims to establish itself as the largest global remanufacturer of auto-products. The Chinese Government has in recent years passed legislations, including the Circular Economy Promotion Law, Product Return Incentives and Labelling and Certification Systems, and has promoted direct investment in supporting infrastructure for the development of the remanufacturing industry (Yan Wang, 2016). Remanufacturing is listed in the 'National 13th Five-Year Plan for Science and Technology Innovation' and in the national strategic plan, 'Made in China 2025', as an emerging strategic industry and also as a key industrial sector for reducing environmental degradation and promoting green growth (PRC State Council, 2016; Yan Wang, 2016). The National Key Laboratory for Remanufacturing was established as a centre of excellence and research for remanufacturing, addressing economic, technological and environmental issues relating to remanufacturing (Zero Waste Scotland, 2015).

D. Remanufacturing experience in Europe

The circular economy in Europe is driven by EU policies and regulations aiming to enhance resource efficiency and waste management. The circular economy policy of the EU is based on the Circular Economy Action Plan 2015 (CEAP 2015). This bill aims to "stimulate Europe's transition towards a circular economy, which is expected to boost global competitiveness, foster sustainable economic growth and generate new jobs" (European Commission: EC, 2015).

The key development of the automotive remanufacturing market in Europe was initiated by the introduction of end-of-life vehicles (ELVs) Directive in 2000 (Directive 2000/53/WE). The directive aims to support the circularity of materials in vehicles. It required that EU members reach ELV targets of 85 per cent (per average weight of vehicle) reuse/recycling and 95 per cent (per average weight of vehicle) for reuse/recovery by 2015. (European Parliament and Council, 2000). There are several important measures of the ELV Directive related to the development of the remanufacturing process. Vehicle manufacturers and professional car importers have responsibility to create the network of collection, treatment and recovery of ELVs. Producers have to ensure, at the stage of design and production of cars, that their auto-products can be dismantled and recycled as ELVs. They are also required to label components and materials to facilitate identification for reuse and recycling (Lewandowska, 2018).

By 2013, nine member states had reached the targets of 95 per cent for reuse/recovery, while other 17 members had reached the target of 85 per cent for reuse/recovery (European Commission: EC, 2017, p.10). The achievement is a proven instance that policies and regulations, the ELV directive in particular, are effective to extend automotive producers' responsibility in the EU regarding ELV treatment in the context of eco-design and elimination of hazardous substances. Finally, The ELV Directive also promotes innovative research for the substitution of the hazardous substances and the treatment of ELVs so as to increase the economic value of the vehicle waste stream (Farmer, 2019).

There are several remanufacturing associations in Europe, including the European branch of APRA and the International Federation of Engine Remanufacturers and Rebuilders (FIRM) (Zero Waste Scotland, 2015). Some academic remanufacturing research institution were established in Europe. These include a Fraunhofer Institute for Remanufacturing, in the University of Bayreuth in Germany, with research focus on automotive remanufacturing; the GSCOP laboratory at the University of Grenoble; and the University of Strasbourg in France, which focuses on design for remanufacturing (Zero Waste Scotland, 2015). Horizon2020 funding has provided a number of research projects for remanufacturing. This includes a European Remanufacturing Network with eight European partners, including inköping University and University of Strathclyde (Parker et al., 2015).

E. The challenges

There are several challenges facing the automotive remanufacturing sector witnessed by the experiences of the countries discussed above. The major challenges include lack of consumer acceptance, constraints on core supply and lack of business models that would serve as a heuristic for investment decisions.

Customer awareness

Lack of customer acceptances on remanufactured auto-products is the biggest challenge to global remanufacturing (Yan Wang, 2016). Customers' perception of remanufactured auto-products poses a major problem in Japan, China, and the EU. (Matsumoto et al., 2018; Parker et al., 2015; Yan Wang, 2016; Yuan et al., 2020). In the USA, Comprehensive actions of the Government have gradually improved awareness of the consumers/customers towards remanufactured auto-products. The Comprehensive actions include increasing awareness of the public about the advantages of remanufacturing; encouraging private companies to run remanufacturing businesses; and supporting consumers/customers who would decide to switch to remanufactured products (Mitra and Webster, 2008). In the USA, consumers' acceptance of remanufactured products in lieu of new manufactured products is a major factor that would explain why remanufacturing has thrived more than remanufacturing elsewhere in the world (Matsumoto et al., 2017).

Matsumoto et al. (2017) compared customers' acceptance of remanufactured auto-products in the US and Japan. They found that in 2010, 90 per cent of alternators in the automotive aftermarket in the USA were remanufactured products, while the ratio was less than a half in Japan (Matsumoto et al., 2017, p.968). Moreover, US customers appear to have greater awareness of remanufactured auto products than their Japanese counterparts. About 80 per cent of car-drivers in the US are reported to be aware about the availability of remanufactured auto-products as an option, while only 20 per cent of car-drivers in Japan are aware of the remanufactured products (Matsumoto et al., 2017).

In case of the EU, although consumer demand for sustainable products is growing, aided by the facilitation of knowledge transfer and support to the recycling industry, the ratio of remanufacturing to new manufacturing in EU is just around 1.9 per cent in general, and only 1.1 per cent in case of remanufactured auto-products (Parker et al., 2015). According to Jansson et al. (2017), around 75 per cent of remanufacturing firms in the EU identified poor customer recognition as the most significant barrier for their businesses. The need for customer recognition is not only awareness of the availability of remanufactured products in the market, but also lack of knowledge about the sustainable benefits of remanufactured products and inaccurate understanding of the 'like-new' quality of remanufactured products (Jansson et al., 2017; Karvonen, Jansson, Behm, Vatanen, & Parker, 2017; Parker et al., 2015).

In case of China, the rapid growth of the automotive remanufactured industry is supported by government-led programmes, including pilot projects, incentive policies, comprehensive legislation, standards and certification systems (Yan Wang, 2016). Thus, the industry is propelled by supply push policies. However, remanufacturing is a new concept that has not been widely recognised by consumers/customers in China, which means that 'market pull' is hardly apparent as a stimulus for the emergence of the remanufacturing of auto-products (Yan Wang, 2016). Chinese consumers are, in general, said to be least aware of the benefits of remanufacturing, and appear to have bought in the stereotype that relegates remanufactured products as second-hand products, which have inferior to new manufactured products (Yuan et al., 2020, p.161).

Volume, availability and quality of cores

Crucial for the remanufacturing of auto-products are the quantity and quality of the cores acquired. Cores is parts or components of an 'end-of use' or 'end-of-life' product. Cores are intended to be throughputs in the remanufacturing process (Parker et al., 2015). Thus, core acquisition is part and parcel of the remanufacturing process; and has a significant bearing on the industry's ability to grow and to meet market demand on a sustainable basis (Wei, Tang, & Sundin, 2015). However, core acquisition in remanufacturing is not without challenges arising from uncertainties relating to core return. The uncertainties include timing, volume and quality of returned cores (Wei et al., 2015).

In the US, a survey of the remanufacturing industry conducted by Robert Lund (1984) indicated that "scarcity of quality cores at an acceptable price" is ranked as the first factor limiting the growth of remanufacturing businesses (Lund & World Bank, 1984).

In the EU, Jansson et al. (2017) found that around 70 per cent of remanufacturer would count core accessibility next to poor customer recognition as a significant barrier militating against the growth of their remanufacturing businesses (Jansson et al., 2017, p.13).

In China, the challenge of core availability arises mainly because of policy barriers (Wang, 2016). That is, by law,' end-of-life' automotive parts and components or cores must be treated as waste materials to be recycled rather than remanufactured. Moreover, it is legally prohibited to use remanufactured auto-parts to service in-warranty cars. As such, Government policy would rather that cores are sent for recycling rather than for remanufacturing (Yan Wang, 2016).

Business models as challenge to the remanufacturing business

Business models serve as heuristic for viable investment decisions. For the remanufacturing business, the question about appropriate business model has yet to be settled. Parker et al. (2015) argue that sustainable remanufacturing would not take place without a viable business case. Depending on their appropriateness, business models would help firms to understand how to do viable remanufacturing businesses

(Bocken et al., 2014a). A business model is appropriate as a guide for investment decisions in remanufacturing when it incorporates all complex aspects of the remanufacturing process that cannot be readily captured by the conventional (linear) business model based on cost-benefit analysis.

In China, automotive remanufacturing businesses have gained increased recognition as circular economy enterprises thanks to Government policy support. However, automotive remanufacturing businesses have not made much headway owing to their lack of knowledge about the specific nature of the remanufacturing eco-system and the Chinese socio-cultural economic, technological and environmental context (Shao, Huang, Lemus-Aguilar, & Ünal, 2019). Remanufacturing businesses in China would, therefore, need a new business model based on the specific Chinese context bridging the existing gap between businesses' awareness of and actual behaviour towards the remanufacturing of auto-products (Liu & Bai, 2014).

Matsumoto (2010) found that a new business model is a challenge for remanufacturing businesses in Japan, especially for independent remanufactures (IRs) (Matsumoto, 2010; Matsumoto & Umeda, 2011). Moreover, suitable business models for remanufacturing businesses in Japan are different for specific remanufacturing industries, including photocopiers, single-use cameras, automotive products, printer ink cartridges & toner cartridges (Matsumoto & Umeda, 2011). This is because of specific factors including different market structures and different levels of consumers' perceptions about remanufactured auto-products (Matsumoto & Umeda, 2011).

2.7 Key Factors influencing transition to circular remanufacturing: conceptual framework for the switching behaviour of consumers/customers

Conceptually, the market for automotive products, whether produced from new or remanufactured materials, is dictated by demand forces. Supply, it is presumed, does not create its own demand, but demand and policy trends can strongly influence the process and product technologies underlying supply. This is particularly so where there is growing recognition of an ever-diminishing global resource base that has prompted calls for the conservation and sustainable use of resources. The question however remains: to what extent does this environmental imperative override the price (economic) incentive, which has traditionally been at the heart of the decision behaviour of producers and consumers? Would the context of transition from linear to circular economy make a difference to customers' response to price incentives? It is the aim of this study to investigate factors that influence consumption decisions to switch from linear business model to circular business model. Customers can be influenced to change their behaviour to select remanufactured automotive products.

In the remainder of this section, factors that bear on the decision behaviour of customers to switch from new manufactured auto-products to 'like new' remanufactured auto-products are discussed from conceptual and empirical perspectives. This will be done in three parts. The first part will discuss 'the theory of consumer choice', which provides the conceptual basis for customers' switching behaviour in their choices between products. This will be seen in the light of the sensitivity of the switching behaviour of customers to the emerging environmental agenda of governments. The second part will introduce the 'Push–Pull–Mooring (PPM) theory of migration' to explain customers' switching behaviour, and to identify the factors that affect consumers' switching behaviour. The potential factors determining consumers' switching behaviour based on empirical literature will be discussed in the third part.

2.7.1 The conceptual basis: the theory of consumer choice

The theory of consumer choice is a neo-classical scheme which describes how consumers decide on what product to choose to purchase, given the options to choose from under competitive situations and subject to income constraint, and assuming all other factors influencing choice remaining constant. The choice, in the context of this study, is between 'environment-friendly' and 'environment-unfriendly' products – i.e. between 'like-new' remanufactured auto-products and new manufactured auto-products. The theory examines the 'trade-off' customers face when making decisions of choice. Trade-off is a situation in which more of one product can be had at the cost of having less of the other (Mankiw, 2016, p.426).

Two economic tools are needed for the analysis of consumer equilibrium: budget lines[8] and indifference curves[9] (IC). A budget line represents the consumer's budget or income constraint to explain how much a consumer can afford to spend on various product-mixes on the indifference curve. Indifference curves (IC) present the consumer's preferences to explain what the consumer would like to spend it on. These, two tools are put together to consider the optimal choice of the consumer to decide on the product-mix that would establish his/her equilibrium position.

Consider, for example, product 'N' (new manufactured auto-product) and product 'R' (remanufactured auto-product), the consumer would like to have one or the other, or the best possible combination of the products N and R to maximize his/her utility, subject to constraint. Given the consumer's utility map represented by IC_1, IC_2 and IC_3 in *Figure 2.5*, the consumer would like to be anywhere on IC_3, but he is income-constrained. He can be on IC_1, but that would be a sub-optimal position as the consumer can do better than that for the income at his/her disposal. In terms of the prevailing market regime, which is conceptually represented by the relative price line NR (which is also the budget line), the equilibrium position for the customer is at the point of tangency between the relative price line and the indifference curve IC_2 – i.e. at E. Thus, under prevailing market circumstances in which prices change and all other factors including income remain constant, the equilibrium point (E) represents the best combination of products N and R available to the consumer. In economic terms, the optimum point at E is where the marginal rate of substitution of the

[8] A budget line presents the various combinations of two products which a consumer can purchase for a given income. The budget line also shows the limitations or constraints where the consumer faces in attempting to satisfy his/her wants by the bundles of the products. The constraint is limited by the consumer's income and by the prices of the products that the consumer must pay. In other words, the consumer faces a budget constraint because of his/her limited income and the given prices of products. The slope (the change in the vertical distance divided by the change in the horizontal distance) of the budget line measures the rate that the consumer can trade off one product for the other product or shows the relative price between the two products.

[9] An indifference curve (IC) presents the various combinations of two products that provide the consumer equal utility. A higher indifference curve (IC) represents a higher level of utility. In the same manner, a lower indifference curve represents a lower level of utility. Movement on the indifference curve represents an ordering of the individual's taste or preference, while shifts in the indifference curve represent improvements or deterioration in the level of satisfaction the individual derives from the bundle of products. The slope of the indifference curve is the rate of the consumer's willingness to trade-off one product (A) for another product (B). The slope is also named as the marginal rate of substitution (MRS). That is the amount of product A the consumer is willing to sacrifice to have product B. Optimality of choice is determined at the point of tangency between the budget line and the indifference curve.

consumer/customer (slope of the indifference curve, IC_2) is equal to the relative price (slope of the budget line, NR) (Mankiw, 2016).

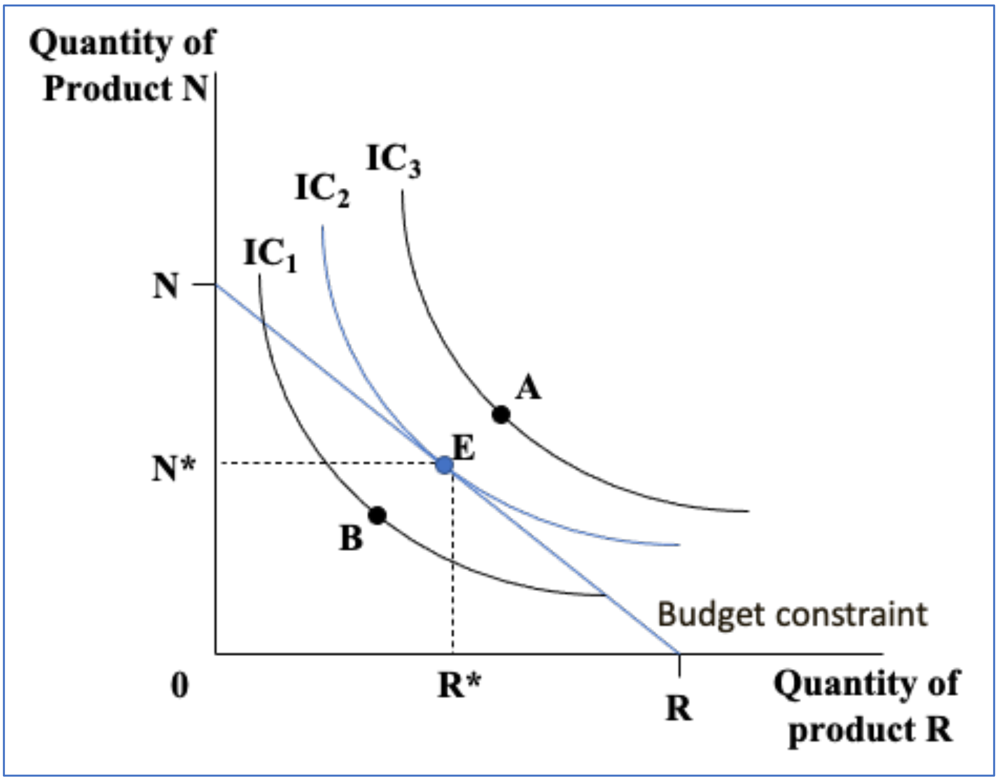

Figure 2.5 The Consumer's Optimum in the Theory of Consumer Choice

How Changes in (relative) Prices Affect the Consumer's Choices

The theory of consumer choice can also explain a consumer's switching behaviour following changes in the relative price of products, in which one product becomes cheaper relative to the other. Prices are determined by interactions between the market forces of demand and supply.

Suppose now the price of product N increases, say because of shortfalls in raw material supply. This shifts the prevailing relative price line from NR to N'R, making product R relatively cheap, and moving the point of consumer equilibrium from E1 to E2 as demonstrated in Figure 2.6. This change in relative price would be expected to influence customers to switch their customs towards product R, increasing their purchase from R1 to R2. The shift from R1 to R2 can be decomposed into two components: the substitution effect[10] and the income effect[11]. The stretch from R1 to R3 is the substitution effect; and the stretch from R2 to R3 is the income effect.

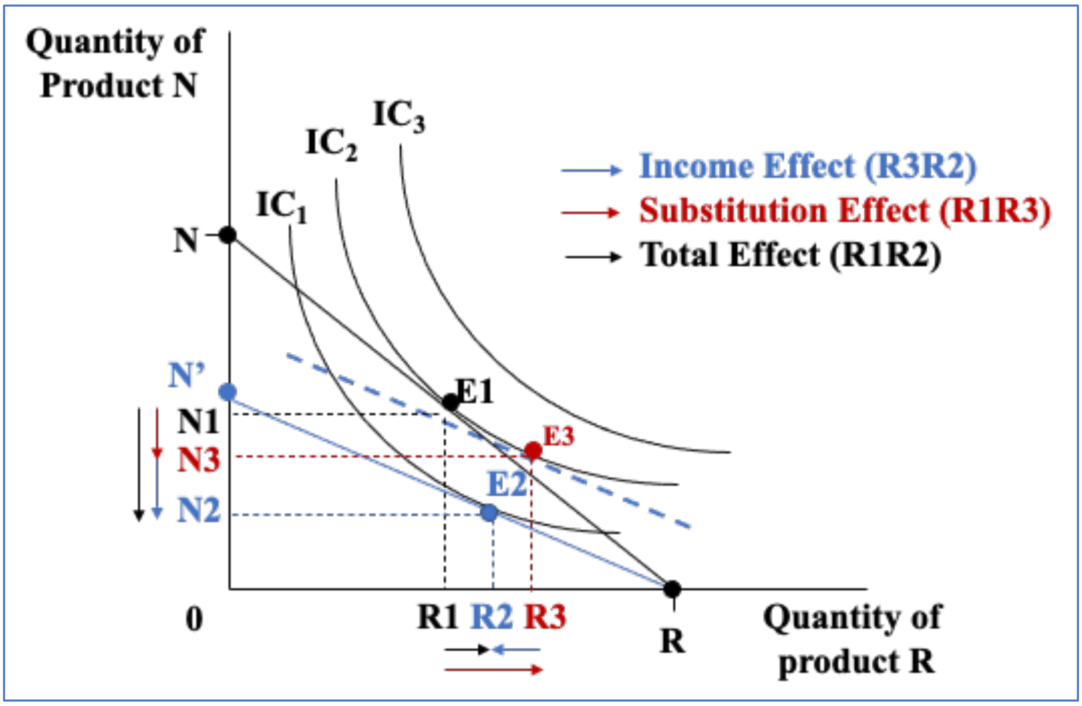

Figure 2.6 Substitution and income effects of changing the relative price

How Changes in the Individual's Preferences (Taste) Affect the Consumer's Choices

Taste or preference is one of the factors which is assumed to remain constant in Figure 2.5 and Figure 2.6. Change in taste, as a result of increased awareness of the private and social benefits of one of the products (say, product R), will change the consumer's utility map, as shown in Figure 2.7. Change in customers' taste is a result of programmes aimed at promoting broad policy objectives by influencing the switching behaviour of customers. This change in the taste of customers in favour of

[10] The substitution effect: the price of product N has increased; the consumer can get more quantity of R for every N that he/she give up. Because the product R is now relatively cheaper, the consumer is likely to purchase less N and more R.

[11] The income effect: the product N is more expensive; the consumer's income has lower purchasing power. The consumer is, in effect, poorer than he/she was. Because of being poorer, the consumer can buy both less N and less R.

product R leads to changes in the structural shape of indifference curves and hence in the marginal rates of product substitution, thus reflecting changes in the switching behaviour of consumers from N to R.

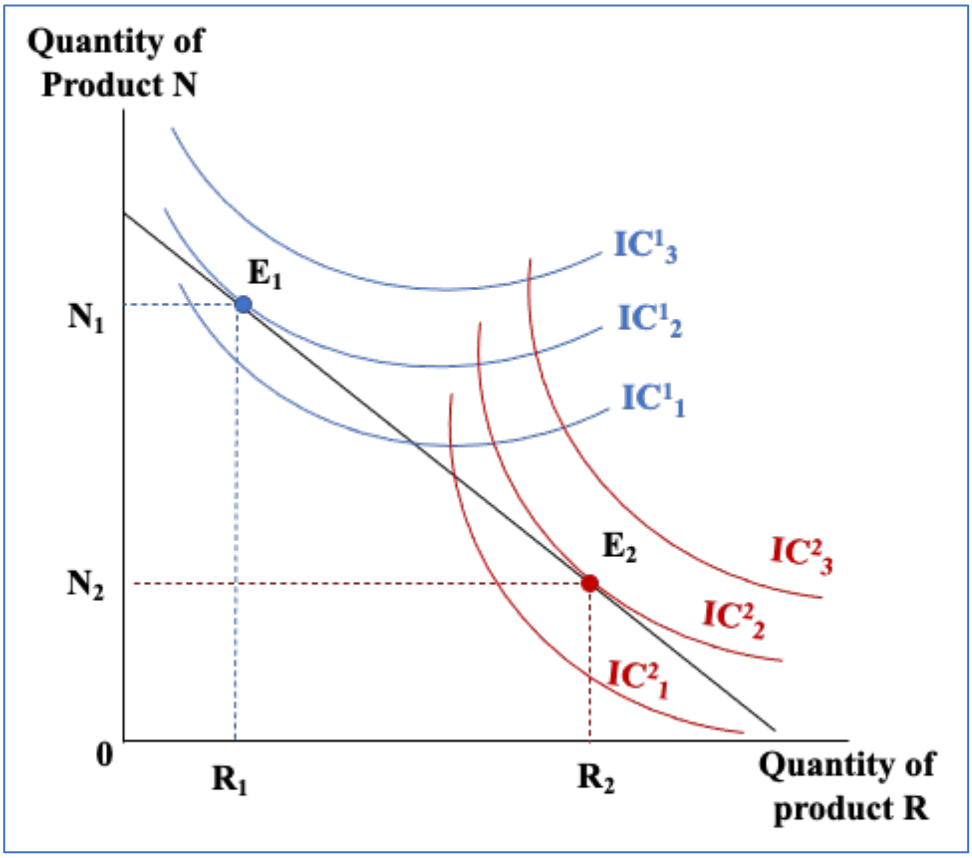

Figure 2.7 An Optimum Change in Individual's Preference, the Theory of Consumer Choices

The effect of change on the customer's preference schedule, regarding choice between products N and R, is to shift the indifference curves from IC^1 (IC^1_1, IC^1_2 and IC^1_3) to IC^2 (IC^2_1, IC^2_2 and IC^2_3 in Figure 2.7). The initial equilibrium, prior to the policy-induced change of the taste/preference of customers, is at point E1 where the consumer optimises his/her utility by purchasing the bundle of the product N at N1 units and the product R at R1 units (point E1 on indifference curve IC^1_2). The change in taste would drive customers away from product N toward the product R. This switch from N to R could be a result of policy drive to persuade customers to choose the more environmentally friendly product, R, instead of N.

The neoclassical theoretical construct discussed above is significant for the analysis of the switching behaviour of customers from new manufactured automotive products (N) to remanufactured auto-products (R) in at least two respects. First, the model, however simplistic, could serve as a heuristic in determining decisions of choice at policy level, at business/industry level, and at the level of individuals and households. In all cases, choice between two options involves trade-offs; and the question is one of optimizing the trade-offs to be had or minimizing the opportunity cost of the favoured option. And the switch from one product to the other is not total but incremental, so that the choice open to the customer is for the most part presented in terms of product-mixes, having more of one product and less of the other. This would make the customer's decision 'Pareto-efficient', but not necessarily 'Pareto-optimal' unless the customer's decision relates to the unique point of consumer equilibrium on the indifference curve (i.e. 'E' in Figure 2.5).

Secondly, the model identifies price as a key factor influencing choice, albeit subject to a *ceteris paribus* clause. On the demand side of the automotive market, customers would be expected to make a choice between new manufactured auto-products and re-manufactured auto products. Customers would determine their choice under different income, technology and taste regimes based on variations in the level of prices of the products, and assuming that there is virtually no difference in the quality and functionality of the two products. Where product R is 'environment-friendly' and product N is not; where there is massive government policy support to promote environment awareness among the public; and where product R has a competitive price edge over product N, customers would be expected to switch their choices from N to R. On the supply side of the automotive market, producers would be under policy pressure to switch production from N to R. So to meet demand for R on a sustainable basis, producers would need to create value, and make this available to customers at a price less than the premium price in an effort to capture the value of environmental gain resulting from the switch of customer preference in favour of product R.

The neoclassical model provides a useful insight for developing an empirical perspective of the switching behaviour of customers in favour of remanufactured or 'circular' products, which is an important aspect of transition to a circular economy. However, insofar as the 'well-behaved' nature the neoclassical model does not make allowance for the stochastic features of multi-variate consumption functions, particularly the dynamics in the 'push', 'pull' and 'mooring' factors behind the decision to switch, the usefulness of the model for policy analysis at both the macro and micro levels leaves much to be desired. Moreover, the assumption underlying the model that all factors except price remain unchanged is unrealistic. All factors influencing switching behaviour can vary simultaneously in different ways, and, as such, have varying contributions to the change in the switching behaviour of customers. This systemic nature in the switching behaviour of customers is at odds with the static and linear nature of the neoclassical model defined by indifference curves and budget lines. It is, therefore, important to go beyond the neoclassical model to be able to investigate empirically the switching behaviour of customers, as will be discussed in the following section.

2.7.2 Empirical Framework: PPM and Switching Behaviour

What is the best way to examine the range of factors that bear on the switching behaviour of customers? The framework used in this study for the empirical analysis of the switching behaviour of customers is based on the Push–Pull–Mooring (PPM) theory of migration (Bogue, 1969, 1977; Lee, 1966; Moon, 1995). In view of its capacity to effectively explain the dynamics in switching behaviour, or the system of migration, the Push–Pull–Mooring (PPM) theory of migration is used as a relevant empirical framework to investigate the switching behaviour of customers in the automotive market.

According to the PPM theory, the switching behaviour of customers is reflection of the switching intention of customers (Figure 2.8). Switching intention is expression of an individual's willingness to act in specific ways, and is driven by three key forces – push, pull and mooring.

The 'Law of Migration' or 'the Push-Pull model' presumes that 'push factors' are negative factors that drive individuals away from their origin. 'Pull factors' are, on the other hand, positive factors that attract individuals to move to their desired destination (Ravenstein, 1885). The model explains only cases of actual migration, where the migrants decide to move, but does not explain the phenomenon why potential migrants have chosen not to move (Lewis, 1982).

The push-pull model of migration was later developed to accommodate interactions with 'mooring factors' (Moon, 1995). The mooring factors have mitigating or moderating effect on the push and pull factors (Nimako & Ntim, 2013). The push and pull factors are macro-level factors, which directly affect switching intentions of people to migrate from one area to other areas. Mooring factors are micro-level factors which indirectly affect the switching intention of individuals by reinforcing the impacts of the macro-push and macro-pull factors (Hazen, Mollenkopf, et al., 2017; Moon, 1995).

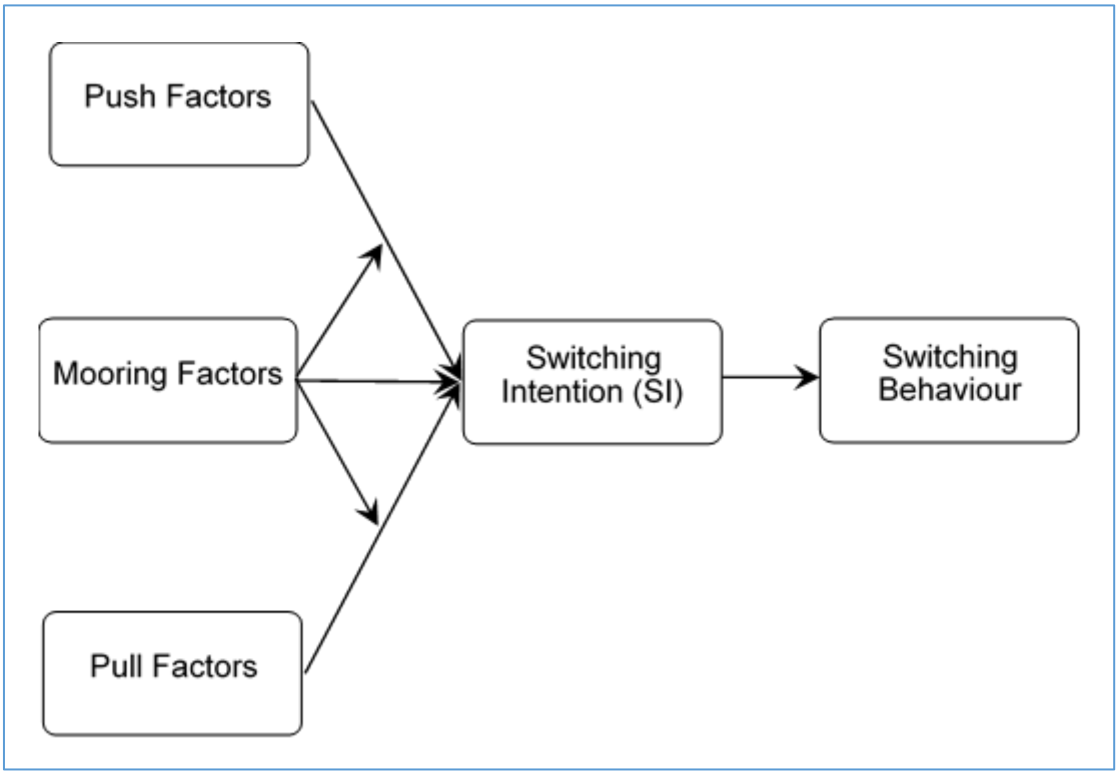

Figure 2.8 Push-Pull-Mooring (PPM) Theory of Migration model (Nimako & Ntim, 2013)

The PPM framework is applied in this research to explain whether or not the auto-market in Thailand will switch from auto-manufacturing based on the traditional linear economy business model to auto-remanufacturing alternatives based on the closed-loop circular economy business model.

This study applies the PPM theory based on the assumption that "switching is a kind of migration". According to Bansal, Taylor and James (2005), the notion of migration from one area to another is conceptually the same as the idea of switching behaviours of a customer from one product to another. The key concept is that the majority of customers (or migrants) voluntarily switch (or move) from a product/service (or an area) to an alternative location to fulfil their individual needs (Bansal, Taylor, & James, 2005).

The application of PPM to studies on the switching behaviour of customers is demonstrated in a number of empirical research involving a wide range of case-studies (Bansal et al., 2005; Chang, Wong, & Li, 2017; Hazen, Mollenkopf, et al., 2017; A.C.Y. Hou, Chern, Chern, & Chern, 2009; Avus C.Y. Hou, Chern, Chen, & Chen, 2011; Jung, Han, & Oh, 2017; Li & Ku, 2018; K. Z. K. Zhang, Cheung, Lee, & Chen, 2008). These include switching behaviours of consumers between service providers (Bansal et al., 2005), between blog service platforms (K. Z. K. Zhang et al., 2008), between online games (A.C.Y. Hou et al., 2009; Avus C.Y. Hou et al., 2011), from a physical retail shop to a mobile retail shop (Chang et al., 2017), from traditional laptops to refurbished laptops (Hazen, Mollenkopf, et al., 2017), between airlines (Jung et al., 2017), and between e-commerce and social-commerce (Jung et al., 2017; Li & Ku, 2018).

2.7.3 Key Factors influencing Switching Behaviour of Consumers

Customers' decisions to switch their preferences from one product to the other involve a whole set of dynamic interactions between factors that influence the decisions. The nature of these dynamic interactions will be fully discussed in Chapters 5 and 6. The following part of this section will discuss, based on the relevant literature, the major factors driving or obstructing customers' willingness to shift their preferences from new manufactured auto-products to 'like new' remanufactured auto-products.

A. Price benefits of remanufactured products

Price or financial incentives: There is a growing body of evidence to show the sensitivity of auto buyers to price changes, which means that price would be expected to be a significant factor influencing buyers to select remanufactured products instead of products produced using new or green materials (Hazen, Mollenkopf, et al., 2017; Jiménez-Parra, Rubio, & Vicente-Molina, 2014; Mugge, Jockin, & Bocken, 2017; van

Weelden, Mugge, & Bakker, 2016). According to studies, the prices of remanufactured products are commonly set at 40-60 per cent of new-manufactured alternatives (Hazen, Overstreet, Jones-Farmer, & Field, 2012; Lund & Hauser, 2010). Moreover, studies show that remanufactured products can offer price benefits together with specific brand preferences (Jiménez-Parra et al., 2014; van Weelden et al., 2016).

B. Environmental benefits of remanufactured products

Environmental benefits: The impact on the environment of consumers' purchasing behaviour is unclear. Jiménez-Parra, Rubio and Vicente-Molina (2014); Hazen, Mollenkopf and Wang (2017); Mugge, Jockin and Bocken (2017) found that the environmental benefit is a significant social (macro-level) factor that can determine the expressed intentions of customers at the micro level with respect to decisions to purchase remanufactured products. Also, Zhang *et al.* (2011); Singh and Jain (2014) indicate that the demand for remanufactured products is in many cases largely associated with the increased concern of consumers about the impact of climate change. Indeed, where the environmental concern is skewed, consumers are likely to trade-off environmental benefits against the economic benefits of remanufacturing. In other words, environmentally aware consumers are more likely to pay more for goods that are labelled green (Offord, 2013). By way of contrast, some studies argue that the environmental driver rarely influences switch to remanufactured products (Hughner, McDonagh, Prothero, Shultz, & Stanton, 2007; van Weelden et al., 2016). This could be a result of the price sensitivity of consumers, on the one hand, and the technologies of remanufacturing processes that do little to make the production of remanufactured products cost-effective, on the other.

C. Special feature benefits of remanufactured products

Remanufactured products have special attributes or special features that would set them apart from new products or gives them a competitive edge over new products. Remanufactured product may be preferred to new manufactured products, where they incorporate new product features or involve new technologies in the remanufacturing process. Therefore, remanufactured products may be of higher quality and robustness than their new manufactured counterparts (Hazen et al., 2012).

Remanufactured products offer the benefits of new technology in terms of functionality, durability, longer warranty and/or closer and better services than what would obtain under the linear business model. These features and benefits of remanufacturing constitute part and parcel of the 'performance economy' as a variant of the circular economy business model (Stahel, 2008).

Remanufactured products may involve new technologies in remanufacturing processes to provide new features that would make the remanufactured option a better choice than the alternative options deriving from the linear business model. For instance, a new technology of Sensor Embedded Products (SEPs) is installed in remanufactured auto-products by Caterpillar in remanufacturing process (Lacy & Rutqvist, 2015). The wireless system technology of Caterpillar can offer their users greater safety features. That is, it can notify auto-product users about the real-time status of the products, such as fuel levels and potential risks (Ellen MacArthur Foundation, 2014a).

Remanufactured products may also offer products that are more durable than new alternatives. Durability is a fundamental driver for remanufacturers to harvest maximum revenues and profits from their remanufacturing businesses. Their performance in revenue creation depends on how they can lengthen the useful lifecycle of their products and materials through increased longevity or times of cascaded utilisation instead of the linear sale-volume arrangement (Lacy & Rutqvist, 2015).

Remanufactured products may also offer longer periods of warranty than new alternatives. To deal with the anxiety of customers about service quality of remanufactured products compared to new products, a popular strategy is to provide warranties on the remanufactured products longer than on the new linear alternatives to ensure the robustness of the remanufactured products (Alqahtani & Gupta, 2017b; Otieno & Liu, 2016). The warranty is a very important factor to select remanufactured products from the consumers' point of view. An extended warranty is a necessary condition whenever choosing to buy remanufactured devices, because good warranty is a signal to show greater product quality and reliability and that the remanufacturers have confidence in their remanufactured products (Gordon, 2011).

Finally, remanufacturers may offer closer relationships with their customers than linear producers, which, in turn, leads to closer and better aftersales services. The returns of remanufacturers are reckoned on how the firms can extend product lifecycle and raise the number of interaction points with their customers. On the other hand, traditional linear producers do not need to interact with their customers after the points of sale to avoid additional costs. Therefore, closer relationships, better services and instant responses to fulfil their customers' appreciations can effectively improve real value to remanufactured products (Lacy & Rutqvist, 2015).

D. Personal attitudes of perceived quality on remanufactured products

Misconception about the quality of remanufactured products is often behind consumers' unwillingness to buy remanufactured products (Hazen, Mollenkopf, et al., 2017; Hazen et al., 2012; Mugge et al., 2017; van Weelden et al., 2016; Yacan Wang & Hazen, 2016). Remanufactured products are usually considered to be second rate whereas they are, at least in principle, produced to be 'like new' or even better than the new alternatives. The attitude of customers can influence their switching behaviour while making the choice between 'like new' remanufactured and new manufactured products (Hazen, Mollenkopf, et al., 2017). However, Hazen *et al.* (2012) found that many consumers would be suspicious about the quality of remanufactured products and would consequently consider such products to be 'inferior' to new manufactured products. Such considerations are often made without any significant knowledge about the nature of the materials used as core components; and what procedures were used in remanufacturing to recover such core components. Consumers may not trust remanufacturers' claim that the remanufactured products on offer are as good as new manufactured products (Hazen et al., 2012; Yacan Wang & Hazen, 2016). As a result, they would be inclined to group remanufactured products at par with second-hand products (Mugge et al., 2017; van Weelden et al., 2016). This attitude towards remanufactured products would cause consumers to reduce their willingness to purchase remanufactured products or to reject such products outright in favour of new products (Hazen et al., 2012; van Weelden et al., 2016).

E. Risk of remanufactured products becoming obsolete

According to van Weelden, Mugge and Bakker (2016), many consumers are prone to suspect that remanufactured products would become obsolete too soon. The perceived lack of newness in remanufactured products is a barrier to the expansion of the remanufacturing market. The risk of remanufactured products becoming obsolete too soon cannot be overlooked, not least because remanufactured products – or their core components – are constituted from used materials, which makes the robustness of the product's functionality suspect in the eyes of some consumers (Mugge et al., 2017; van Weelden et al., 2016).

2.8 Key Factors influencing transition to circular remanufacturing of producers

Making decision to enter automotive remanufacturing industry will require automotive producers have to consider some factors. The review of literature gathers a set of strategic determinants that potentially affects remanufacturing decision-marking of automotive manufactures from a lot of studies, which are discussed below. Based on the previous literature, the factors affecting the decision of a firm to conduct remanufacturing can be grouped into three main areas:

A. Financial remanufacturing cost

In comparison with conventional auto-manufacturing, the auto-remanufacturing can save production costs due to the reuse of raw materials and core components, and reduction in energy use. However, remanufacturing has specific overhead costs in order to ensure that quality of remanufactured products is at least as their original performance. These costs include core management costs, reverse logistic costs, and quality assurance testing costs. This can be a cause for remanufacturers' failure to run auto-remanufacturing business. For instance, high expenses for setting reverse logistic networks, high product testing costs for the remanufacturing of products from ELVs, can act as banner to the adoption of the CE business model (Subramoniam, Huisingh, & Chinnam, 2010). Remanufacturing cost can be a barrier against entry into the auto-remanufacturing market.

B. Product design for remanufacturing

The availability and durability of core components is vital to the remanufacturing process (Subramoniam, Huisingh, & Chinnam, 2009). Remanufacturing-friendly products are the products that are designed to be easily and economically dismantled/separated for remanufacturing (Subramoniam et al., 2010). If auto-products are designed to be 'remanufacturing-friendly' early in the product design stages, the costs of core dismantling will decrease in remanufacturing stage (T. Zhang et al., 2011).

Moreover, if the auto-product designers are to be concerned with the product life cycle costs, which include aftermarket, disposal costs, and environmental impact costs, early in the product design stages, there is potential for the designers to integrate remanufacturing-friendly condition into their product designs (E. Sundin, Larsson, & Nielsen, 2005). This would make it easier to disassembly EoU auto-products in the remanufacturing stage. Therefore, eco-friendly design for remanufacture and product life cycle costs is a facilitating factor for entry into the auto-remanufacturing market.

C. Intellectual property rights (IPRs)

IPRs are a tool for protecting remanufactured products particularly in developed countries from fake products whether new or remanufactured products, especially from developing countries which are usually cheaper than IPR remanufactured products in developed countries (Cruickshank, 2006 in Subramoniam et al., 2010). However, Zhang et al. (2011) argued that the IPR is a significant barrier for the independent remanufacturers (IRs) to reuse the IP protected EoU products for remanufacturing. Because of IPRs, core components must be authorised by OEMs to IRs before remanufacturing (T. Zhang et al., 2011). Therefore, the IPR factor can be both a facilitating and inhibited factor to enter the auto-remanufacture industry. This depends on who are the remanufacturers -- OEMs or IRs.

D. Product recovery value

Even though a product is designed for remanufacturing but if there is low value of recovery core, producers would not be interested to recover the core for remanufacturing. That is, for product with a higher recovery value there is higher opportunity for remanufacturing (Subramoniam et al., 2010). In cased of the automotive product, auto-products are a type of modular products of which some auto-parts have high recovery value as cores such as engine, gear box, electronic parts (Kohpaiboon, 2011). Therefore, product recovery value of collected cores is a facilitating factor for auto-remanufacturing.

E. Consumer recognition/perceptions on remanufactured products

Although by definition remanufactured products are like or better than new products in conditions, many consumers prefer new products and reject the remanufactured products due to their perceived new about product quality. Consumers' perceptual specifications concern the performance of used parts in the remanufacturing process, while undermines competitiveness of remanufactured products in comparison with new alternatives (Hazen et al., 2012; Subramoniam et al., 2010). Beside quality perception, consumers should be aware of sustainable benefits of remanufactured products such as environmental benefits and skilled-labour job creation (Parker et al., 2015). As a result of consumer behaviour, producers may decide to reject the remanufacturing business. Therefore, consumers' product specification shows preference for products as against remanufactured alternatives is a factor for auto-remanufacturing.

F. Product disposal costs

In many developed countries, the governmental regulations stringently enforce producers to take responsibility for their EoL products, including Extended Producer Responsibility (EPR), and End of Life Vehicles Directive. The regulatory requirements often come up with additional costs of producers such as waste management costs. Remanufacturing is an option of green processes, which can enhance cost-effectiveness of life cycle management. That is, remanufacturing can help producers not only to comply with the environmentally friendly restrictions, but also to reduce the potential additional costs of waste management, and can restore market value of the waste (Subramoniam et al., 2010). Therefore, product disposal costs can act as a facilitating factor for auto-remanufacturing.

G. Uncertainty of core management

Core availability via an efficient core management process is the main pillar of the remanufacturing business (Subramoniam et al., 2010). There is an uncertainty of ELV collection in terms of both quality and quantity of the ELV returns. That is, imbalances between the ELV returns and demand for remanufactured products, workable quality condition of the ELV returns, and the necessary of network cooperation for setting a reverse logistic system, all of them can directly impact core management costs for remanufacturers (V. Guide & Daniel, 2000; van der Laan & Salomon, 1997). Excess availability of cores also leads to core inventory costs of storage and maintenance (Nasr, Hughson, Varel, & Bauer, 1998). Beside the quantity aspect, quality of core is also a very essential barrier. While access to core is obviously significance, the core availability can be undermined if the accessible cores are in poor condition (Parker et al., 2015). These difficulties reflect on capabilities of reverse logistics of firms across the industry. Therefore, the uncertainty of core management can be an inhibiting factor for auto-remanufacturing.

H. Lack of Technology and product knowledge

There are a lot of necessary knowledge and technologies for manufacturing, including reverse logistics, dismantling, cleaning, recovering, reassembling and other life prediction technologies. Technology standards to insure the quality of remanufactured products are also essential. However, these technologies and standards need further research and development in developing countries in particular (T. Zhang et al., 2011).

I. Speed of technology innovation

Speed of automotive technological innovation can be a cause that make remanufacturing to be much more difficult in several ways. Firstly, technological complexity of automotive products has rapidly increased through technological innovation (Kemps & Vos, 2016). In addition to technological complexity, technical knowledge and information for diagnosis and work-around is also a significant issue for remanufacturing. In many cases, OEMs attempt to make it more difficult for others to copy and reengineer (Parker et al., 2015). As a result, this also a significant barrier for remanufacturing.

Furthermore, advanced technology trends are also a problem. For instant, electrical and digital technologies is dramatically glowing in motor vehicles. This requires technical knowledge and specific skills to conduct in remanufacturing (Parker et al., 2015). In addition, this additional technology leads to an increase of investment costs for remanufacturers to improve their capacities with the other new technologies, to cooperate with firms in other relative industries, and/or to do R&D to catch up the advancement (Parker et al., 2015).

Finally, Speed of auto-technological innovation can affect design and product lifespan (Chaowanapong et al., 2017; Robert T. Lund, 1984a; Matsumoto, 2010). According to Lund (1984), remanufacturing is suitable with products that to be designed stability without considerable changes of design in a substantial period (Robert T. Lund, 1984a). Likewise, if the physical lifespan of a product is short, the product is unsuitable for remanufacturing (Matsumoto 2010). For example, mainly because of an action to comply with more strict regulations with carbon emission, motor-engine technology is altered in every 2-3 years (Parker et al., 2015). This causes product lifespan of motor engines is shorter. In addition, motor-engines to be rapidly design changed to become more advanced and, of course, more complex. As a result, to remanufacture the motor-engines are heavier incrementally. This in turn leads to a reducing trend of third party to entry engine remanufacturing industry (Matsumoto, 2010; Parker et al., 2015).

J. Skilled labour costs and unavailability

Remanufacturing requires highly skilled labours. Especially in the automotive industry, the auto-remanufacturing needs various specifically technical skills to conduct in remanufacturing process. That is, the step of remanufacturing is complex to diagnose and work-around in order to recover the EoU products back into like new condition. It needs specific knowledge and information of products such as design, function, components of the products (Chaowanapong et al., 2017; Parker et al., 2015). This leads to a requirement of skilled workers who are specialists in specific issues. Therefore, an availability and high costs of expertise workers can lead to a barrier to conduct remanufacturing activities.

K. Domestic legislation restriction

Domestic regulations in some countries does not permit to establish remanufacturing businesses. For example, according to Zhang et al. (2011), because of the restrictive regulations, OEMs cannot register to run the remanufacturing business in China. In addition, they do not have obligation to manage their ELVs aftermarket. As a result, they are not likely to be interested to enter the auto-remanufacturing market in China (T. Zhang et al., 2011). Unfortunately, the difficulty of remanufacturing-business registration also exists in other developing countries, India and Brazil included (Chaowanapong et al., 2017).

By way of contrast, some developed countries including US and the UK are significant players in the auto-remanufacturing market. An important reason of this because their readiness and restrictive implementation of their domestic regulations (Abdulrahman, Subramanian, Liu, & Shu, 2015). As a result, To establish a remanufacturing enterprise in developed countries is probably more comfortable and be more supported by domestic regulations than in developing countries (Chaowanapong et al., 2017).

L. Company profitability creation

Remanufacturing can create additional streams of revenues from residual embedded-values of EoU products by extending products' life expectancy (Lacy & Rutqvist, 2015). Not only direct financial benefits from new-user cycle creation, but remanufacturing can also create consumers' loyalty and relationships between customers and businesses at some points throughout the remanufacturing products' lifecycle. The relationship can be enhanced by giving customers incentives to engage with suppliers' activities. The activities include activities of product upgrading, aftermarket product feedback, and reverse logistic (Lacy & Rutqvist, 2015).

M. Green perception from remanufacturing as a green initiative

Remanufacturing is an option to induce an environmentally friendly business. Because of the fact that remanufactured products are greener products, this effort for green initiative may lead to other benefits for the remanufacturers, such as green tax support from the government, and green marketing strategies (Subramoniam et al., 2010). Therefore, the green initiative would count as is a facilitating factor for auto-remanufacturing. According to Wei et al. (2015), responsibility for environmental and ethical concerns is the most significant facilitator inducing to enter remanufacturing market in China (Wei, Cheng, Sundin, & Tang, 2015).

N. International trade regulation

International trade regulation is also a significant factor for decision-making to remanufacturing business in the automotive sector (Subramoniam et al., 2009). In some countries, remanufactured products are considered as used products or waste, which they are imposed under some trade regulations. The trade measures include completely import prohibition, special rates of fees and tariffs, and special requirements of products; inspection and/or certification (World Trade Organization, 2005).

For instant, trade regulation in China prohibits to import EoL vehicles for remanufacturing, even though remanufacturers who are allowed to do remanufacturing activities through the project of Pilot Remanufacturing of Automotive Components in China (T. Zhang et al., 2011) Moreover, Brazil, recognising cores as EoU goods, prohibits to import used goods for encouraging domestic manufacturing (U.S. International Trade Commission: USITC, 2012). Malaysia also bans to import EoU auto-parts, auto-remanufactured products included (U.S. International Trade Commission: USITC, 2012). These cases of trade measures potentially cause an unavailable problem of cores in a domestic market, which in turn leads to a barrier on remanufacturing business operation (Subramoniam et al., 2009).

O. Environmental regulation

Environmental regulation is an important enabler to decision-making for remanufacturing (Subramoniam et al., 2009, 2010). It can induce businesses to start the remanufacturing projects faster than no regulatory pressures (Subramoniam et al., 2010). The ELV directives of the European Commission is a good example. In fact, the EU environmental regulations (Directive 2000/53/EC and Directive 2005/64/EC) aim to control management process of EoL vehicles to be more environmentally friendly (European Commission, 2018). Because of the EU regulations, collection rate of End-of-Life vehicles in the EU is more than 70 per cent of total EoL vehicles (Ellen MacArthur Foundation, 2012). While, the rate in China, which do not have any regulations like the EU directives, is around only 40 per cent of ELVs (T. Zhang et al., 2011). As a result, the low rate can in turn leads to a lack of core components for remanufacturing. However, Seitz (2007) argued that the ELV directives are not a significant factor to encourage remanufacturing activities in the EU, because the auto-remanufacturing industry in the EU has been developed for a long time before environmental issues became a crucial topic (Seitz, 2007).

P. Creation of local network

Remanufacturing causes reinforcement of local value chains. That is, the loop model provides an opportunity for multinational corporations (MNCs) to cooperate with local small and medium enterprises (SMEs) (Lacy & Rutqvist, 2015). This collaboration is order to several benefits. Firstly, there is to initiate a service for local customers with a local tailor-made adjustment or 'field services' for specific local testes and needs. This, in turn, leads to added-value from the additional field services (Lacy & Rutqvist, 2015; Subramoniam et al., 2010). Furthermore, the other benefit is to earn promotion from the local government for operating remanufacturing business (Subramoniam et al., 2010). Finally, remanufacturing can encourage a business plan of social sustainable promotion, if a company integrates social sustainable issue by encouraging local jobs in its business plan (Subramoniam et al., 2010).

Q. Complication of internal management

The capability of a business to generate efficient integration, alignment and communication between its internal departments is a factor to operate remanufacturing. The effective internal cooperation includes efficient integrating of divisions and a combination of manufacturing and remanufacturing operations. The effectiveness of cooperation influences success in remanufacturing operation in term of cost reduction and productivity improvement (Matsumoto, 2010).

R. Asset and brand protection

OEMs trends to conduct remanufacturing businesses by themselves in order to protect brand reputation and reduce a risk to be disreputable by independent remanufacturers (IRs) (Seitz, 2007; Subramoniam et al., 2010). That is, If OEMs is not conduct remanufacturing, the business potentially attract new competitors, IRs in particular. By reverse engineering the products by the outside competitors, the technology is likely to accessible outside OEMs. This in turn leads to a risk of OEMs to lose their competitive advantage in the market. Moreover, the IRs may remanufacture and sell them with the OEMs' brands. This can cause a risk to be infamous for OEMs (Subramoniam et al., 2010).

However, in this scenario, OEMs will operate remanufacturing businesses by themselves. Furthermore, they will not outsource the activities to outsides. Absolutely, they also will not distribute information, technology and cores to IRs (Seitz, 2007).

Therefore, although the factor of brand protection can facilitate OEMs to conduct remanufacturing. On the other hand, the factor can obstruct IRs to operate remanufacturing businesses (Chaowanapong et al., 2017).

S. Competition from cheap new-products

Cheap new products is also a significant barrier for conducing remanufacturing business (Parker et al., 2015; Subramoniam et al., 2010). Low-cost new products (particularly from the far east countries) and also not fully remanufactured products (including repaired, reconditioned, or refurbished products) can provide lower price alternatives competing with remanufactured products. However, these products might not well perform in quality. In addition, the bad performance may cause remanufactured goods are infamous (Subramoniam et al., 2010). Moreover, the cheap new products lead to price pressure on remanufactured products, which in turn leads to make margins for remanufacturing to be unattractive (Parker et al., 2015).

T. Protection of Cannibalisation effects

Worry of cannibalisation effects is a significant factor that could obstruct a decision-making of auto-remanufactures to perform remanufacturing. Market cannibalization is the negative effect to sales performance or market share of existing and related product of a company due to a lunch of a new alternative of the company. The effect is feasible to drop overall revenue, although sales of the new alternative raise (V. D. R. Guide & Li, 2010; Haynes, Thompson, & Wright, 2014; Moorthy & Png, 1992).

That is, introduction of a remanufactured product can cause a drop of new products' seals for the OEM. The revenue reduction is presumably greater than the compensating revenue from sales of the remanufactured alternative (Abdulrahman et al., 2015; Matsumoto, 2010). The existence of market stealing is statistically significant with cannibalization effects, especially in high-tech industries (Haynes et al., 2014). As a result, with this scenario, OEMs potentially deny opportunities for run remanufacturing businesses, in order to protect their revenue from the cannibalisation effect.

However, some study argued that the negative effect of cannibalisation depends on other determinants (V. D. R. Guide & Li, 2010; Moorthy & Png, 1992; Östlin, Sundin, & Björkman, 2009). That is, the potential of the cannibalisation effect is based on consumers' willingness to pay (WTP) for both new and remanufactured products. If the WTP between the new and remanufactured products is obvious different, the risk of the cannibalisation is minimal (V. D. R. Guide & Li, 2010). Also, if the new and remanufactured products are sold in different timing and market sector, the cannibalisation effect is insignificant (Moorthy & Png, 1992; Östlin et al., 2009). Consequently, with the last scenario, the cannibalisation effect may not significantly influence decision-making of auto-manufacturers to operate remanufacturing businesses.

U. Pressures of downstream supplier

Not only of consumers, but also environmental requirements of downstream suppliers are significant determinants that could facilitate a decision-making of upstream manufactures to perform green-supply-chain-management activities, remanufacturing included (Q. Zhu & Geng, 2001). In the process of upstream-supplier selection of many foreign direct investment (FDI) companies or multi-transnational enterprises (MNEs) in China for purchasing their raw materials, they preferred upstream-suppliers from their hometowns or joint ventures to local Chinese suppliers. This is because questionings on capability of Chinese companies to deliver green products for them (Huang, Tan, & Li, 2012).

As a result, some local enterprises in China improved their eco-performances to obtain international environmental certification, in order to reach the environmental requirements of these MNEs (Q. Zhu & Geng, 2001). For instant, environmental requirements of Toyota Xerox, General Motors and Ford stimulates their local suppliers to enhance green management systems to be harmonised with ISO 14001 (Global Environmental Management & Initiative: GEMI, 2001; Q. Zhu & Geng, 2001).

Table 2.2 A list of factors influencing switching intention of auto-manufacturers

#	Factors	+/-	Reference
A	Financial remanufacturing cost	-	Subramoniam et al. (2010)
B	Product design for remanufacturing	+	Subramoniam et al. (2009; 2010); Zhang et al. (2011); Sundin, Larsson, & Nielsen (2005)
C	Intellectual property rights	+	Subramoniam et al. (2010)
		-	Zhang et al. (2011)
D	Product recovery value	+	Subramoniam et al. (2010)
E	Consumer perceptions	-	Hazen et al. (2012); Subramoniam et al. (2010); Parker et al. (2015)
F	Product disposal costs	+	Subramoniam et al. (2010)
G	Uncertainty of core management	-	Subramoniam et al. (2010); Guide & Daniel (2000); van der Laan & Salomon (1997); Nasr et al. (1998); Parker et al. (2015)
H	Lack of Technology and product knowledge	-	Kohpaiboon (2011); Zhang et al. (2011)
I	Speed of technology innovation	+	Lacy & Rutqvist (2015)
		-	Kemps & Vos (2016); Parker et al. (2015)
J	Skilled labour costs and unavailability	-	Chaowanapong et al. (2017); Parker et al. (2015)
K	Domestic legislation restriction	+	Abdulrahman et al. (2015).
		-	Zhang et al. (2011), Chaowanapong et al. (2017)
L	Company profitability creation	+	Lacy & Rutqvist (2015)
M	Green initiative	+	Wei et al. (2015)
N	International trade regulation	+	APEC (2013); UNEP (2013)
		-	Zhang et al. (2011); USITC (2012); Subramoniam et al. (2009)
O	Environmental regulation	+	Subramoniam et al. (2009; 2010); Ellen MacArthur Foundation, 2012
		-	Seitz (2007)
P	Creation of local network	+	Lacy & Rutqvist (2015); Subramoniam et al. (2010)
Q	Complication of internal management	-	Matsumoto (2010)
R	Asset and brand protection	+	Seitz (2007); Subramoniam et al. (2010)
		-	Chaowanapong et al. (2017)
S	Competition from cheap new-products	-	Parker et al. (2015); Subramoniam et al. (2010)
T	Protection of Cannibalisation effects	-	Abdulrahman et al. (2015); Matsumoto (2010)
U	Pressures of downstream supplier	+	GEMI, 2001; Huang *et al.*, 2012; Zhu and Geng, 2001

Where: + represents that the factor acts as facilitator to initiate auto-remanufacturing business
- represents that the factor acts as obstructers to initiate auto-remanufacturing business

2.9 Sustainable Business Model: Conceptual framework

To initiate a sustainable business model (SBM) towards remanufacturing for a circular economy that is suitable for the automotive sector in Thailand. This study will introduce an SBM in a form of categorisation of groupings of mechanism, strategies and solutions which may contribute to initiate a practical business model for sustainability. The mechanism, strategies and solutions will be derived from the contribution of the main findings of the study, that is, the key factors influencing the switching behaviour of consumers.

The aim of the categorised SBM derived from the key findings of this study is to initiate a practical approach for auto-businesses in Thailand. The proposed SBM will be expected to be applied as a key driver of competitive advantage for remanufacturing circularity businesses in Thailand's automotive sector. In turn, the proposed SBM may lead to be an accelerator to encourage circular economy and sustainable development in Thailand.

2.9.1 Sustainable Business Model

Starting with the concept of business model, the business model in this study is based on the definition of the business model created by Osterwalder & Pigneur, (2010, p.14). That is, "a business model describes the rationale of how an organization creates, delivers, and captures value". The definition is applied for this study because the concept is basic and intuitively comprehensible based on the simple logic of how an enterprise intends to make value (Osterwalder & Pigneur, 2010).

The business-model concept can be depicted through four main pillars, including value propositions, value creations, value delivery and value capture as shown in Figure 2.9.

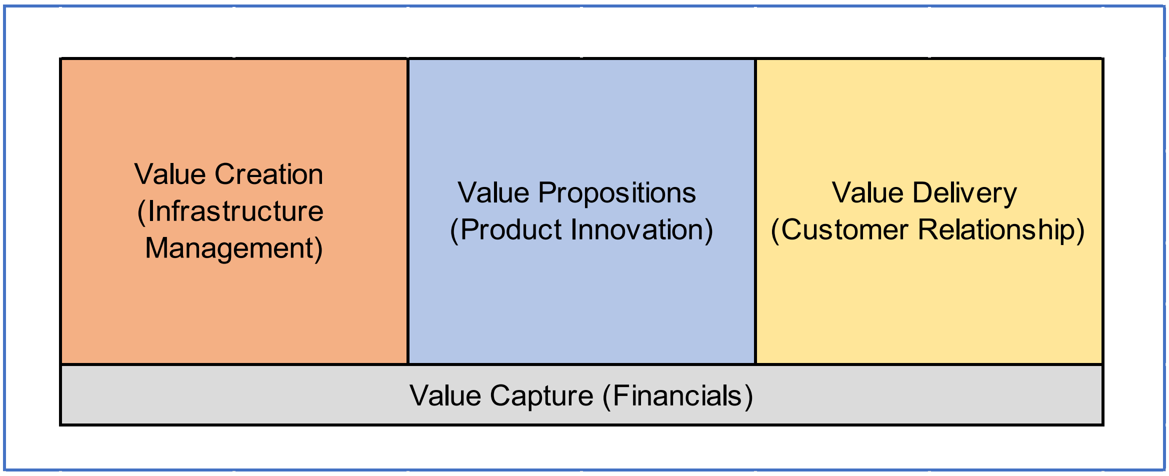

Figure 2.9 Adapted sustainable business model (developed from Osterwalder & Pigneur, 2004).

The value propositions (or product innovation) will propose values to compete. That is a value with what a business offers higher than competitors to solve customer problems and satisfy customer needs (N.M.P. Bocken, Schuit, & Kraaijenhagen, 2018; Osterwalder & Pigneur, 2010). The value delivery (or customer relationship) is the issue to be identified who are targeted customers of the business and the process of how to provide the value propositions to the customers (Bhasin, 2017; N.M.P. Bocken et al., 2018; Osterwalder & Pigneur, 2004). The value creation (or infrastructure management) is a process of how the value proposition is taken into action by order management of resources to be a greater utility for other humans (N.M.P. Bocken et al., 2018; Jorgenson, 2015). Finally, the value capture (or financials) describes the revenue model of the business (N.M.P. Bocken et al., 2018; Osterwalder & Pigneur, 2010).

Moving on the concept of 'Sustainable business model (SBM)', the SBM in this study is based on Bocken, Short, Rana, & Evans (2014) where sustainability is embedded into the basic concept of business model. That is, a sustainable business model (SBM) recognises firm-level perspective with a triple bottom line approach which realises environmental and social issues together with economic issues as stakeholder interests (Bocken et al., 2014, p.44).

Components of the sustainable business model (SBM) in this study will be developed from the sustainable business model archetypes (N. M.P. Bocken et al., 2014b). Also, the business model canvas (Osterwalder & Pigneur, 2004, 2010) will be applied.

According to (Osterwalder & Pigneur, 2004, 2010), the business model canvas can be divided into eight building boxes respecting main processes how an organisation operates: Customer segments (CS), Value Propositions (VP), Channels (CH), Customer Relationships (CR), Key Resources (KR), Key Activities (KA), Key Partners (KP), Cost Structure (C$) and Revenue Streams (R$) (Osterwalder & Pigneur, 2010, pp.18-19).

According to (Bocken et al., 2014, pp.47-48), the SBM archetypes are comprised to three pillars, which regard to the significant kinds of business model innovation: technological, social, and organisational oriented innovations (Boons & Lüdeke-Freund, 2013). That is, the pillars of value proposition (referring to technological innovations), value creation & delivery (referring to social innovations) and value capture (referring to organisational innovations) (N. M.P. Bocken et al., 2014b).

2.9.2 Sustainable Business Model Framework

The conceptual framework of 'Sustainable business model (SBM)' in this study is that a business configuration/arrangement to explain the rationale of how an organization creates, delivers, and captures sustainable values of a triple bottom line approach with concern of participation of stakeholders. 'The stakeholders' in the study are mainly focused on the roles of auto-customers. On the grounds that this research mainly focuses on demand study of factors influencing switching behaviour of auto-customers in Thailand to be willing to participate in the remanufacturing circularity auto-market. As a result, the proposed SBM is expected to be a practical business model that can potentially induce costumers in the automotive market in Thailand to switch their behaviour to select remanufactured auto-products instated of traditional linear-economy alternatives.

The proposed SBM for auto-remanufactured business in Thailand based on the demand-driven study is comprised of four main pillars and total ten sub-elements as shown in

Figure 2.10. The first pillar is 'value propositions', comprising of three sub-elements; economic value, social value and environmentally friendly value. The second pillar is 'value delivery', comprising of three sub-elements; Customer Segments, Customer relationship and Channels. The third pillar is 'value creation', comprising of three sub-elements; key partners, key resources and key activities. The final pillar is value capture where the study will limit the pillar only in aspect of price-setting strategy.

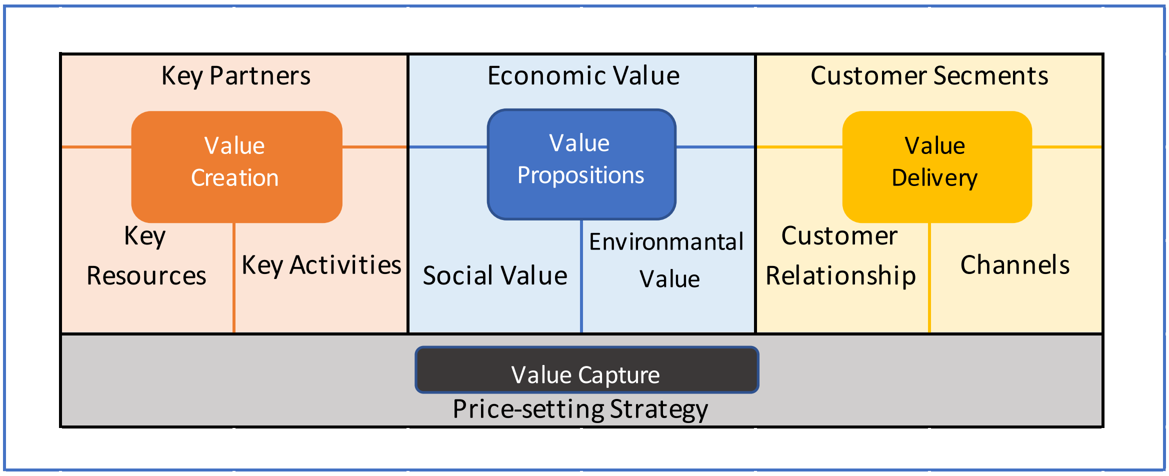

Figure 2.10 Framework of the proposed SBM for auto-remanufactured business in Thailand based on the demand-driven study

2.10 Conclusion

Circular Economy is an economic system that employs resources for as long as possible, maximising their usability and minimising the negative impacts arising from the use of new material resources. Transition to the CE can enhance the long-term resilience of economies; reducing the scope for waste; and bringing forth a wide range of economic, social and environmental benefits.

The CE scheme discussed in this chapter includes options such as reuse, repair, recondition, remanufacturing and recycling. The focus of this study is, however, on the remanufacturing option of the closed-loop business model for activities in the automotive sector.

Remanufacturing involves a series of comprehensive and rigorous industrial processes which restores end-of-life products or components to original working condition as 'like-new' or even better performing products than new manufactured products. The rigorous industrial processes include complete disassembly, thorough cleaning, reconditioning, reassembly and quality control testing to fully equivalent or superior in performance, condition, expected lifetime and warranty to the original new-manufactured alternatives.

Remanufactured products are claimed to be more 'environmentally friendly' than new and recycled alternatives. In addition, remanufactured parts are perfectly rebuilt to safeguard consumers from the risk of potential problems. Their quality is often better and safer than reused, repaired and refurbished products.

Considering its implication for the automotive sector, remanufacturing can solve the availability problem of spare parts in the automotive after-market, especially where products have become obsolete and spare parts for such products cannot be expected to be readily available in the market. Remanufactured parts are also considered to be versatile and can serve the increasing diversity of automotive products resulting from the endless development of automotive technology. Moreover, remanufacturing is the only closed-loop business model that can provide a chance for adopting sophisticated technologies to upgrade their reused auto-components in order to re-manufacture price and quality competitive auto-products (Automotive Parts Remanufacturers Association: APRA, 2015).

Remanufacturing has the effect of enhancing the long-term resilience of economies. Much is said about it as a driver of eco-innovation (Ellen MacArthur Foundation et al., 2015). It can mitigate global environmental and sustainable pressures. This is because the cores used for re-manufacturing effectively hold important embedded resources, such as material, energy and labour resources that were used to make the cores in the first place.

Chapter 3

Methodology

3.1 Introduction

This chapter presents the methods this study has used to examine the factors influencing the behaviour of producers and customers in Thailand to switch their preference from conventionally manufactured new auto-products to 'like new' remanufactured ones. The methods selected to investigate the switching behaviour of producers and customers of automotive products in qualitative and quantitative terms are described in full. The chapter is divided into eight parts. Following this brief introduction, the method to investigate important factors influencing the behaviour of automotive producers in Thailand to conduct remanufacturing businesses is showed in the second part.

Then, the conceptual and empirical framework to investigate the key factors influencing the switching behaviour of customers in transition to circular remanufacturing is set out in the third part. In the fourth part, the analytical framework for the quantitative is described. The carefully designed process of questionnaire development is presented in the fifth part. In the seventh part, the method of data collection through the administration of a questionnaire-based survey is discussed. The method of data analysis is presented in the sixth part. The eighth part concludes the chapter.

3.2 The significant factors influencing behaviour of automotive producers in Thailand to conduct remanufacturing businesses

To investigate the important determinants for making decision to enter auto-remanufacturing business in case of Thai automotive manufacturers, a quantitative method of research is designed to be used in this part. This involves conceptual framework, data collection, and data analysis.

3.2.1 Conceptual framework

The conceptual framework to analyse the decision behaviours on the supply side will be based on the model of 'Barrier Analysis'. Theoretically, Barrier Analysis is an assessment instrument in order to mention behavioural factors related to a specific behaviour (Davis Jr., 2004). In practical aspects, Barrier Analysis is a survey which concentrates on specifying what obstructs and facilitates a target group of people to adopt a target behaviour (DeCoster, Shankar Seal, & Rahman, 2015; Kittle, 2013). That is, there are barriers and enablers. According to DeCoster et al., a barrier is anything that is obstructing the beginning of a new behaviour. An enabler is anything that is helping or making the beginning of a new behaviour easier (DeCoster et al., 2015). Therefore, as a result of the analytical model, if significant behavioural factors are specified, it means more productive behavioural strategies and supporting activities can be initiated (Davis Jr., 2004).

In application for this research, the Barrier Analysis model will be used to investigate important barriers and enablers that are obstructing and facilitating automotive manufacturers in Thailand to run businesses in the remanufacturing market in Thailand. Practically, the analysis process will step-by-step follow the method proposed by Davis Jr. (2004), which is consistent with Kittle (2013) as shown in Figure 16 (Davis Jr., 2004; Kittle, 2013). That is, the barrier analysis model can be divided into the following seven procedures:

Step 1: Defining the aim, behaviour and target group;

Step 2: Creating the behaviour screening question;

Step 3: Creating questions about factors;

Step 4: Organising the analysis sessions;

Step 5: Collecting survey data;

Step 6: Organising and analysing the results; and

Step 7: Using the results.

Furthermore, the step-by-step application of the model of Barrier Analysis for the study is shown in the Table 3.1.

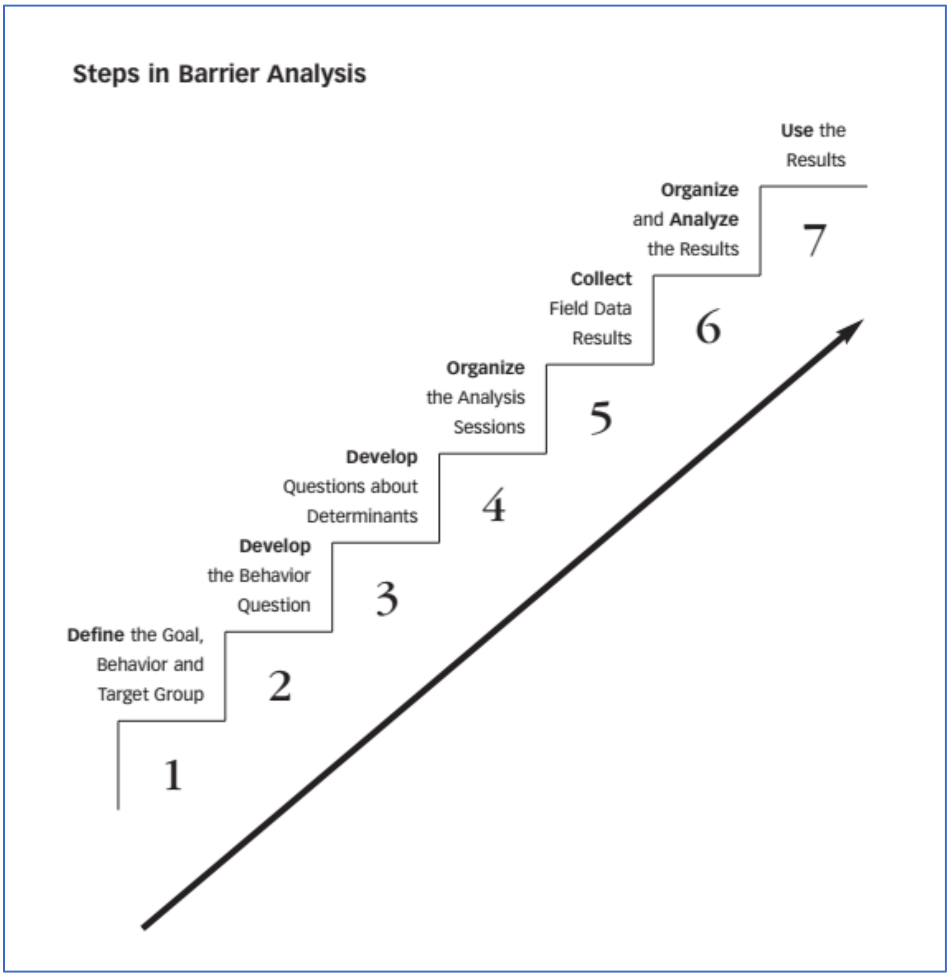

Figure 3.1 Steps in Barrier Analysis (Davis Jr., 2004)

Table 3.1 The application of this study from the steps in Barrier Analysis model

Steps	Procedures	(expected) Actions
1	Defining the aim, behaviour, and target group	Aim: as the aim of the research, to study how to switch the behaviour of Thai producers in the automotive sector for transition to circular economy (remanufacturing). Behaviour: operating a business in remanufacturing market in Thailand. Target groups: auto-manufacturers in Thailand who have potential to be remanufacturers

Steps	Procedures	(expected) Actions
2	Creating the behaviour screening question	How to switch behaviour of Thai producers in automotive sector for transition to circular economy (remanufacturing)?
3	Creating questions about factors	From a review of the literature, the factors can be divided into three groups. That is: • Factors of Business Feasibility are Technical aspects (Product Design, Core management, & Product knowledge); Product maturity (Product recovery value, Consumer perceptions, Speed of technology innovation, & Competition from cheap new products); Skilled labour costs and unavailability; and Financial remanufacturing costs. • Factors of Business Strategies are Green initiative; Company profitability creation; Asset and brand protection; Protection of Cannibalisation effects; Organisational aspects (Pressures of downstream supplier, Creation of local network, & Complication of internal management). • Factors of Governmental Policy, Law and Regulation are Domestic legislation restriction; International trade regulation; Intellectual property rights; and Environmental regulation.
4	Organising the analysis sessions	The data will be used secondary data facilitated by Chaowanapong et al., (2017).
5	Collecting survey data	The data were collected from 16 automotive manufacturers in Thailand by semi-structure Interviews

Steps	Procedures	(expected) Actions
		conducted in February–June 2014 (Chaowanapong et al., 2017).
6	Organising and analysing the results	The secondary data provided by Chaowanapong et al., (2017) analysed by descriptive statistical analyses, such as averages, medians, and standard deviation (SD).
7	Using the results	The results were discussed and concluded for initiating some policy recommendations for encouraging remanufacturing market in Thailand.

3.2.2 Data collection

The secondary data were collected and organised by Chaowanapong et al., (2017). According to Chaowanapong et al., (2017), the data were collected through semi-structured interviews with 16 selected automotive firms in Thailand. All 16 auto-firms were selected based on their relevance, knowledge, and experiences in remanufacturing or relevant activities in the automotive industry in Thailand.

Characteristics of the respondents in remanufacturing CE activities, most of them are replacement equipment remanufacturers (RER) in Thailand's automotive part industry. In fact, they are almost remanufacturers by theoretical definition; their CE activities are at the level of rebuilding or refurbishing. Fifteen companies are independent remanufacturers (IRs) which are primarily Thai-owned companies. Meanwhile, another firm is an original equipment remanufacturer (OER) which is a foreign-owned company. Eleven firms are small-medium enterprises (SMEs), while the other five firms are large enterprises (LEs).

In aspects of enterprises' products, 12 of them run only remanufacturing businesses, while four of them produce both new and remanufactured products. Their auto-products are varied; six engines, four transmissions, two crane trucks, two driveshafts, an AC compressor, and an alternator & starter motor remanufacturer. These firms are three to six times cheaper than new OEM goods.

Interviews were taken place in February–June 2014 in Thailand with business owners (11 firms), executive managers (4 firms), and senior officers (1 firm). The respondents were asked to express their perception on the potential levels of how each potential factor influence their decision to initiate remanufacturing auto-business in Thailand, facilitated by a structured questionnaire with indicators on a five-point Likert scale (Chaowanapong et al., 2017).

3.2.3 Data analysis

The study analysed the secondary data based on Chaowanapong et al. (2017) to investigate the influential levels of each factor. The analysis method was descriptive statistical analyses, averages in particular. The study prioritised and grouped all factors by using their mean scores into four groups of influential levels. These groups of influential levels are level one representing the least influential factors; level two represents a negligibly influential factor; level three represents a moderately influential factor; and level four represents a very influential factor. These four groups ranged by their mean score from 1.00-1.99, 2.00-2.99, 3.00-3.99, and 4.00-5.00, respectively.

3.3 Empirical frameworks for the switching behaviour of customers: Key Factors influencing transition to circular remanufacturing

Conceptually, the market for automotive products, whether produced from new or remanufactured materials, is dictated by market demand. Supply does not create its own demand, but demand and policy trends can strongly influence process and product technologies underlying supply. This is particularly so where there is growing recognition of an ever-diminishing global resource base that has prompted calls for resource conservation and sustainable use of resources. The question however remains: to what extent does this environmental imperative override the price incentive, which has traditionally been at the heart of the decision behaviour of producers and customers? Would the context of transition from linear to circular economy make a difference to producers' and customers' response to price incentives? It is the aim of this study to investigate factors that influence customers' decisions to switch from new manufactured to 'like new' remanufactured products. Consumers can be influenced to change their behaviour to select remanufactured automotive products. The decision factors that bear on the decision behaviour of consumers are discussed in "the Conceptual Framework for Switching Behaviour of Consumers".

The framework on literature review will be discussed in three parts. The first part reviews research studies on the Push–Pull–Mooring (PPM) theory of migration to explain consumers' switching behaviour. The second part of the review will address how the theory may be applied to develop an empirical model for testing hypotheses. The final part will review the influences of significant factors determining consumers' switching behaviour from some academic literature based on the PPM theory to support proposed hypotheses of this study.

3.3.1 Research Framework

In an attempt to explore the relationship between the switching intentions of auto-customers, a set of four hypotheses and sub-hypotheses are proposed and discussed below in this section. The hypotheses about the switching behaviour of customers are set and explored within the framework of the 'push-pill-mooring' (PPM) theory introduced in Chapter 2 and further discussed in the next section of this chapter.

The 'push-pull-mooring' (PPM) analytical framework is developed to examine the statistical significance of factors influencing the switching intention of automotive customers in Thailand, given the choice between brand new 'linear' auto-motive products and 'like new' remanufactured 'circular' products. The proposed analytical framework, which is developed in the form of a structural path analysis model, is shown in Figure 3.4 below.

The research question about the determinants of the switching intention of auto-customers can also be expressed in terms structural equation model, as shown in equation (1), based on the empirical literature discussed in Chapter 2.

$$SI = f[Pushing\ factor(P), Pulling\ factor(EB, SB), Mooring\ factor(PA, OR)] \quad (1)$$

Where:

SI represents the switching intention of customers from new auto-products to 'like new' remanufactured alternatives;

P represents price disadvantages of new auto-products compared with remanufactured alternatives;

EB represents environmental benefits of remanufactured auto-products;

SB represents special feature benefits remanufactured auto-products;

PA represents the personal attitudes of consumers on auto-remanufactured products;

OR represents obsolescence risk of remanufactured auto-products.

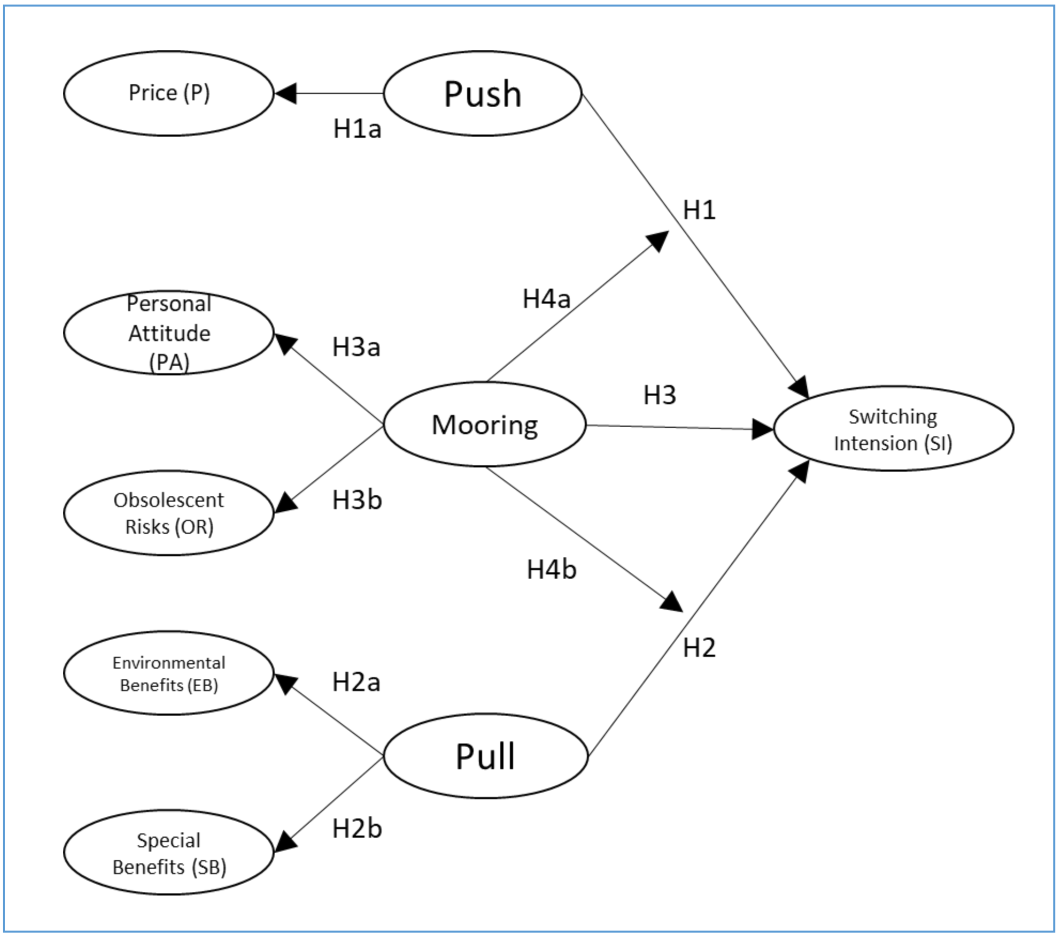

Figure 3.2 Path Analysis Model of the Research Framework

3.3.2 Hypothesis development

The aim of this section to discuss the factors affecting (driving or obstructing) customers' willingness to purchase remanufactured products. According to the PPM theoretical framework, the factors can be grouped into three: Push, Pull and Mooring factors (Figure 3.2). These PPM factors and the specific switching determinants can affect the switching intention of auto-customers via direct and moderating effects (Figure 3.3).

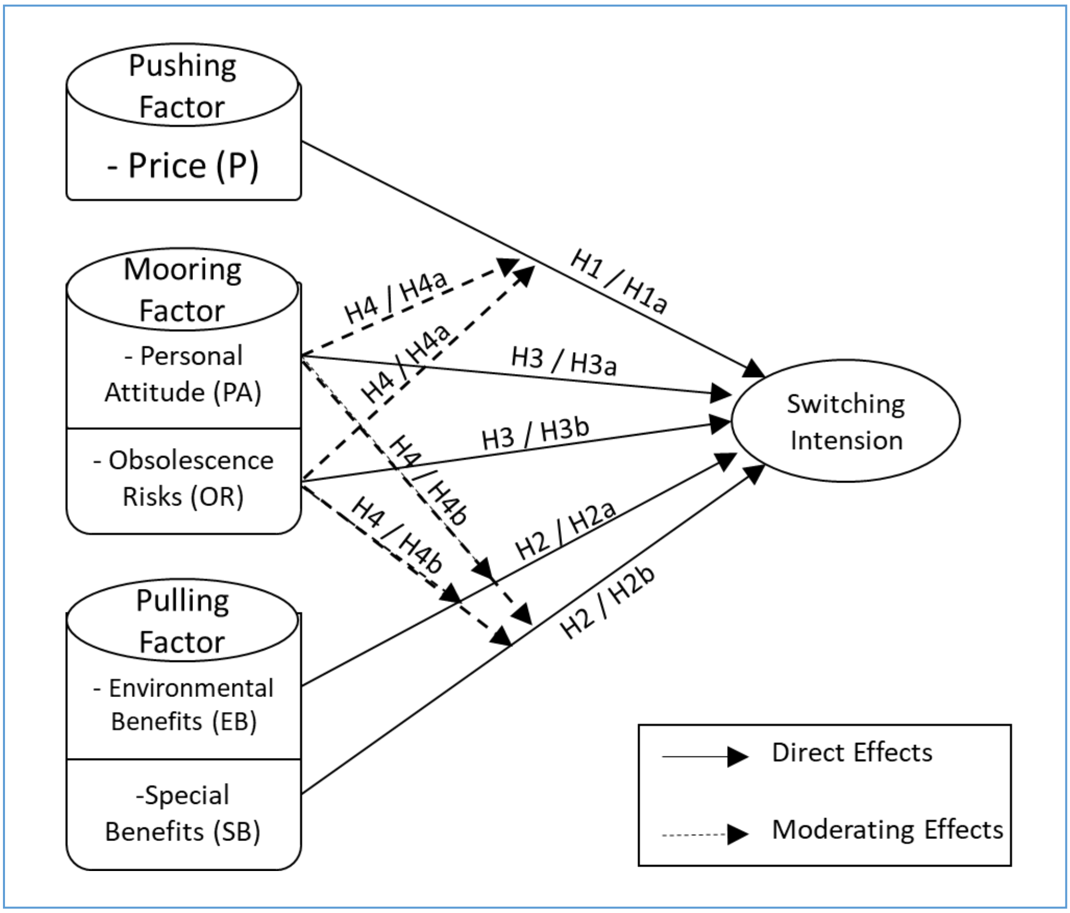

Figure 3.3 Links or Effects of PPM factors and determinants to switching intention

The relationship between the switching intentions of auto-customers to choose remanufactured auto-products and the factors that bear on the switching behaviour of auto-customers is set and explored within the PPM framework through the investigation of the following hypotheses.

Hypothesis 1: Push factors positively affect the switching intention of auto customers to select remanufactured products.

In migration theory, push factors are presumed to constitute negative influences on the perception of an individual migrant that bring pressure to bear on the individual to move away from one area to a new location. These negative factors are by definition *sui generis* to the original location (Bogue, 1969, 1977; Lee, 1966; Moon, 1995). In the context of consumer behaviour, push factors relating to the market and technological characteristics of products have the effect of changing the perception of an individual consumer to switch from products deriving from the application of linear business models to products remanufactured circular-auto-products. As a result, push factors would be expected to positively relate to the intention of auto-customers to switch to remanufactured auto-products (H1 in Figure 3.3). A major 'push' factor considered in this study is the perception of customers about the 'price disadvantage' (P) of substitutable products (Figure 3.2, Figure 3.3).

Hypothesis 1a: Perception of customers that the price disadvantages of new auto-products (P) positively affects their switching intention to select remanufactured products.

Price disadvantages of new linear-auto-products or price advantages of remanufactured circular-auto-products would be expected positively relate to the switching intention of auto consumers/users (H1a in Figure 3.3). The price hypothesis is based on the law of demand – i.e. the purchased quantity of products and services is negatively associated with price of the products/processes. The price advantage of remanufactured circular auto products has over new manufactured products produces both income and substitution effects on customers who would then be inclined to migrate away from automotive products arising from the linear business model to the price and quality competitive 'like new' remanufactured products deriving from the circular business model.

Hypothesis 2: Pull factors positively affect switching intension of customers to select remanufactured products.

Some studies have shown the positive influence pull factors have on the switching intention of consumers (Bansal et al., 2005). Whether this also holds for customers of remanufactured auto-products has, however, yet to be put to the test. Pull factors pull the customer (or the migrant) to switch (or to move) from new auto-products to 'like new' remanufactured auto-products. As a result, pull factors should positively relate to the switching intention of auto-customers to select remanufactured auto-products (H2 in Figure 3.3). The pull factors considered in this study include perception of customers with respect to 'environmental benefits (EB)' and 'special benefits (SB)' of remanufactured auto-products (Figure 3.2, Figure 3.3).

Hypothesis 2a: Perception of customers about the environmental benefits of remanufactured auto-products (EB) positively affects their switching intention to select the remanufactured products.

The eco-friendly perception of consumers would be expected to have a positive influence on their switching intention given the choice between 'linear' and 'circular' products (H2a in Figure 3.3). Hazen et al. (2016); Rubio and Vicente-Molina (2014); Jiménez-Parra et al. (2014); Mugge et al. (2017) indicated that the environmental benefit arising from the choice of 'circular' products is an important social (macro-level) determinant which can influence the willingness of individuals (micro-level) to opt for remanufactured products (Hazen, Mollenkopf, et al., 2017; Jiménez-Parra et al., 2014; Mugge et al., 2017). Also, Singh and Jain (2014); Zhang et al. (2011) found that customers' demand for remanufactured products increasing positively as a result of increased awareness about climate change and its adverse consequences (Singh & Jain, 2014; T. Zhang et al., 2011). Furthermore, there is evidence to suggest that the willingness of Thai consumers to pay a premium price for eco-friendly products is a result of their environmental awareness (Dokmai, 2018). In the same vein, Offord (2013) argues that environmentally aware consumers are more likely to pay more for goods that are labelled green (Offord, 2013). In contrast, some studies argue that the environmental driver rarely influences consumers to shift preference to remanufactured products (Hughner et al., 2007; van Weelden et al., 2016).

Hypothesis 2b: Perception of customers about the special benefits of remanufactured auto-products (SB) positively affects their switching intention to select remanufactured products.

According to Hazen *et al.* (2012), the special features of or special benefits deriving from the use of remanufactured auto-products would be expected to positively influence the switching behaviours of consumers/users in favour of remanufactured auto-products (H2b in Figure 3.3) (Hazen et al., 2012). There are various special features and benefits of remanufactured products that make the products' performance, functionality and quality better than new brand alternatives deriving from the linear business model. Remanufactured products offer the benefits of new technology in terms of functionality, durability, longer warranty and/or closer and better services than what would obtain under the linear business model. These features and benefits of remanufactured products constitute part and parcel of the ‘performance economy’ as a variant of the circular economy business model (W. R. Stahel, 2008).

Hypotheses on the direct and indirect effects ‘mooring factors

Factors mitigating or moderating, or constraining the influence of ‘push’ and ‘pull’ factors (Nimako & Ntim, 2013) on the switching intention of customers to select remanufactured products are variously referred to as ‘mooring factors’ (Moon, 1995), or ‘intervening variables’ (Jackson, 1986) or ‘intervening obstacles’ (Lee, 1966). While decision-making on migration is, in theory, dependent on the evaluation of ‘push’ and ‘pull’ factors, the evaluation is modified by mooring factors within the context of individual circumstances (Bansal et al., 2005; Lee, 1966).

As determinants of the switching behaviour of customers, ‘mooring’ factors are perceived to obstruct customer switch-over from new linear-auto-products to ‘like-new’ remanufactured auto-products. The obstacle can be divided into two. First, ‘mooring’ factors have direct negative influences on the switching intention of customer to opt for remanufactured auto-products (H3 in Figure 3.3). Second, ‘mooring’ factors should have indirect negative influences on the switching intention of customers to be inclined to choose remanufactured auto-products via the ‘push’ factors (H4a in Figure 3.3) and ‘pull’ factors (H4b in Figure 3.3).

The ‘mooring’ factors considered in this study relate to the perception of customers or ‘personal attitude (PA)’ towards remanufactured auto-products; and ‘obsolescence risks (OR)’ of remanufactured auto-products (Figure 3.2, Figure 3.3).

Hypothesis 3: The direct effects of ‘mooring factors’ would be expected to negatively affect the switching intention of consumers to select remanufactured products.

There are two parts to this hypothesis: H3a and H3b, which are discussed below.

Hypothesis 3a: Personal attitude of auto-users expressed in terms of quality misconception of remanufactured auto-products (PA) is inversely related to the switching intention of auto-users to select remanufactured products.

Misconception about the quality of remanufactured products is a factor behind customers’ unwillingness to select remanufactured products (Hazen, Mollenkopf, et al., 2017; Hazen et al., 2012; Mugge et al., 2017; van Weelden et al., 2016; Yacan Wang & Hazen, 2016). Remanufactured products are produced to be ‘like new’, or even better than new manufactured products deriving from linear business models. However, Hazen et al. (2012) found that, in the opinion of many customers, remanufactured products are simply recognised as assembly of components used in the past. As such, customers may not trust that 'like-new' remanufactured products could be as robust as new manufactured products. They may, therefore, consider remanufactured products at par with second-hand products or inferior to new manufactured products (Mugge et al., 2017; van Weelden et al., 2016; Hazen et al., 2012; Wang & Hazen, 2016). The prevalence of such attitude towards remanufactured products would cause customers to reduce their willingness to purchase remanufactured products or to reject the products altogether to avoid uncertainty or risks associated with the products (Hazen et al., 2012; Wang & Hazen, 2016; van Weelden et al., 2016).

Therefore, the personal attitude of consumers largely based on their misconception about the quality of remanufactured auto-products (PA) would be expected to negatively affect their switching intention in favour of remanufactured products (H3a in Figure 3.3).

Hypothesis 3b: Perception of customers on obsolescence-related risks of remanufactured auto-products (OR) negatively affects their switching intention with respect to remanufactured products.

Many consumers/users of remanufactured products are said to have the anxiety that such products bear the risk of becoming obsolete too soon (van Weelden et al., 2016). This perception of rapid obsolescence ascribed to remanufactured products would act a barrier to consumer preference for remanufactured products. This perception, however misconceived, is based on the fact that remanufactured products, at least their core components, are used before; so in the opinion of some consumers, remanufactured products can only be as good as second hand products in terms of functionality (Mugge et al., 2017; van Weelden et al., 2016). As a result, Obsolescence risks (OR) are expected to be negatively associated with switching behaviours of consumers with respect to remanufactured products (H3b in Figure 3.3).

Hypothesis 4: The moderating or indirect effects of mooring factors mitigate the effects of push and pull factors on the switching intention of customers towards remanufactured products.

There are two parts to this hypothesis: H4a and H4b, which are discussed below.

Hypothesis 4a: Mooring determinants (personal attitude (PA) and obsolescence risks (OR)) moderate the association between the push determinant (Price (P)) and the switching intention of customers to switch to remanufactured auto-products (H4a in Figure 3.3).

Hypothesis 4b: Mooring determinants (personal attitude (PA) and obsolescence risks (OR)) moderate the association between pull determinants (environmental benefits (EB) and special benefits (SB) of remanufactured auto-products) and the intention of customers to switch to remanufactured auto-products (H4b in Figure 3.3).

Inclusion of the moderating effect of 'mooring' factors on the effects of 'pull' and 'push' factors makes adoption the PPM model attractive for analysing the switching behaviour of customers in this study. The model can explain the reasons why customers may not switch from new manufactured auto-products to 'like new' remanufactured auto-products, even when they consider the effects of 'push' and 'pull' factors to be strong. For example, auto-motive customers may be inclined to stick to eco-unfriendly new manufactured auto-products simply because they are attracted by the 'newness' of these products, even when remanufactured auto-products are more durable and less expensive than the eco-unfriendly traditional auto-products. This state of affairs can be explained by the direct and moderating effects of the mooring factors on the perception of customers of auto-products, in general.

The direct influence of mooring factors is reflected through the perception of automotive customers that remanufactured auto-products are essentially inferior to new manufactured auto-products and no better than second-hand products. As a result, they would be inclined to reject remanufactured products even when such products offer attractive special benefits. This happens when the direct effect of 'mooring' factors (Personal Attitude: PA) is greater than the direct effect of 'pull' factors (Special benefits: SB).

The moderating influence of mooring factors also involves the perception (personal attitude) of customers of auto-products, which renders remanufactured products as just second-hand products; but this influence is not strong enough to affect switching intention directly. It may appreciate (or devalue) the perceived relative durability of new auto-products (or their ‘like new’ remanufactured alternatives). Thus, when personal attitude or perception moderates the effects of the ‘pull’ factor (Special benefits: SB) as a mooring factor, customers of auto-products would not be expected to switch to remanufactured auto-products.

The PPM model incorporating the moderating effects of mooring factors is capable of explaining the switching behaviour of automotive customers more effectively than the model that applies only direct effects. Hence the importance of incorporating the ’mooring’ factor into the PPM model to indirectly influence the switching intention of customers of auto-products. The empirical results of this procedure is then be compared with results of analysis when only the direct-effect model is used to explain the switching behaviour of customers of auto-products.

3.4 The ‘push-pull-mooring’ (PPM) analytical framework

The analytical framework adopted for this study is based on the ‘push-pull-mooring’ (PPM) migration theory. The framework is developed to examine the statistical significance of factors influencing the switching intention of automotive customers, given the choice between brand new manufactured auto-motive products and ‘like new’ remanufactured auto-products. The proposed analytical framework, which is developed in the form of a structural model, is shown in Figure 3.4 below.

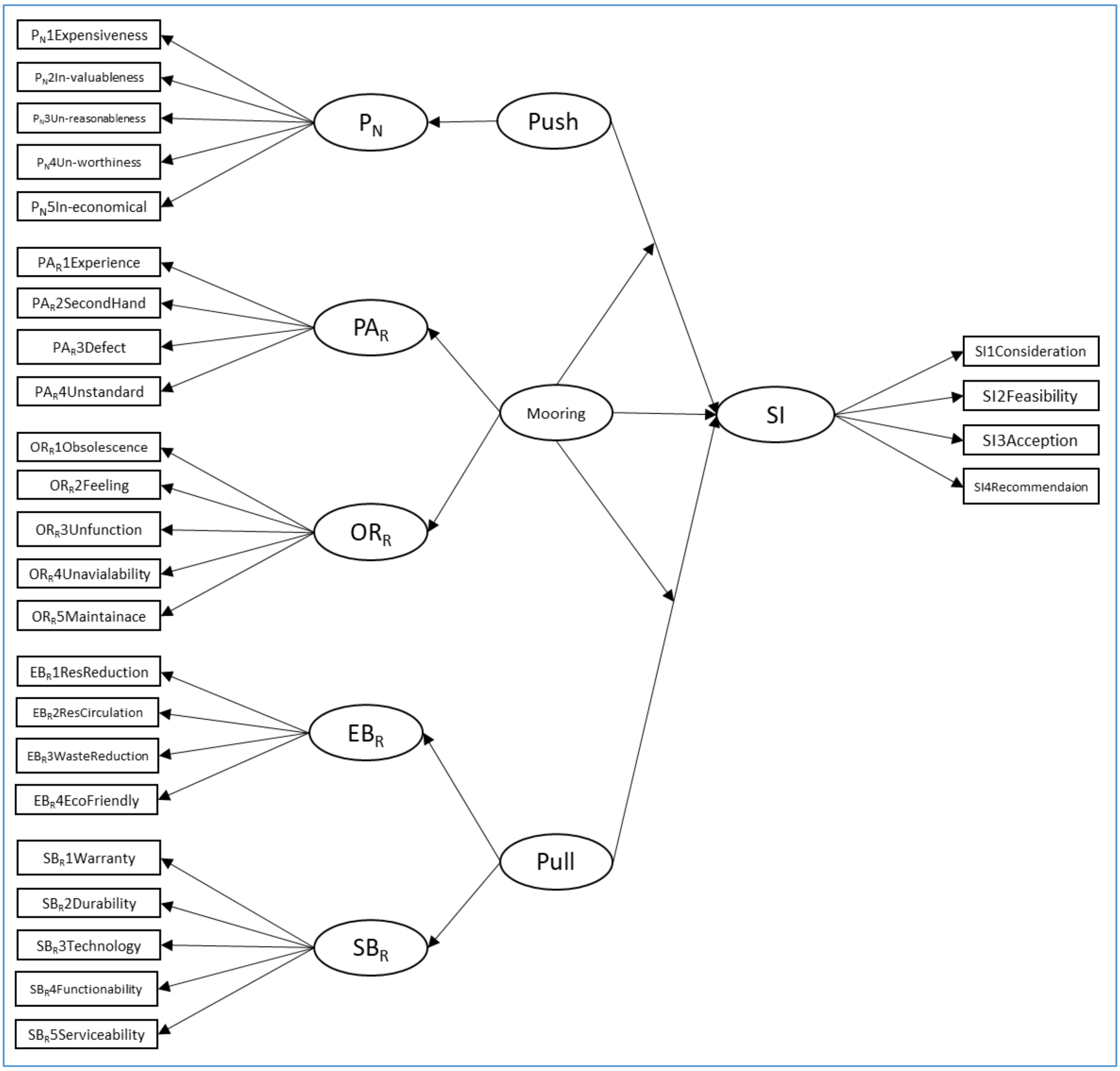

Figure 3.4 Proposed Conceptual Framework based on the PPM Migration Theory

The major hypothesis to be tested within the PPM theoretical framework, set out above in Figure 3.2, is that the switching intention (SI) of customers is influenced by factors, including the price advantage of remanufactured auto-products or price disadvantage of new-manufactured auto-products (P_N); environmental benefits (EB_R) due to remanufactured auto-products; special benefits deriving from the use of remanufactured auto-products (SB_R), (such as provisions for better services, longer warranties and more durable materials); personal attitudes of customers towards 'like new' remanufactured auto-products (PA_R); and perceived vulnerability of remanufactured auto-products to the risk of technological obsolescence (OR_R). These factors are drawn from the literature to explain changes in the relative preference of customers as between new manufactured auto-products and 'like new' remanufactured auto-products (Collins, Steg, & Koning, 2007; Hazen, Mollenkopf, et al., 2017; Hsu, 2014; Lacy & Rutqvist, 2015; Mugge et al., 2017; Tavakol & Dennick, 2011; van Weelden et al., 2016). Because of the subjective nature of the personal perception of customers, these determinants cannot be directly measured, but can be inferred from other observed indicators (see Figure 3.4).

3.4.1 Specification of variables/factors for data collection

Data on factors proposed to explain switching behaviour of customers were obtained by asking respondents covered in a questionnaire-based survey questions/statements related to the determinants of the switching decisions of customers (see questionnaire in Appendix B). For example, the 'price disadvantage' (P_N) factor can be inferred from some keywords in statements like 'expensiveness'[12], 'value-for-money'[13], 'reasonableness'[14], 'worthiness'[15], and 'economical'[16]. These words are broadly similar in meaning and can refer to the relative price between two alternative products. The five-point Likert scale is adopted in this study to show the extent individual respondents would agree or disagree with statements in responding to questions. Individuals' responses to questions about explanatory factors could vary, but the individual responses can be aggregated and used to indicate the extent of consensus among respondents on the value to be attached to the factors (Tavakol & Dennick, 2011).

As shown in Figure 3.4, the switching intention (SI) was measured by four indicators: Consideration to switch or not to switch (SI1Consideration); Feasibility of decision to switch (SI2Feasibility); Willingness to switch (SI3Acceptance); and Recommendation for others to also switch (SI4Recommendaion). These indicators

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[12] Expensiveness (price) is costing a lot of money.

[13] Value (importance for money) is very helpful or important of something for someone.

[14] Reasonable (fair for money) is fair, and neither too cheap nor too expensive.

[15] Worthy (suitable for money) is suitable or deserve to buy.

[16] Economical (cost-effective for money) is not using a lot of money based on individual economic status.

show the intention of individual customers to select remanufactured auto-products in terms of the four statements of action listed below using the five point *Likert scale (Hsu, 2014)*.

- The statement regarding the indicator of 'Consideration' (SI1Consideration) is: 'I am considering switching from a new auto-part to a like-new remanufactured auto-part'.

- The statement regarding the indicator of 'Feasibility' (SI2Feasibility) is: 'The prospect of switching to like-new remanufactured auto-parts is high'.

- The statement regarding the indicator of Willingness to switch (SI3Acceptance) is: 'I am willing to switch to buy a like-new remanufactured auto-part'.

- The statement regarding the indicator of 'Recommendation' (SI4Recommendaion) is: 'I would recommend like-new remanufactured auto-parts to friends and relatives'.

In the same manner, the factor about the price advantage of remanufactured auto-products (P_N) is shown by five indicators. These are: Expensiveness (P_N1Expensiveness); Value-for-money (P_N2Value-for-money); Reasonableness (P_N3Reasonableness); Worthiness (P_N4Worthiness); and Economical (P_N5Economical) (Figure 3.4). These indicators are measured by the level of acceptance of the respondents using the five-point Likert scale, while responding to the following statements (Hazen, Mollenkopf, et al., 2017):

- The statement regarding the indicator of 'Expensiveness' (P_N1Expensiveness) is: 'New auto-products are expensive than like-new remanufactured auto-products'.
- The statement regarding the indicator of 'Value-for-money' (P_N2Value-for-money) is: 'New auto-products do not provide more value-for-money than like-new remanufactured auto-products'.

- The statement regarding the indicator of ‘Reasonableness’ (P_N3Reasonableness) is: ‘New auto-products are not more reasonably priced than like-new remanufactured auto-products’.
- The statement regarding the indicator of ‘Worthiness’ (P_N4Worthiness) is: ‘Other more expensive auto-products are not more worthy than like-new remanufactured alternatives’.
- The statement regarding the indicator of ‘Economical’ (P_N5Economical) is: ‘New auto-products are not more economical than like-new remanufactured auto-products’.

Similarly, the factor about the Environmental Benefits (EB_R) of remanufactured auto-products are shown by the following indicators: Reduction of resource use (EB_R1ResReduction); Resource circulation (EB_R2ResCirculation); Reduction of landfill waste (EB_R3WasteReduction); and Ecosystem friendliness (EB_R4EcoFriendly) (Figure 3.4). These indicators are measured by the level of respondents’ acceptance (based on five-point Likert scale) of the following statements (Collins et al., 2007):

- Reduction of resource use (EB_R1ResReduction): ‘Switching to ‘like-new’ remanufactured auto-products will help save finite resources’.

- Resource circulation (EB_R2ResCirculation): ‘Switching to ‘like-new’ remanufactured auto-products will help increased use of reusable/recyclable resources’.

- Reduction of landfill waste (EB_R3WasteReduction): ‘Switching to ‘like-new’ remanufactured auto-products will help minimise landfill waste pollution’.

- Ecosystem friendliness (EB_R4EcoFriendly): ‘Switching to ‘like-new’ remanufactured auto-products will help minimize negative effects on natural ecosystems’.

Remanufacturing is often associated with better performance conditions and offers customers better warranty to ensure that remanufactured products are no less competitive in terms of safety, quality and effectiveness of functionality than new manufactured products. The 'special benefits' factor of remanufactured auto-products (SB_R) is shown in terms of five indicators: longer warranties (SB_R1Warranty); durability (SB_R2Durability); application of new technologies in product design and remanufacturing processes (SB_R3Technology); versatility as well as robustness of product functions (SB_R4Functionability); and provision for servicing of products (SB_R5Serviceability) (see Figure 3.4). Based on the five-point Likert scale, these indicators show the influence of the 'special benefits' factor on the decision of respondents to switch their customs from new auto-products to 'like-new' remanufactured ones. The Likert scale points are based on the responses of respondents to the following statements (Lacy & Rutqvist, 2015):

- Long warranties (SB_R1Warranty): 'Like-new remanufactured auto-products offer longer warranties than new alternatives'.
- Durability (SB_R2Durability): 'Like-new remanufactured auto-products offer more durable materials than new alternatives'.
- Upgradability of product to higher and new technology levels (SB_R3Technology): 'Like-new remanufactured auto-products offer better upgrading options to new technology levels than new alternatives'.
- Versatility of functions (SB_R4Functionability): 'Like-new remanufactured auto-products offer more features/functions than new alternatives'.
- Better service (SB_R5Serviceability): 'Like-new remanufactured auto-products have better service backing than new alternatives'.

the 'personal attitudes' factor, which seeks to isolate the misconception of customers about the quality of remanufactured auto-products as mediocre and shoddy (PA_R), are shown by four indicators as shown in Figure 3.4. These are indicators of incidents of bad experiences with the use of remanufactured products (PA_R1Experience); conception of remanufactured products as second-hand products (PA_R2SecondHand); conception of remanufactured products as essentially defective products (PA_R3Defect); and the lack of product standardisation in remanufacturing (PA_R4Unstandardisation). The indicators are measured by the level of agreement of customers of automotive products based on the application of the five-point Likert scale to the following statements (Hazen, Mollenkopf, et al., 2017).

- Bad experiences (PA_R1Experience): 'I have had bad experience with using like-new remanufactured auto-products'.
- Remanufactured products as second-hand products (PA_R2SecondHand): 'I feel that like-new remanufactured auto-products are second-hand products'.
- Remanufactured products as defective products (PA_R3Defect): 'I feel that like-new remanufactured auto-products are defective products'.
- Lack of product standardisation in remanufacturing (PA_R4Unstandardisation): 'I do not have confidence in the remanufacturing process of 'like-new' remanufactured auto-products as they do not comply with any standards, even if the products are the same or better than new manufactured alternatives'.

Finally, the obsolescence risk factor associated with 'like-new' remanufactured auto-products in comparison with new manufactured alternatives (OR_R) is shown by five indicators as shown in Figure 3.4. These are: very short life of remanufactured products due to obsolescence (OR_R1Obsolescence); stigma associated with remanufactured products due to perceived lack of newness in such products (OR_R2LackingNewness); risk of dysfunctionality of remanufactured products (OR_R3Dysfunction); risk of unavailability of remanufactured products (OR_R4Unavailability); and high-maintenance costs of remanufactured products (OR_R5High-maintenance), These indicators are measured by the level of agreement (based on the five-point Likert scale) of targeted customers with these following statements (Mugge et al., 2017; van Weelden et al., 2016).

- Risk of fast obsolescence (OR_R1Obsolescence): ‘Like-new remanufactured auto-products will become old-fashioned too soon’.
- Perceived lack of newness in remanufactured products (OR_R2LackingNewness): ‘Like-new remanufactured auto-products do not inspire confidence of newness (at least their core components)’.
- Perceived risk of dysfunctionality of remanufactured products (OR_R3Dysfunction): ‘Like-new remanufactured auto-products are prone to dysfunctionality unlike new manufactured products’.
- Perceived risk of unavailability of remanufactured products in general markets (OR_R4Unavailability): ‘Like-new remanufactured auto-products are not available in general retail channels’.
- High maintenance costs of remanufactures products (OR_R5High-maintenance): ‘Like-new remanufactured auto-products involve high maintenance compared with new manufactured alternatives’.

Table 3.2 Measurement statements for the unobserved underlying factors

Underlying Factors	Code	Indicators	Code	Measurement items/statements
Price disadvantages of new products (or Price advantages of remanufactured products)	**P_N**	Expensive price	P_N1Expensiveness	'New auto-products are expensive than like-new remanufactured auto-products'.
		Value for money	P_N2Value-for-money	'New auto-products do not provide more valuable for money than like-new remanufactured auto-products'.
		Reasonable price	P_N3Reasonableness	'New auto-products are not more reasonably priced than like-new remanufactured auto-products'.
		Worthy for money	P_N4Unworthiness	'Other more expensive auto-products are not more worthy than like-new remanufactured alternatives'.
		Economic price	P_N5Economical	'New auto-products are not more economical than like-new remanufactured auto-products'.
Environmental Benefits of remanufactured products	**EB_R**	Reduction of resource use	EB_R1ResReduction	'Switching to a like-new remanufactured auto-product will help save finite resources'.
		Resource circulation	EB_R2ResCirculation	'Switching to a like-new remanufactured auto-product will help increase use more reusable/recyclable resources'.
		Reduction of landfill waste	EB_R3WasteReduction	'Switching to a like-new remanufactured auto-product will cause minimise landfill waste pollution'.
		Ecosystem friendliness	EB_R4EcoFriendly	'Switching to a like-new remanufactured auto-product will minimize negative effects on natural ecosystems'.
Special Benefits of remanufactured products	**SB_R**	Long warranties	SB_R1Warranty	'Like-new remanufactured auto-products offer longer warranties than new alternatives'.
		More durable materials	SB_R2Durability	'Like-new remanufactured auto-products offer more durable materials than new alternatives'.
		New upgrading technology	SB_R3Technology	'Like-new remanufactured auto-products offer new upgrading technology than new alternatives'.
		More features/functions	SB_R4Functionability	'Like-new remanufactured auto-products offer more features/functions than new alternatives'
		Better services	SB_R5Serviceability	'Like-new remanufactured auto-products offer better services than new alternatives'

Underlying Factors	Code	Indicators	Code	Measurement items/statements
Personal Attitudes of remanufactured products	**PA$_R$**	Bad experiences	PA$_R$1Experience	‘I have a bad experience with using like-new remanufactured auto-products’.
		Second-hand products	PA$_R$2SecondHand	‘I feel that like-new remanufactured auto-products are second-hand products’.
		Defective products	PA$_R$3Defect	‘I feel that like-new remanufactured auto-products are defective products’.
		Unstandardised remanufacturing	PA$_R$4Unstandardisation	‘I do not rely on remanufacturing process and care less for the standard of ‘like-new’ remanufactured 'auto-products even if they are the same or better than new alternatives’.
Obsolescent Risks of remanufactured products	**OR$_R$**	Old-fashioned too soon	OR$_R$1Obsolescence	‘Like-new remanufactured auto-products will become old-fashioned too soon’.
		A lack of feeling of newness	OR$_R$2LackingNewness	‘Like-new remanufactured auto-products do not inspire confidence of newness (at least their core components)’.
		Without some functionality	OR$_R$3Dysfunction	‘Like-new remanufactured auto-products are without exiting functionality which new products can give’.
		Unavailable via general retail channels	OR$_R$4Unavailablility	‘Like-new remanufactured auto-products are not available via general retail channels’.
		High maintenance costs	OR$_R$5HighMaintenance	‘Like-new remanufactured auto-products involve high maintenance compared with new alternatives’.
Switching Intension	**SI**	Consideration	SI$_R$1Consideration	‘I’m considering switching from a new auto-part to a like-new remanufactured auto-part’.
		Feasibility	SI$_R$2Feasibility	‘The prospect of switching to like-new remanufactured auto-parts is high’.
		Acceptation	SI$_R$3Acception	‘I willing to switch to buy a like-new remanufactured auto-part’.
		Recommendation	SI$_R$4Recommendaion	‘I would recommend like-new remanufactured auto-parts to friends and relatives’.

3.4.2 Specification of analytical regression model

Based on the PPM migration theory (Bansal et al., 2005; Jung et al., 2017), the switching intention (SI) of automotive customers is regressed as a dependent variable on independent variables, including 'push' factors (P_N), 'pull' factors (EB_R and SB_R) and 'mooring' factors (PA_R and OR_R). The baseline regression model is shown below in equation (2).

$$SI = f\ (P_N,\ EB_R, SB_R, PA_R, OR_R\ ) \qquad (2)$$

Where:

SI represents switching intention of customers from new manufactured auto-products to remanufactured alternatives;

P_N represents price disadvantages of new auto-products over 'like new' remanufactured alternatives;

EB_R represents environmental benefits of remanufactured auto-products;

SB_R represents special feature benefits of remanufactured auto-products;

PA_R represents the personal attitudes of consumers on auto-remanufactured products; and

OR_R represents obsolescence risks of remanufactured auto-products.

However, an outstanding feature of the PPM migration model is its awareness of the moderating influence of the 'mooring' factors (PA_R and OR_R) on the 'push' and 'pull' factors (Bansal et al., 2005; Jung et al., 2017). As shown in Figure 3.4, the moderating effects of the 'mooring' factors on the dependent variable (switching intention) is indirect with these indirect effects being transmitted to the dependent variable through the independent variables. Thus, a new baseline regression model is developed as shown in equation (3) below.

$$SI = f\ [P_N, EB_R, SB_R, PA_R, OR_R, (P_N \cdot PA_R), (EB_R \cdot PA_R), (SB_R \cdot PA_R), (P_N \cdot OR_R), (EB_R \cdot OR_R), (SB_R \cdot OR_R)] \quad (3)$$

Where:

The influences of P_N, EB_R, SB_R, PA_R and OR_R represent the direct effects of independent variables ('push' factor: P_N, 'pull' factors: EB_R and SB_R, and 'mooring' factors: PA_R and OR_R) on dependent variable (SI).

The influences of ($P_N \cdot PA_R$), ($EB_R \cdot PA_R$) and ($SB_R \cdot PA_R$) represent the indirect moderating effects of the 'mooring' factor – i.e. the moderating influence of PA_R on dependent variable (SI) via independent variables (push factor: P_N, and 'pull' factors: EB_R and SB_R).

In the same way, the moderating influences of ($P_N \cdot OR_R$), ($EB_R \cdot OR_R$) and ($SB_R \cdot OR_R$) represent the indirect moderating effects of the 'mooring' factor OR_R on the dependent variable (SI) via the independent variables ('push' factor: P_N, and 'pull' factors: EB_R and SB_R).

3.5 Questionnaire design and development

Questionnaire administration was the main survey mechanism used for the collection of data. The questionnaire was designed in order to elicit data from randomly selected individuals to represent potential customers or users of auto-motive products in Thailand. The central question being investigated through the questionnaire-based survey is: what would it take for customers or users of new manufactured automotive products to switch their preference to 'like new' remanufactured options?

Designing a 'good questionnaire' is crucial for the robustness of the data to be collected (Crawford, 1997). Accordingly, the questionnaire for the survey conducted for this study was carefully designed drawing on the various aspects of the research question and on review of the relevant literature. Figure 3.5 below shows the procedures followed in the development of the questionnaire.

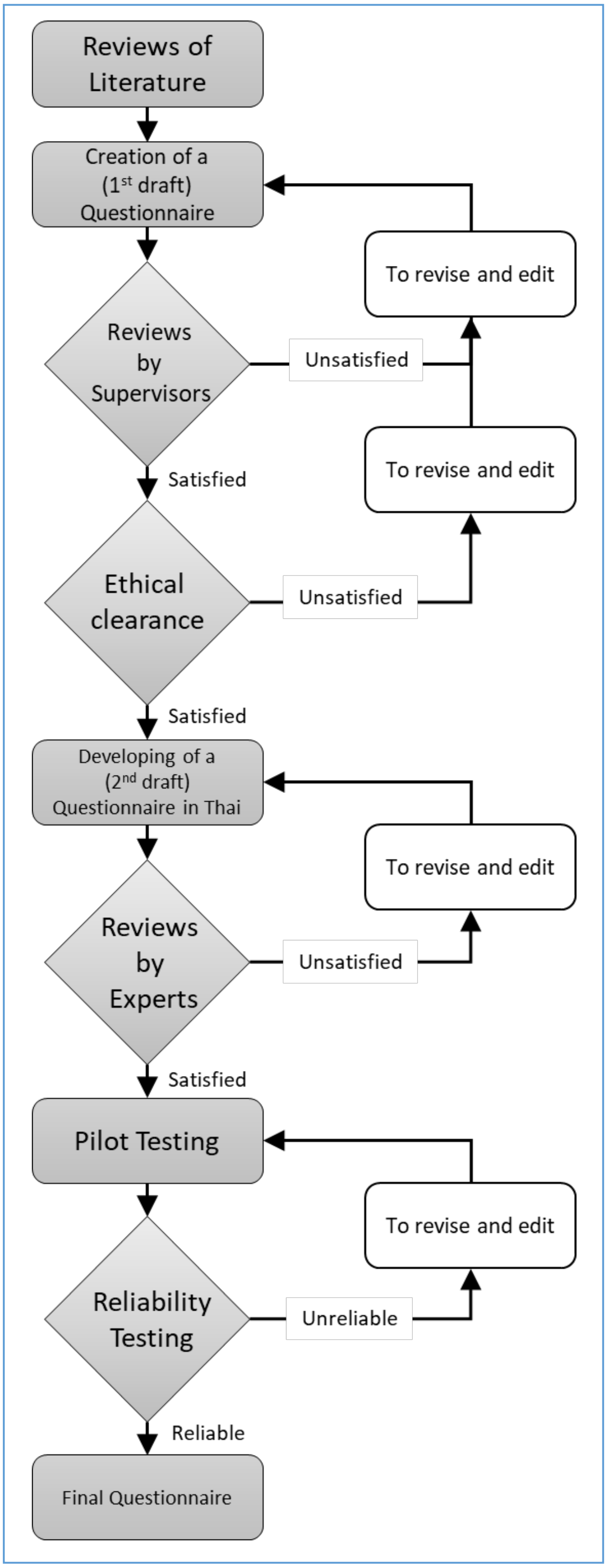

Figure 3.5 Steps to creating the survey questionnaire

3.5.1 Finding context for questionnaire in the literature

The first step for questionnaire design and development was to look into the literature. The aim here is to set the context for the questionnaire in relation to the aim and objectives of the study. It is possible to learn from the literature how similar research questions were addressed under different circumstances. This would help shed light on a number of key methodological questions: what kind of data would be needed to investigate the research question; how are these to be obtained; in the case of questionnaire-based survey, who should be the survey targets; how are they to be selected and accessed; etc. Potential determinants expected to influence switching behaviour of customers - like price (P_N), environmental benefits (EB_R), special benefits (SB_R), personal attitude (PA_R) and obsolescence risks (OR_R) – are identified based on review of the relevant empirical and theoretical literature. The literature also offers insight as to how data on these variables can be collected.

3.5.2 Process of designing questionnaire

The survey questionnaire is structured into four parts. This includes the introduction, briefly setting out the preamble to the questionnaire for the benefit of respondents. This part aims to describe basic information that respondents should know before filling the questionnaire, such as overview of the study, definition of 'remanufacturing', and differences between 'like new remanufacturing' and 'new manufactured' alternatives. The second part of the questionnaire covers questions about the respondents. Personal data on education, age, gender and income are sought as they can be helpful in the categorization of behavioural traits. In the third part, information about the perception of participants on some aspects of remanufactured auto-products is queried. These aspects include the quality, durability, functionality, obsolescence risks, price advantage or affordability, and the environmental benefits and special benefits (in the form of longer warranty) deriving from 'like new' remanufactured auto-motive products.

The fourth part of the questionnaire explores questions about the switching intention of respondents. To measure their level of willingness to switch to remanufactured auto-products, respondents were asked questions about their disposition towards remanufactured auto-products in terms of consideration of switching; viability or prospect of switching; willingness to switch; readiness to recommend remanufactured auto-motive products to others. The role of price differentials – particularly the level of price differential between new auto-products to select remanufactured ones - in inducing the willingness to switch is also explored. Finally, methods that can motivate their willingness to return end-of-used auto-products were queried.

3.5.3 Ethics clearance

The questionnaire was submitted to the Ethics Committee of the Department of Civil and Environmental Engineering of the University of Strathclyde for ethical clearance before being administered to respondents for data collection. The process complies with the code of practice of the University on investigations involving human beings (University of Strathclyde, 2016). The ethics clearance procedure was completed in September 2018.

3.5.4 Translation of draft questionnaire into Thai

To administer it to Thai respondents in Thailand, the ethics-cleared questionnaire was translated into Thai language. The translated questionnaire was subsequently commented on by individuals from academia, industry and the general public who are all native Thai speakers and are also familiar with the Thai automotive products and industry. Based on the feedback obtained, the questionnaire was slightly revised for some structural flaws, ambiguity, and repetitiveness of questions. The feedback also helped in initiating the process of validating the revised questionnaire by experts.

3.5.5 Reviews by Thai Experts (Validity Testing of questionnaire)

The process of expert review of the second draft questionnaire was made for content validity and clarity of the questionnaire, and for its ability to elicit robust information and data.

The tool, which was used to evaluate content and language validity of the questionnaire, is what is known as “Item-Objective Congruence (IOC) Index”. The IOC index, initiated by Rovinelli and Hambleton, is a procedure in which experts justify the quality of content of a research instrument, like questionnaires. Experts or reviewers evaluate quality levels based on particular objectives specified by the test creator (Rovinelli & Hambleton, 1997; Turner & Carlson, 2003).

Five Thai experts reviewed the different aspects of the questionnaire. Amongst the reviewers is a researcher with qualified expertise in Thai automotive sector, and in Thai remanufacturing research. This reviewer is also owner of a Thai automotive-part company, and user of Thai automotive product.

All reviewers were asked to assess and identify any problems in the questionnaire. There are four elements that experts were asked to consider:

- Concordance of content between the English and the Thai versions of the questionnaire;
- Problems about linguistic structures and about clarity of questions;
- Completeness of questions and choices to meet objectives of the survey; and
- Assessment of questions that are likely to show errors in the evaluation process.

The five experts were asked to judge the quality of the questionnaire, item by item, question by question, whether the questions asked can really satisfy the above listed objectives of content validity. To measure the quality of each question, the experts were asked to grade the content validity score (Table 3.3):

- The score is 1 when the expert was satisfied that the question can deliver the objectives of content and language validity.
- The score is –1 when the expert was confident that the question cannot deliver the objectives of content and language validity.
- The score is 0 when the expert was doubtful that the question can or cannot deliver the objectives of content and language validity.

Moreover, the experts were asked to recommend how to improve the questions they were not satisfied with (Table 3.3).

Then, the IOC index was calculated. The IOC index is the average score of total expert scores for each question. For questions to qualify as satisfactory, they had to gain IOC index score of more than 0.5 (Table 3.3).

Table 3.3 IOC Index and results of experts' reviews for the second draft questionnaire

Factors	Experts' Scores					Issues/ recommendations	IOC Index
	1	2	3	4	5		
Part 1: Introduction of the study	1	1	1	1	1	-	1.0
Part 2: Personal demographic data							
· Highest level of acquired educational qualification	1	1	1	1	1	-	1.0
· Age	1	1	1	1	1	-	1.0
· Gender	1	1	1	1	1	-	1.0
· Monthly income level	1	1	1	1	1	-	1.0
Part 3: Switching behaviour factors and switching intention							
Perceived price of new auto-products compared with like-new remanufactured alternatives							
• New auto-products are **expensive** than like-new remanufactured auto-products.	1	1	1	1	1	-	1.0
• New auto-products do not provide more **valuable** for money than like-new remanufactured auto-products.	1	0	1	1	1	Valuable is similar to worthy	0.8
• New auto-products are not more **reasonably priced** than like-new remanufactured auto-products.	1	1	1	1	1	-	1.0
• Other more expensive auto-products are not more **worthy** than like-new remanufactured alternatives.	1	0	1	1	1	Worthy is similar to valuable	0.8
• New auto-products are not more **economical** than like-new remanufactured auto-products.	1	1	1	1	1	-	1.0
Perceived environmental benefits of like-new remanufactured auto-products compared with new alternatives							
• Switching to a like-new remanufactured auto-product will help **save finite resources**	1	1	1	1	1	-	1.0
• Switching to a like-new remanufactured auto-product will help increase use **more reusable/recyclable resources**	1	1	1	1	1	-	1.0
• Switching to a like-new remanufactured auto-product will cause **minimise landfill** waste pollution	1	1	1	1	1	-	1.0

Factors	Experts' Scores					Issues/ recommendations	IOC Index
	1	2	3	4	5		
• Switching to a like-new remanufactured auto-product will **minimize negative effects** on natural ecosystems	1	1	1	1	1	-	1.0
Consumers' attitudes towards like-new remanufactured auto-products							
• I have a **bad experience** with using like-new remanufactured auto-products	1	1	1	-1	1	Concern with consumers who have had no experience	0.6
• I feel that like-new remanufactured auto-products are **second-hand products**	1	1	1	1	1	-	1.0
• I feel that like-new remanufactured auto-products are **defective products**	1	1	1	1	1	-	1.0
• I do not rely on remanufacturing process and **careless for the standard** of like-new remanufactured auto-products even if they are the same or better than new alternatives	1	1	1	1	1	-	1.0
Perceived filling of obsoleteness to like-new remanufactured auto-products compared with new alternatives							
• Like-new remanufactured auto-products will become **old-fashioned** too soon	1	1	1	1	1	-	1.0
• Like-new remanufactured auto-products do not inspire **confidence of newness** (at least their core components)	1	1	1	1	1	-	1.0
• Like-new remanufactured auto-products are without **exiting functionality** which new products can give	1	1	1	1	1	-	1.0
• Like-new remanufactured auto-products are **not available** via general retail channels	-1	1	1	1	1	Unavailable is not obsoleteness	0.6
• The **price advantage** like-new remanufactured auto-products have over new products is attractive	-1	-1	1	-1	1	Duplicate with price factor	-0.2
• Like-new remanufactured auto-products involve **high maintenance** compared with new alternatives	1	1	1	1	1	-	1.0
Perception of special benefits/promotions with respect to like-new remanufactured auto-products compared with new alternatives							
• Like-new remanufactured auto-products offer **longer warranties** than new alternatives	1	1	1	1	1	-	1.0
• Like-new remanufactured auto-products offer **more durable materials** than new alternatives	1	1	1	1	1	-	1.0

Factors	Experts' Scores					Issues/ recommendations	IOC Index
	1	2	3	4	5		
• Like-new remanufactured auto-products offer **new upgrading technology** than new alternatives	1	1	1	1	1	-	1.0
• Like-new remanufactured auto-products offer **more features/functions** than new alternatives	1	1	1	1	1	-	1.0
• Like-new remanufactured auto-products offer **better services** than new alternatives	1	1	1	1	1	Close relationship is a significant benefit of remanufacturing	1.0
Part 4: Switching Intention factor The **switching intention** for like-new remanufactured auto-products							
• I am **considering** switching from a new auto-part to a like-new remanufactured auto-part	1	1	1	1	1	-	1.0
• The **prospect of switching** to like-new remanufactured auto-parts is high	1	1	1	1	1	-	1.0
• I **willing to switch** to buy a like-new remanufactured auto-part	1	1	1	1	1	-	1.0
• I would **recommend** like-new remanufactured auto-parts to friends and relatives	1	1	1	1	1	-	1.0
"You may consider switching your selection to the like-new (or better than new) remanufactured auto-products, if the prices of the remanufactured auto-products are cheaper than new auto-alternatives." According to the statement, at what point of price differential would you decide to switch to like-new remanufactured auto-products?	1	1	1	1	1	-	1.0
Which strategy has the most potential encouraging you to be willing to return your end-of-used auto-products promptly when you do not need them anymore?	1	1	1	1	1	-	1.0

Where: 1 refers to satisfied, -1 refers to unsatisfied, 0 refers to unsure

Following expert review of the questionnaire for content and language validity, the questionnaire was revised as follows. First, the questions with IOC index less than 0.5 were disqualified. This relates to the question on “perception of obsoleteness” in part 3 of the questionnaire. This is the question about the price advantage that ‘like-new’ remanufactured auto-products have over new products. Second, one question was added under the topic of “Perception of special benefits/promotions” in part 3 of the questionnaire. That relates to the question about ‘like-new remanufactured auto-products offering better services than new manufactured alternatives’.

3.5.6 Pilot testing

Before conducting the survey, the questionnaire was pilot-tested on 30 respondents. The purpose of the pilot test is to ensure that the questions asked are clear and transparent, so that administration of the questionnaire during the course of the survey would be effective.

3.5.7 Reliability testing

“Reliability is concerned with the ability of a research instrument to measure consistently” (Tavakol & Dennick, 2011). The validity test discussed above does not, however, confirm reliability of the questionnaire. According to Tavakol & Dennick (2011), a research instrument, questionnaire included, cannot be valid if it is not reliable. Still, the reliability of a research instrument does not depend on its validity (Cohen, 2010). Therefore, tests for both the validity and reliability for the questionnaire were conducted.

The tool used to measure the reliability of the questionnaire in this study is the Cronbach Alpha Coefficient (α) test. The Cronbach alpha (α) coefficient, developed by Lee Cronbach in 1951, is widely used to measure reliability in terms of internal consistency. The test is most generally used when multiple Likert-scale questions are used in a survey (Laerd Statistics, 2018). Internal consistency explains whether all the items or questions in a test measure the same thing, concept, or construct. The coefficient is calculated based on connection or the inter-relatedness of each pair of items (questions) in the questionnaire (Tavakol & Dennick, 2011).

The formula to calculate Cronbach's alpha is:

$$\propto = \frac{N \cdot \bar{C}}{\bar{V} + (N-1) \cdot \bar{C}} \qquad (4)$$

Where:

N refers to the number of items (questions),

$\bar{C}$ refers to the average internal covariance among the item-pairs, and

$\bar{V}$ refers to the average variance.

The coefficient ranges from 0 to 1. The reliability estimation shows the magnitude of measurement error in a test (questionnaire). That is, the alpha coefficient is used to derive the index measurement error by squaring the correlation coefficient and deducting the product from one. For instance, if a test has a reliability (or Cronbach's Alpha Coefficient) of 0.71, the index measurement error or error variance of the test will be 0.4959 – i.e. (0.71x0.71 = 0.5041; 1.00 – 0.5041 = 0.4959). If the alpha-coefficient score of reliability increases, it means that the measurement error of the test will decrease (Tavakol & Dennick, 2011). Therefore, the acceptable value of the reliability score, i.e. the internal consistency score, or Cronbach's Alpha coefficient (α), is more than 0.7. If the measurement error of the test is less than 0.5, this will make the test acceptable.

Furthermore, the level of thresholds of Cronbach's Alpha (α) can be divided into six levels as follows (Stephanie Glen, 2014b):

- If $0.9 \le \alpha$, the internal correlation of the test is Excellent
- If $0.8 \le \alpha < 0.9$, the internal correlation of the test is Good
- If $0.7 \le \alpha < 0.8$, the internal correlation of the test is Acceptable
- If $0.6 \le \alpha < 0.7$, the internal correlation of the test is Questionable
- If $0.5 \le \alpha < 0.6$, the internal correlation of the test is Poor
- If $\alpha < 0.5$, the internal correlation of the test is Unacceptable

In this study, the reliability scores or Cronbach's Alpha were calculated for all factors. This is in order to show that all questions or indicators of each factor are measuring the same purpose. The Cronbach's alpha scores were calculated using the programme of Statistical Package for the Social Sciences (SPSS Statistics) 25.0, as shown in Table 3.4 and Table 3.5.

Table 3.4 Reliability Statistics measured by Cronbach's Alpha

Factors	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items (questions)
P_N	0.692	0.734	5
SB_R	0.734	0.725	5
EB_R	0.815	0.837	4
PA_R	0.724	0.724	4
OR_R	0.669	0.638	5
SI	0.915	0.917	4

Source: Calculated using the SPSS Statistical software programme

According to in Table 3.4, almost all reliability coefficients (Cronbach's Alpha) are at acceptable levels. That is, the Cronbach's Alpha coefficients of the factors SB_R, EB_R, PA_R, and SI are 0.734, 0.815, 0.724, and 0.915 respectively. That means the reliability status for them are acceptable, good, acceptable and excellent, respectively. However, the reliability status for P_N and OR_R is questionable at 0.692 and 0.669 respectively. So, based on this test, some questions relating to the factors P_N, and OR_R have had to be removed.

Table 3.5 Item-Total Statistics of the Factor P and OR

Items, Questions, Indicators	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Price (P_N)					
P1Expensiveness	14.83	3.178	0.599	0.421	0.598
P2Value-for-money	15.60	2.938	0.259	0.076	0.771
P3Reasonableness	15.00	2.759	0.627	0.573	0.561
P4Worthiness	15.07	3.030	0.590	0.539	0.590
P5Economical	14.97	3.482	0.334	0.165	0.685

Items, Questions, Indicators	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Obsolescence Risk (OR$_R$)					
OR1Obsolescence	13.73	3.926	0.659	0.638	0.489
OR2LackingNewness	13.40	4.317	0.524	0.573	0.566
OR3Dysfunction	13.90	4.576	0.491	0.283	0.584
OR4Unavailability	12.90	6.507	0.095	0.204	0.722
OR5High-maintenance	13.53	5.223	0.332	0.324	0.657

Source: calculated by the programme of SPSS Statistics

Table 3.5 presents the Cronbach's alpha value of the factors P and OR when particular questions or indicators are removed. By removing the question relating to the indicator 'P2In-valuableness' (P2Value-for-money) (i.e. New auto-products do not offer more value for money than 'like-new' remanufactured auto-products), the Cronbach's alpha coefficient of the factor P was raised from 0.692 to an acceptable level 0.771. In the same way, by removing the question relating to 'OR4Unavailability' (i.e. 'Like-new' remanufactured auto-products are not available via general retail channels), the reliability level of the factor OR$_R$ was improved from 0.669 to 0.722.

So, the questionnaire design process was, as discussed above, played out through stages based on the five steps for developing an effective questionnaire created by Rama Radhakrishna (2007). These included the processes of research background development, questionnaire conceptualization, structure and data analysis planning, and validity and reliability testing. Validity was tested by experts, and reliability, by using the Cronbach Alpha statistic. The questionnaire was then tried out on a sample of 30 individuals who are in the same targeted group of the primary participants.

In the course of its development, the questionnaire was monitored by the research supervisor, nominated as Principal Investigators (PIs); and was granted ethical clearance by the ethics administration of the University of Strathclyde. Copy of the questionnaire used to survey the switching behaviour of customers of automotive product is shown in Appendix B.

3.6 The Sample Survey

The survey based on administration of questionnaires was conducted in Thailand from November 2018 to January 2019. The sample of population to be surveyed was randomly selected based on a non-probability convenience-sampling technique. The survey was both online and paper-based, aimed to cover automotive customers, including end-users (remanufactured vehicles), and possibly also those using auto-parts, such as garage operators.

The targeted number of questionnaires were calculated based on the formula for proportions developed by Yamane (1967) as shown in the equation (5):

$$n = \frac{N}{1+Ne^2} \qquad (5)$$

Where:

n represents sample size;

N represents population size; and

e represents the level of allowable error.

Thus, according to the formula above, the prospected participation is expected to cover 381 respondents of automotive customers in Thailand. In fact, the number is calculated based on the number of average sales of passenger cars (vehicles) per month in 2018 in Thailand, which 45,410 units (Bank of Thailand: BoT, 2019).

The survey targeted only customers of automotive products in Thailand who are considering to purchase automotive products during the survey period. The questionnaires were therefore mainly distributed at 'The 35th Thailand International Motor Expo 2018'. The Motor Expo is the biggest trade fair of automotive products in Thailand which is held once a year. In 2018, the event was held from 29th November to 10th December 2018 at Impact Exhibition Centre, Muang Thong Thani, Nonthaburi, Thailand. The main objective of the event was to bring together product suppliers and customers in Thailand which is a big chain of auto supply with 160 nationwide automotive stores in Thailand.

Although the targeted number of respondents to be covered in the survey was 381, a sample of 401 Thai customers of automotive products participated in the process. However, after cleaning ineffective responses, 342 responses (n=342) were used as basis for data analysis. Of this total, 209 were online respondents to the questionnaire that was administered electronically by using the Qualtrics online survey. The rest, including 133 respondents, participated through paper-based questionnaires. After cleaning ineffective responses by discarding incomplete questionnaires (significant questions and/or too many questions were not completed) and extreme outliers, 342 responses (n=342) were used in the data analysis.

The survey data relating to the personal features of respondents reflect on three aspects of the automotive market in Thailand. Firstly, there was no gender bias. That is, about 52 per cent of the randomly selected respondents were males, which is not significantly different from the proportion of females (about 48 per cent). The age profile of all respondents ranges from 21 to 69. This means that all respondents were in the age range that would be legally entitled to be car owners and to have a driving licenses in Thailand. The largest group of respondents was in the 31-40 years old cohort.

More than four-fifths of the respondents are graduates with tertiary level education. Their average monthly income was approximately £917.50 (36,700 baht), which is higher than the £489.61 per month Thai income per capita in 2019 (World Bank, 2019). According to some previous studies, the demand for personal automobiles, especially in developing countries, is a function of income (Ecola, Rohr, Zmud, Kuhnimhof, & Phleps, 2014; Vasconcellos, 1997). Also, income elasticity of demand for personal auto-mobility is more than one (Fouquet, 2012). That is: at higher income levels, personal ownership of automobiles is expected to grow at a rate higher than the rate of growth of income.

3.7 Methods of Data Analysis

The quantitative research method is used in complement with the qualitative method for analysis of the survey data that is largely of quantitative nature. The quantitative method involves use of statistical models for testing hypotheses. In view of the nature of the survey data, the quantitative method is used in this study in two forms: descriptive statistical and inferential statistical methods.

The descriptive statistical method is used to describe, show and summarise the relationships, differences and similarities of the collected data on the various variables and to compare and contrast the correlation of variables. The quanitative method is expected to suggest the level of perceived discount rate that would trigger the willingness to switch from a new automotive product to ‘like new’ remanufactured alternatives.

The inferential statistical method is applied to the survey data to explore the efficacy of the Push-Pull-Mooring (PPM) migration model and to make generalisations through the estimation of parameters and the statistical testing of hypotheses. Estimation of parameters is intended to reflect on the significance of factors that determine the switching behaviour of individuals in favour of remanufactured auto-products. The inferential statistical method was conducted by using the technique of structural equation modelling (SEM).

3.7.1 Structural Equation Model (SEM)

Structural equation modelling (SEM) is considered to be more suitable and robust than multiple linear regression analysis, because of the ability of the PPM theory to address complex behavioural traits chiefly arising from the impact of the moderating variables embedded in the mooring factors, which can significantly affect the robustness and direction of the correlation between dependent and independent variables. The SEM was selected to analyse the survey data, showing in quantitative terms the impacts of the moderating variables, which are a kind of latent variables; and the relevance of the PPM model to the issue of the switching behaviour of customers of automotive products.

SEM: Capturing the effects of Latent Variables

The traditional techniques, like multiple regression analysis, are not capable of producing robust estimates of the parameters of the proposed PPM model because of the effects of the latent variables (SAS Institute Inc, 2015). The latent variables are variables which cannot be directly observed, measured or scored, but can be inferred from other observed variables through the application of a mathematical model (Bollen, 2002). Latent variables are also known as hidden or unobserved variables (Jeff Sauro, 2016).

Many studies (Astrachan, Patel, & Wanzenried, 2014; Bollen, 2002; He, He, Yang, & Zhao, 2011) have found that latent variables play an essential role in the process of customers' decision-making. Such latent variables include personal attitudes; personal preferences; and experiences of individuals (He et al., 2011; Johansson, Heldt, & Johansson, 2006; Prato et al., 2012). The 'mooring' factors that occur as moderating variables in the PPM migration model are the latent variables interfering with the direct effects of 'push' and 'pull' factors, thereby impacting the switching behaviour of customers.

Two significant component techniques used to deal with the measurement errors owing to latent variables are dimension reduction and predictive modelling techniques. The dimension reduction technique assesses correlation based on the relationships between variables. A widely used method for dimension reduction is factor analysis. The predictive modelling technique is a technique used to estimate variables by likelihood (Bock, n.d.). SEM is a hybrid of factor analysis (a dimension reduction technique) and econometric regression analysis (a predictive modelling technique). SEM is thus an advanced statistical technique that calculates the inter-correlations or covariances between observed variables to mathematically infer (by probability) the existence and relationship of latent variables (Bock, n.d.; Jeff Sauro, 2016). SEM is also referred to as covariance structure modelling or covariance structure analysis. SEM is also able to serve as mean structure modelling (Garson, 2015).

Not only does SEM utilise the factor analysis technique to mitigate the measurement error; it also can display complex causal paths taken by the mediating or moderating variables; and can test models with multiple dependent variables. This means that SEM outperforms the method of multiple regression analysis based especially on ordinary least squares (OLS), which estimates the dependent variable with a function of the sum effects (Garson, 2015).

3.7.2 Relevance of SEM for testing PPM

SEM is often selected to verify whether a research model with theoretical underpinning is consistent with empirical data (Garson, 2015). In comparison with multiple regression analysis, SEM can test overall models rather than coefficients individually. Moreover, SEM is more attractive for being able to test models by using a graphical modelling interface in the form of a structural model to show causal relationships (Garson, 2015). SEM analysis is processed in two steps: the measurement model testing, and testing of the structural model.

The first testing step is handled by using the technique of “confirmatory factor analysis” (CFA). The process is aimed to confirm the measurement of latent variables in the proposed model. If SEM analysis shows a good fit between latent variables and their specified indication variables, this would verify two aspects of the proposed research model – i.e. PPM. Firstly, this good fit indicates that the indication variables in the proposed model can properly reflect the effects of the latent variables. Also, the good fit means that the latent variables are different from each other in the model. In all this, the CFA process is the technique used to verify convergent and divergent validity in the proposed research model (Garson, 2015).

The second step in SEM analysis is, as noted above, structural model testing. This involves measurement of the latent variables and the paths and co-variances connecting them (Garson, 2015).

To test the proposed structural model, the survey data is put through the statistical packages for Social Sciences (SPSS Statistics) 25.0 and Analysis of MOment Structure (AMOS) 25 .0. Investigation of the factors determining the switching intention of customers of automotive products, and the efficiency of the proposed conceptual model based on PPM theory in relation to the case of ‘like new’ remanufactured auto-products, involved the following two procedures discussed below.

3.7.3 Testing the proposed hypotheses against empirical data

The procedures for testing the proposed hypotheses are graphically presented in Figure 4.5. First, the SEM method examines the factors determining the decision of customers to switch to 'like new' remanufactured auto-products. After the CFA test, confirming that indicator variables could reasonably measure latent variables statistically, the empirical covariance matrix (S) was created from the observed (collected) data. Subsequently, the SPSS programmes estimated the parameters ($\hat{\beta}$) specified in the proposed structural model. The parameters were then calculated to create an implied covariance matrix (∑). The estimated parameters ($\hat{\beta}$) of a structural model are generated by minimising the discrepancy between the sample covariance matrix (S) and the implied covariance matrix (∑) (Bian, 2012). That is *min f (∑, S)*.

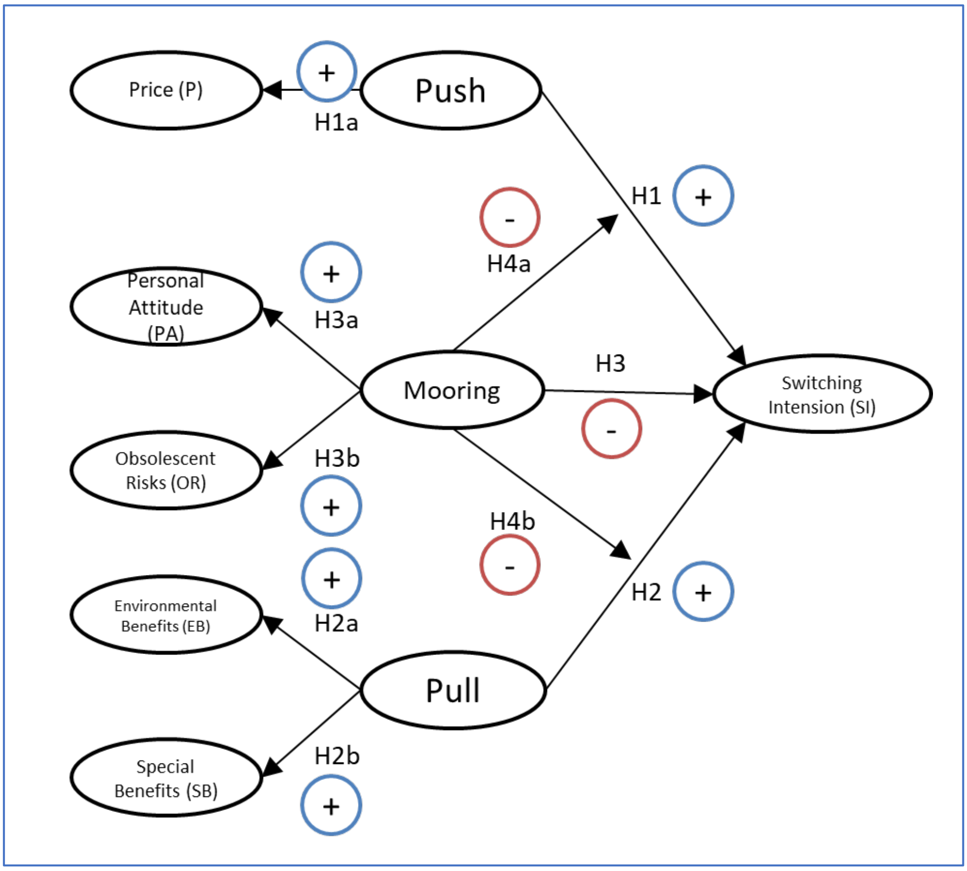

Figure 3.6 Proposed Hypotheses of relationships between variables in Path Analysis Model of the Research Framework

The investigation to find out the significant factors determining the decision of customers to switch to 'like new' remanufactured auto-products involved the following:

- Testing the proposed hypotheses of relationships between switching intentions and selected potential determinants against the evidence borne out by the survey data produces estimates of parameters ($\hat{\beta}_i$) within the SEM framework. Is the sign of the estimated parameters ($\hat{\beta}_i$) the same as that specified in the proposed-hypotheses (H_i)? For instance, H1 and H2 were hypothesised as having positive effect on the switching intention of auto-customers. The expectation is, therefore, for the estimated coefficients, $\hat{\beta}_1$ and $\hat{\beta}_2$, to be positive (+). Similarly, with H_3 and H_4, and all the other sub-hypotheses (Figure 4.5).

- $\hat{\beta}_{1a}\hat{\beta}_{2a}\hat{\beta}_{2b}\hat{\beta}_{3}\hat{\beta}_{4a}\hat{\beta}_{4b}\hat{\beta}_{3a}\hat{\beta}_{3b}$, represent estimates of the parameters of potential determinants (P, PA, EB, SB, PA and OR), with p-value test for each estimated parameter ($\hat{\beta}_i$). Thus:
  - If the p-value is less than 0.001 (***p<0.001), the specified relationship will be statistically significant within the 99.99% confidence interval.
  - If the p-value is between 0.001 and 0.01 (**p<0.01), the specified relationship will be statistically significant within the 99% confidence interval.
  - If the p-value is between 0.01 and 0.05 (*p<0.05), the specified relationship will be statistically significant within the 95% confidence interval.
  - If the p-value is more than 0.05, the specified relationship will be statistically insignificant at the 5 per cent level.

3.7.4 Usefulness of SEM for testing effectiveness of PPM theory to explain switching behaviour of Customers

As noted above, the application of SEM is important insofar as it helps to bring out the effectiveness of the proposed conceptual model based on the PPM theory to explain the switching behaviour of customers towards 'like new' remanufactured auto-products.

Given the sample covariance matrix (S) and the implied covariance matrix (∑), which are both calculated by the SPSS programmes, the proposed structural equation model is tested by examining the difference between the two matrices. If the difference between these matrices is small, the proposed model is considered robust enough to fit the empirical data. This represents the null hypothesis (H0) to be tested. On the other hand, if the difference is large, the proposed model is not compatible with the observed data; and the model is, therefore, not empirically robust. However, for such a case to happen, it is not necessarily the proposed model that is at fault; the quality of the collected data can also be far from robust with the result that the measurement of goodness of fit can be at odds with the theoretical expectation of the proposed hypotheses. In the testing process, this represents the position of the alternative hypothesis (H1), where the proposed structural model does not fit the sample data, and where, therefore, the sample covariance matrix (∑) is significantly different from the implied covariance matrix (S). (∑ ≠ S).

The statistical indexes used to measure the goodness-of-fit of the proposed structural model to the sample data (to accept H0 and reject H1) comprise three absolute fit indexes (Hooper, Coughlan, Mullen, & Hooper, 2008). These indexes include CMIN/DF, RMSEA , GFI and AGFI.

- *CMIN/DF ($\chi 2$/df): the ratio of chi-square to the degrees of freedom or the minimum discrepancy divided by its degrees of freedom*: The index should be close to one for the best fit of the structural model to the sample data. This study adopted a threshold of ratios less than two (CMIN/DF < 2) to signify a reasonable fit (Byrne, 1989; Marsh & Hocevar, 1985).
- *The Root mean square error of approximation (RMSEA: $\sqrt{max\,\{[\chi 2 - df] \,/\, [(N - 1) \cdot df]\,, 0\}}$):* The RMSEA index, initiated by Steiger and Lind (1980) and J.H. Steiger & Lind (1980), is an index of the size of the standardised residual correlations. It measures the goodness of fit of a structural model to the sample data. Less error of parameter estimation means more accuracy of the implied covariance matrix. This, in turn, would be more likely to fit the empirical covariance matrix (Hooper et al., 2008). The index ranges from zero (perfect fit) to a positive value (poor fit) (Schumacker & Lomax, 2010). However, there is a degree of arbitrariness in setting the upper level beyond which the goodness of fit fails to be robust, although in many cases, the acceptable level is set at 0.05 (Browne & Cudeck, 1992; Schumacker & Lomax, 2010), 0.07 (James H. Steiger, 2007) or 0.08 (Maccallum, Browne, & Sugawara, 1996). Accordingly, this study adopted a baseline of the RMSEA value not more than 0.05 (RMSEA

< 0.05) to indicate an acceptable level of fit (Browne & Cudeck, 1992; Marsh & Hocevar, 1985; Schumacker & Lomax, 2010).

- *Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index (AGFI):* GFI, $(1 - [\,\chi^2_{model} \,/\, \chi^2_{null}\,])$, is the proportion of variance that is accounted by the estimated population covariance to measure the extent the estimated model can duplicate the observed covariance matrix. In other words, in a multiple regression model, the GFI, represented by the R-squared [17] (R^2) statistic, indicates the discrepancy in the evaluation of the variance-covariance model. However, the efficiency of GFI deceases as the degree of freedom increases. As a result, AGFI ($1 - \{[\,\chi^2_{model}/\,df_{model}\,]\,/\,[\,\chi^2_{model}/\,df_{null}]\}$) was created by adjusting the GFI with degree of freedom. Both GFI and AGFI indexes range from zero (no fit) to one (perfect fit) (Schumacker & Lomax, 2010). Traditionally, when the values of GFI and AGFI are less than 0.90, these values are not considered acceptable enough to signify robustness in the goodness of fit of the models subject to test (Hooper et al., 2008). However, both GFI and AGFI have still a systematic problem of values varying as sample sizes vary (Bollen, 1990; MacCallum & Hong, 1997; Shevlin & Miles, 1998). For this reason, they should be used together with other indexes such as RMSEA index to enhance reliability (Hooper et al., 2008; MacCallum & Hong, 1997).

[17] R-squared (R2) is useful to test goodness of fit for a regression model. It is the proportion of the variances to measure how much extent that the variance of independent variables in a regression model can explain the variance of the dependent variable in the model.

3.8 Conclusion

The aim of this study is to investigate the research question: what would it take for customers of automotive products to switch from new auto-products manufactured, based on linear economy business model, to 'like new' remanufactured auto-products, based on circular economy business model? Addressing this question involved empirical analysis of the factors that bear on producers and customers in the course of deciding whether or not to support 'like new' remanufactured auto-products.

The study thus designs an empirical analysis framework analysing secondary data collected and organised by Chaowanapong et al. (2017) to investigate important factors influencing behaviour of automotive producers in Thailand to conduct remanufacturing businesses. Also, the study focuses on the demand side of the remanufacturing activity, based on the economic principle that the existence of a strong demand can bring forth supply in the market; and that conceptually, it would be wrong to assume that supply would create its own demand. The Push-Pull-Mooring (PPM) Migration Theory is proposed as the conceptual analytical framework to analyse the switching behaviour of customers of automotive products.

The PPM theory of migration explains that consumers' switching behaviour is decided by their switching intentions. And changes in switching intentions result from the interactions of three forces: 'push', 'pull' and 'mooring' forces, via direct and moderating effects.

'Push' factors force customers to migrate or switch their customs from new manufactured auto-products (the production of which is based on linear economy business model) to 'like new' remanufactured auto-products (whose production is based on circular economy business model). The 'push effect' on customers to switch to remanufactured auto-products is due to the price disadvantage of new manufactured auto-products in relation to 'like new' remanufactured auto-products (P_N). The 'pull effect' on customers is due to the advantages offered by remanufactured auto-products, like the environmental benefits of remanufactured auto-products (EB_R); and the special benefits of remanufactured auto-products (SB_R) occur in the form of longer warranty, durability, robustness and functionality. The 'mooring effect' on customers' decisions to switch to 'like new' remanufactured auto-products operates as a moderating influence on 'push' and 'pull' factors. This has the effect of influencing customers to delay consumers' intention to switch to remanufactured auto-products or not to switch at all. As such, the 'mooring effect' in the analytical model works through customers' personal attitudes, especially their misconception regarding the quality and robustness of 'like new' auto-remanufactured products (PA_R); and the perceived obsolescence risk and other risks customers often attribute to 'like new' remanufactured auto-products (OR_R).

The research question was investigated through a questionnaire-based survey, covering randomly sampled potential customers of automotive products based on a non-probability convenience-sampling technique. The survey was conducted in Thailand from October 2018 to January 2019. Although a sample size of 401 customers of automotive products was targeted, the actual sample size used as basis for the empirical study is 342 (n=342).

Analysis of the survey data is proposed to be conducted using the conceptual analytical model based on the PPM theoretical framework, and the structural equation model (SEM). The SEM process in this study is conducted in two stages. The first stage involves model testing to verify the capacity of observable indicators to measure unobservable factors in the proposed conceptual framework. This process is facilitated by the technique of confirmatory factor analysis (CFA), consisting of communality testing and Eigenvalue scree plot. The second step of the SEM procedure involves testing of the structural model. The procedure measures the relationships between dependent and independent variables in the proposed conceptual model. The results deriving from this process include the estimated coefficients ($\hat{\beta}$) and the statistical p-values of these estimates. The estimates can help identify the significant factors influencing the switching behaviour of customers in favour of remanufactured auto-products. Furthermore, the proposed conceptual analytical model based on the PPM theoretical framework will be tested to measure its efficacy to explain the switching behaviour of individuals towards the adoption of 'like new' remanufactured auto-products.

The methodology discussed in this chapter is carefully designed to address the research question of the study and to test the set of hypotheses arising from it. But it is not without limitations, as it focuses on the demand-side of the remanufacturing market, on the assumption that remanufacturers would respond to trends in customers' switching behaviour between new manufactured auto-products and 'like new' remanufactured auto-products. However, a complete study of the transition of the sector to circular business model would also need to engage in a thorough empirical investigation of the constraints on the supply side of the transition scheme. This is particularly important since no such study has been conducted to date in the context of Thailand.

However, time and budget constraints on administration of the fieldwork survey have, as mentioned above, limited this study to the demand side of the transition problem. But even when limited to analysis of the demand side of the circular business model, the proposed study is not without problems. For instance, automotive products are heterogeneous as between intermediate auto-parts and end-use auto-products; and even within these two demand categories, there is a wide range of product differentiation. However, for practical reasons, auto-products are considered in this study in generic terms. Also, customers of auto-products are varied – i.e. those like motor garages and SMEs who would use auto-products to cover their intermediate demand, and those like individuals and households who would use auto-products as consumer durables. However, the sample, though big in size, does not stratify respondents according to their specific demand for auto-products as intermediate capital goods and consumer durables and according to the technical specifications of automotive products. A larger study with a larger research budget is required for this. Moreover, future studies could survey remanufacturing businesses to determine empirically their market and technological responses to the switching behaviour of customers between new manufactured auto-products and 'like new' remanufactured auto-products.

Chapter 4

Background to transition of the case study of the automotive sector in Thailand to circular economy through remanufacturing

4.1 Introduction

This chapter examines the current state of the automotive sector in Thailand, its significance for the economy, and the scope for remanufacturing in the sector as the way forward to transition to circular economy.

During the last six decades, Thailand has gone through the implementation of eleven National Economic and Social Development Plans (NESDPs); and its economy has evolved, with the dominance of agricultural activities giving way to growth in industrial and manufacturing activities, and progress in science and technology that provide the basis for the development of knowledge economy. During this period, policy has provided resources for the development of infrastructure, import substituting industrialisation; and institutional mechanisms for the development of innovation systems and technological progress.

It is within this planning and policy framework that the automotive sector was established in Thailand, which has since played a strategic role as the engine of industrialisation and economic growth. However, the industrialisation system that evolved in Thailand over the years raises questions of sustainability, as it is based on the 'make-use-dispose' linear economic model. The unsustainability of industrialisation against the background of slow technological progress has resulted not only in low productivity growth (see Appendix A) but also in the excessive extraction for production of finite primary or green material and energy resources and the subsequent reduction of these into waste spinning off into environmental pollution (Aroonsrimorakot & Akaraj, 2010). In the circumstances, what is needed is for policy to put less and less emphasis on of the traditional linear system of industrialisation and economic growth and look into options for the development of knowledge-based economy largely through investment in R&D and STI, and so enhance the long-term transition of Thailand to circular economy, with the remanufacturing of automotive products as a strategic point of entry.

The aim of this chapter is to set in context the issue of transition of the automotive sector in Thailand through the development of remanufacturing activities. The remainder of the chapter is in four parts. In the part following this introduction, the state of the automotive manufacturing in Thailand is discussed. The third part highlights some of the challenges of sustainability facing the sector. In the fourth part, the scope for the development of circular economy in the industry is discussed. The fifth part presents the results of the supply-side study based on an analysis of secondary data to investigate factor influencing automotive manufacturers in Thailand to conduct remanufacturing auto-businesses. The sixth part is the part of perspectives of the Thai government to a CE transition. The final part presents conclusion of the chapter.

4.2 The State of Automotive Manufacturing in Thailand

The automotive industry is a significant sector of Thailand's economy. It is associated with many economic activities not only in the automotive manufacturing, but also in other industries and services (Thailand Automotive Institute: TAI, 2014). Considering only the automotive manufacturing sector, the value-added of automotive industry in Thailand in 2018 was 379,432 million baht (around £9.5 billion), accounting for 8.67 per cent of Thailand's GDP from manufacturing (Figure 4.1). The value-added of the Thai automotive manufacturing has been on an increasing trend since 1990 as shown in Figure 4.1. It grew from below 30,000 million baht (around £0.7 billion) in 1998 to 397,432 million baht (around £9.5 billion) in 2018. This amounts to a compound annual growth rate (CAGR) of 8.65 per cent per year.

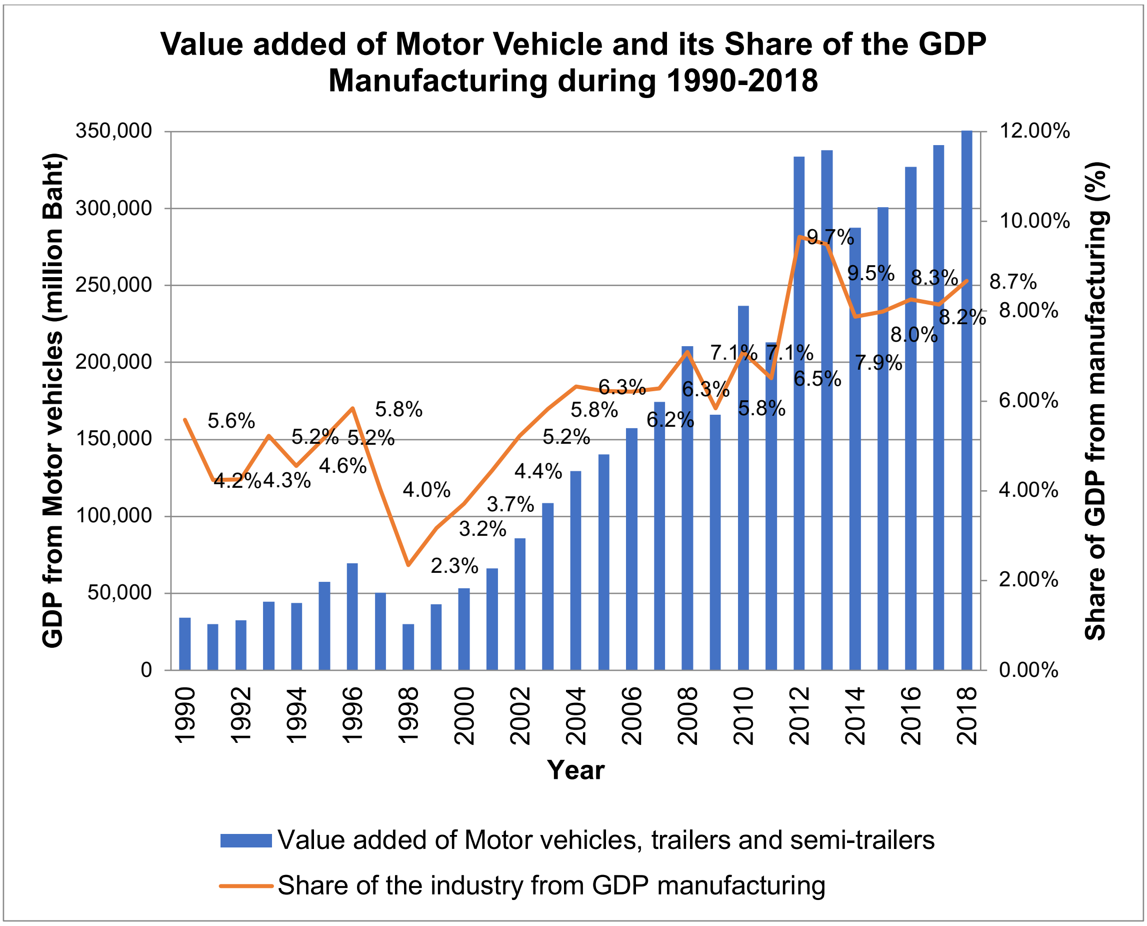

Figure 4.1 Value added of Motor Vehicle and its Share of the GDP Manufacturing during 1990-2018 (National Economic and Social Development Council: NESDC, 2020)

Thailand is also one of the major motor-vehicle producers in the world. In 2019, Thailand's motor-vehicle production was 2.01 million units. On this record, it ranked eleventh on the world motor-vehicle production league, and top among countries in the Southeast Asia region (International Organization of Motor Vehicle Manufacturers: OICA, 2020). The level of output in 1998 was 158,130 units. The compound annual growth rate (CAGR) over the 21 years after 1998 is 12.88 per cent per year.

The number of firms in the Thai automotive industry in 2014 was 1,617 companies, employing approximately 525,000 workers (Thailand Automotive Institute: TAI, 2014) as shown in Figure 4.2.

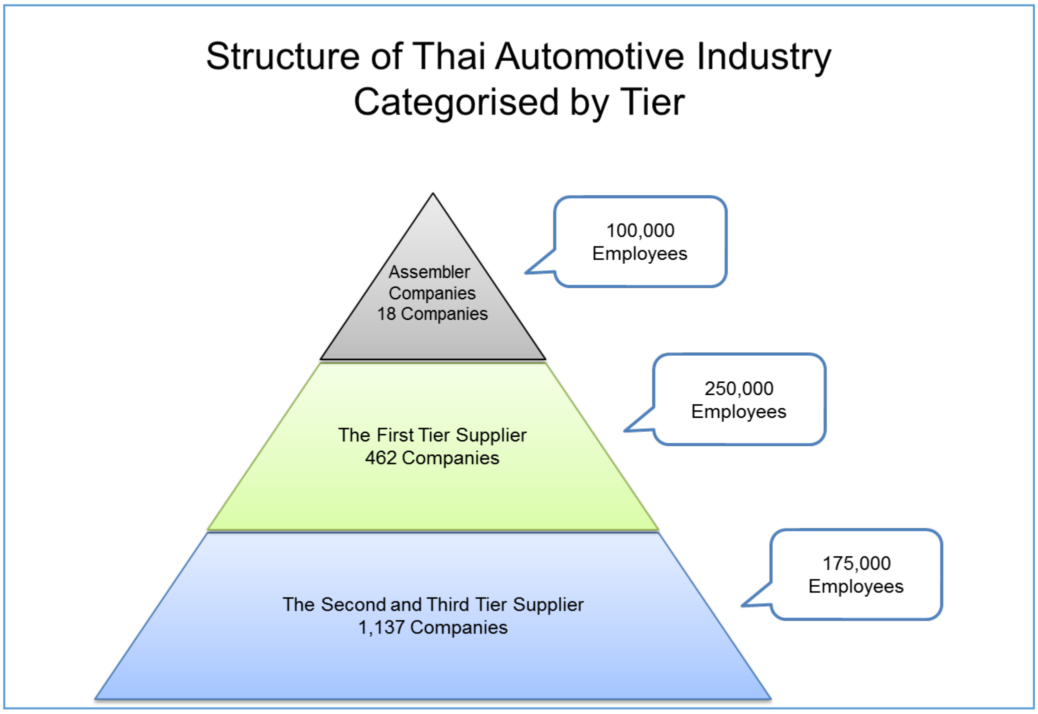

Figure 4.2 Structure of Thai Automotive Industry categorised by Tier and Employment (Thailand Automotive Institute: TAI, 2014)

4.3 Unsustainable Problems of Thailand's Automotive Industry

Two major aspects of the automotive industry in Thailand are that it is dominated by foreign investment and that its operation is largely based on the traditional linear business model that has precipitated the problem of end-of-life vehicle (ELV) pollution. These are discussed below.

4.3.1 Dependency of Thailand's automotive industry on foreign investment

The Thai automotive industry is dominated by multinational corporations (MNCs). According to Thailand Automotive Institute (2014), there are 1,599 auto-part supplier companies. These can be divided into three groups: large enterprises including 980 companies (or 61 per cent of the total auto-part firms); medium size enterprises including 310 firms (or 20 per cent of the total auto-part firms); and 309 small enterprises which constitute 19 per cent of the total number of auto-part (Figure 4.3).

Most of the large-scale enterprises (980 firms or 62 per cent of the large scale companies) are owned and controlled by foreigners, while most of the firms owned by Thai nationals are small and medium enterprises. On the other hand, Thai owners control about 63 per cent of the 310 medium enterprises 87 per cent of the 309 small enterprises are managed by Thai nationals as shown in Figure 4.3.

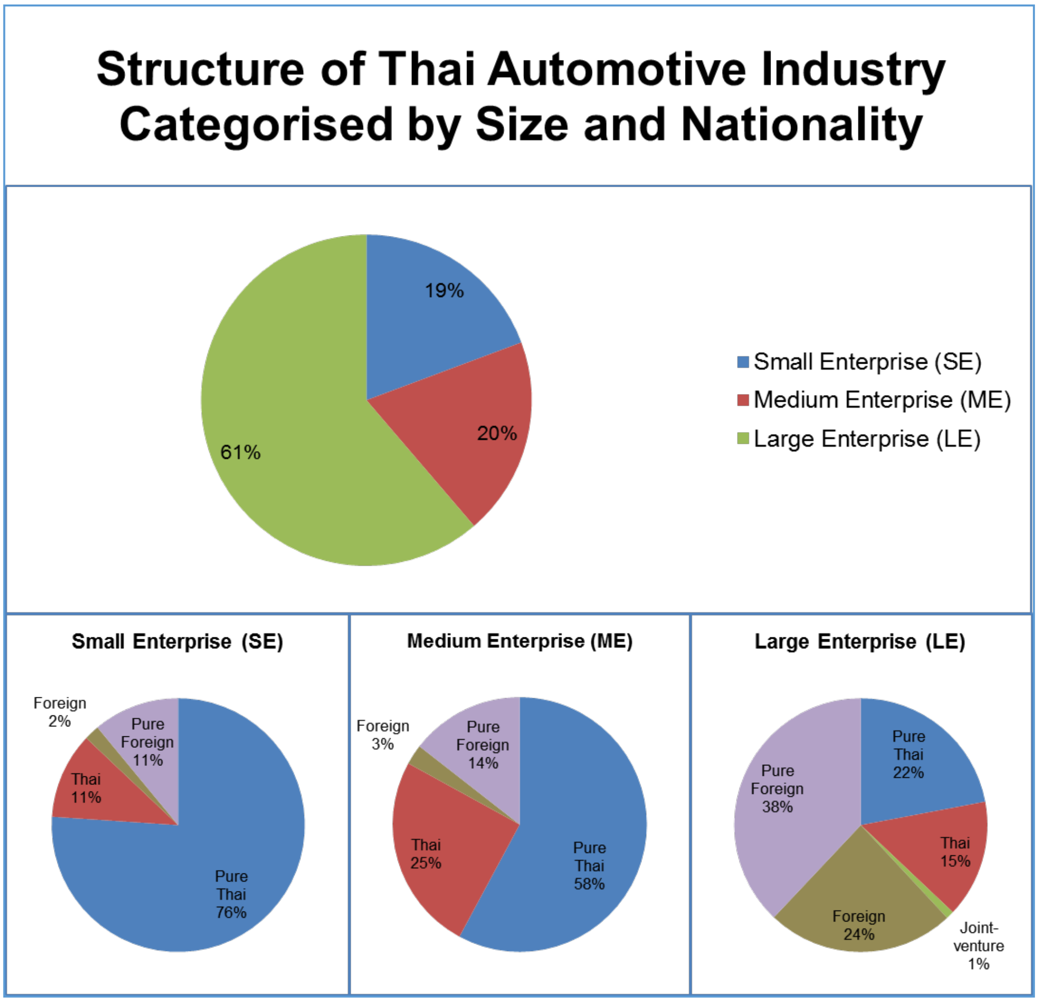

Figure 4.3 Structure of Thai Automotive Industry categorised by Size and Nationality (Thailand Automotive Institute: TAI, 2014)

The shares of income generated by Thai-owned and foreign-owned auto-part companies are shown in Figure 4.4. Foreign-owned companies, which constituted 47 per cent of the auto-part industry, generated 63 per cent of total income in the industry in 2014. During the same year, Thai-owned companies, which constitute 52 per cent of the auto-part industry, accounted for 33 per cent of total income in the industry (Thailand Automotive Institute: TAI, 2014).

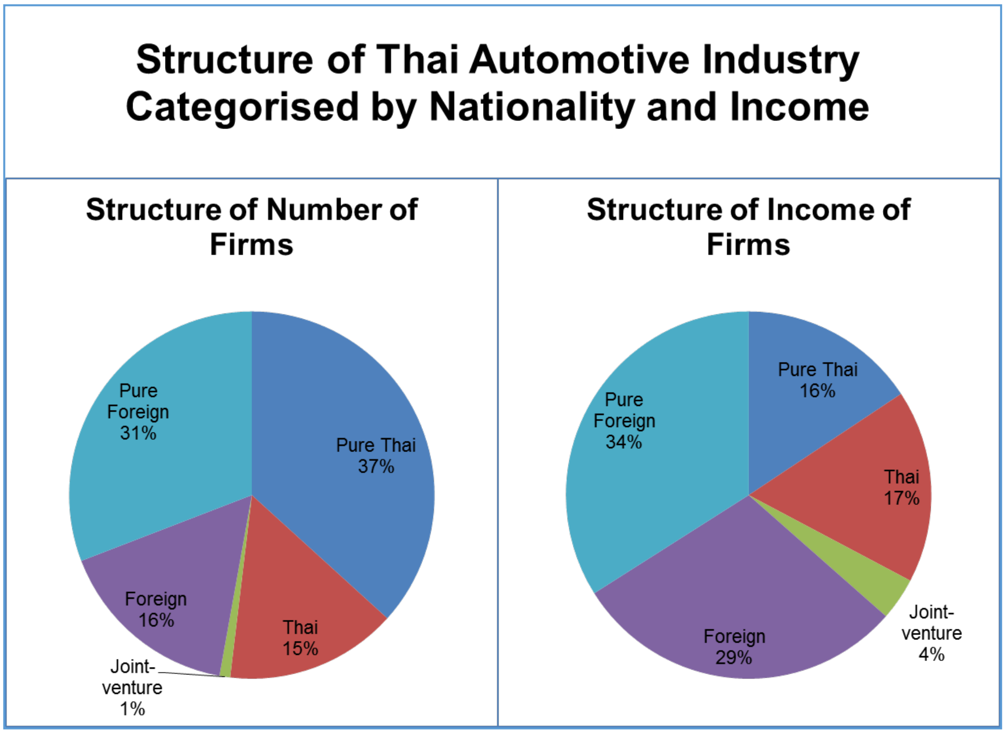

Figure 4.4 Structure of Thai Automotive Industry categorised by Nationality and Income (Thailand Automotive Institute: TAI, 2014)

4.3.2 End-of-life vehicle (ELV) pollution

There is growing concern about pollution arising from the increasing number of end-of-life vehicles (ELV) in Thailand. The number of light commercial vehicles and small passenger cars registered in Thailand in December 2019 was 16.76 million units. This includes 9.99 million small passenger cars and 6.78 million pick-ups (Figure 4.5). Figure 4.5 shows a steady increase of this number since 1989. The number of small passenger cars has grown from 0.64 million units in 1989, at the annual growth rate (CAGR) of 9.61 per cent during 1989-2019. Also, the number of light commercial cars has increased from 0.79 million units in 1989 at the annual rate of 7.44 per cent over the 30 years since.

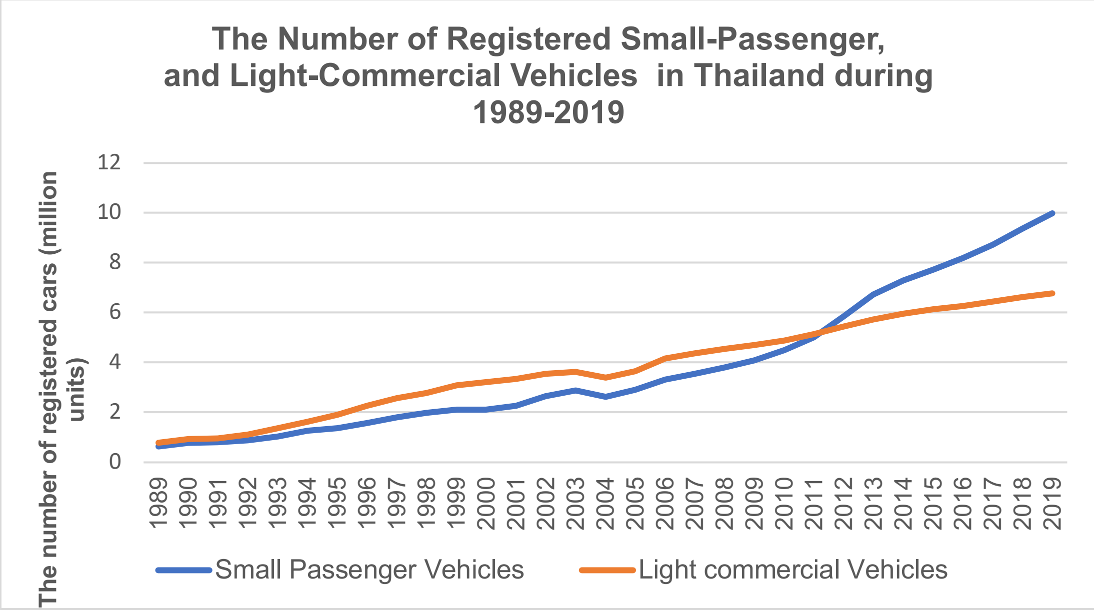

Figure 4.5 The Number of Registered Small-Passenger, and Light-Commercial Vehicles in Thailand during 1989-2019 (Department of Land Transport, 2020)

ELVs would result in vehicle-waste pollution in the absence of strategies for mitigating the problem. But the waste in ELVs can be recovered under a model of resource management as they contain millions of tonnes of valuable secondary resources for circular production (Ellen MacArthur Foundation, 2012).

4.3.3 Linear Economy in Thai Automotive Sector

Thailand's automotive industry operates on the basis of the conventional linear business model (take-the country's-consume-dispose). As shown in Figure 4.6, car production in Thailand relates to Thailand's import value of automotive parts and accessories. The important automotive parts and accessories are gear boxes and parts (HS code: 870840) which constitute 27.56 per cent of total import value of automotive parts and accessories (HS code: 8708) in 2019 (Thai Customs, 2020).

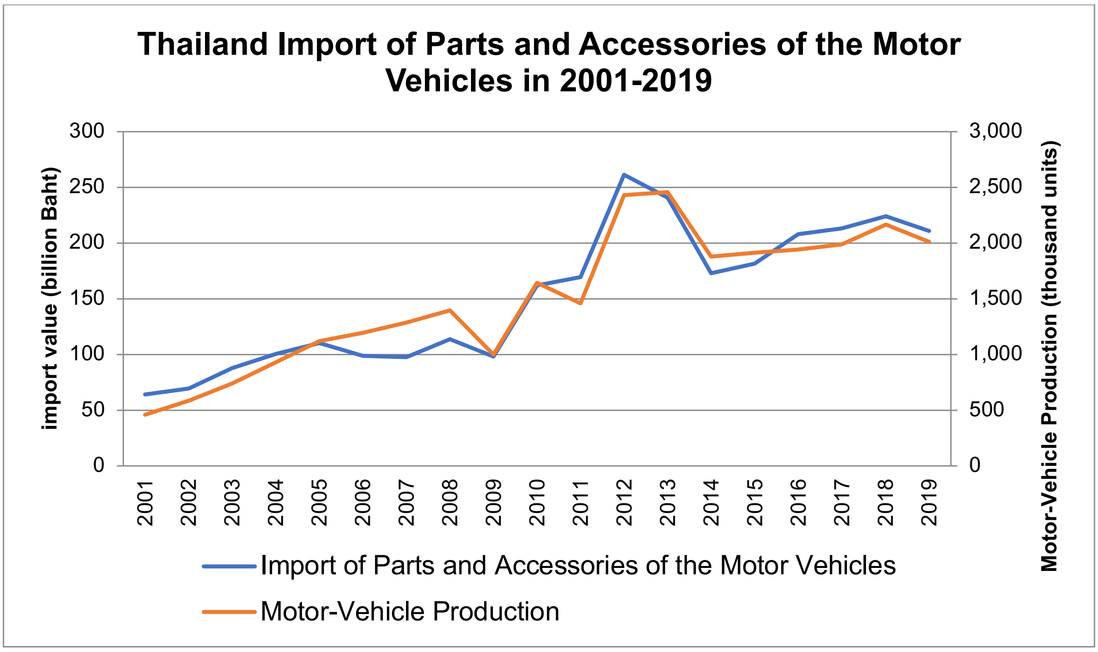

Figure 4.6 Comparison between Import of Parts & Accessories and Production of Motor Vehicles of Thailand in 2001-2019 (International Organization of Motor Vehicle Manufacturers: OICA, 2020; Thai Customs, 2020)

The correlation between growth of auto-production and auto-parts import value shows that the Thai automotive industry is locked in the traditional resource-intensive linear system production. The import-dependent production model of production is neither sustainable nor competitive, owing to increasing resource prices. In this study, circular economy – particularly remanufacturing of auto-products - is explored as a way out of the problem by improving the scope for the effective and efficient resources to make the Thai automotive industry innovative and competitive.

4.4 The Circular Economy in the Thai Automotive Industry

Automotive remanufacturing has been going on in developed in developed countries for over 30 years now (Winans, Kendall, & Deng, 2017; T. Zhang et al., 2011). However, with more than a decade of experience, it is at the preliminary stage in Thailand, particularly in its CE form. CE production exists in the form of refurbishing, especially among Thai auto-part SMEs, for serving in the replacement equipment market. The ability to refurbish is based on the availability and use of domestic or imported core components. Unlike remanufactured products, the automotive products from the refurbishing process are generally 70 per cent 'like-new' products in quality and warranty. There are bad quality products in some cases, which, in turn, lead to the 'lemon market' problem[18] in this market (Kohpaiboon, 2011; Office of Industrial Economics: OIE, 2012).

The automotive remanufacturing industry in Thailand is mainly operated by Original Equipment Manufacturers (OEMs), such as Mercedes. They remanufacture big and high value auto-parts, including engines, injection, and electronic components, which import core components from developed countries, especially from Japan, Germany and China (see Table 4.1) (Kohpaiboon, 2011; Office of Industrial Economics: OIE, 2012).

Table 4.1 Import values between new and used engines between 2017-2020 categorised by import countries (Thai Customs, 2020)

Country	2017		2018		2019		2020 (Jan-Nov)	
	New	Used	New	Used	New	Used	New	Used
Japan	£15,729,084	£4,759,627	£14,311,386	£5,277,188	£12,333,804	£4,301,844	£10,360,469	£4,733,626
Germany	£6,462,936	£970	£33,224	£5,531	£30,501	£13,378	£0	£17,060
China	£743,629	£137,470	£4,867,459	£34,541	£6,751,683	£33,600	£143,705	£14,474
Korea	£693,018	£0	£0	£0	£0	£0	£0	£93,445
Taiwan	£55,010	£0	£58,238	£7,013	£0	£0	£0	£88,155
UK	£0	£3,621	£0	£0	£0	£5,200	£0	£0
US	£0	£0	£0	£9,694	£0	£34,544	£0	£44,706
Others	£43,436	£35,056	£13,416	£25,429	£2,011	£73,133	£0	£76,385
SUM	**£23,727,113**	**£4,936,745**	**£19,283,722**	**£5,359,394**	**£19,118,000**	**£4,461,699**	**£10,504,174**	**£5,067,850**

[18] Lemon market problem (Akerlof, 1970), initiated by George Akerlof in August 1970, is why bad-quality products push good-quality ones out of the market. This is owing to asymmetric information between the consumers and the sellers about the actual values of the products.

For instance, according to Brown (2007), to explain the conceptual impacts of lemons and asymmetric information, there is a classic example put forward by Akerlof (1970) of used vehicles between inferior used cars (referred to as lemons) and good-quality used cars (referred to as plums). The lemons sellers are willing to sell for £1,000, while the sellers of plums are willing to sell for £2,000. On the other hand, the consumers are willing to buy up to £1,200 for a lemon, while up to £2,400 for a plum. There are assumptions. Firstly, purchasers know that the probability of purchasing a leman in the used-car market is 50 per cent, but they cannot differentiate the differences between lemons and plums. Finally, only sellers can perceive what actual type of their cars.

As a result, purchasers will buy simply up to prices reflecting on their expected probability that a specific car is a lemon. That is, they will buy any car up to £1,800 (equalling to 50 per cent of £1,200 plus 50 per cent of £2,400). Hence, for the price of £1,800, merely the lemons sellers are willing to sell, while the plums sellers are not. Therefore, in equilibrium the bad-quality used cars or lemons can be sold for equilibrium price during £1,000 to £1,200, while good-quality used cars or plums cannot be sold and, in turn, be chased out of the used car market in finally.

According to the study of Office of Industrial Economics (2012), there are barriers trapping Thai Replacement Equipment Manufacturers (REM) in the refurbishing industry, preventing them from developing remanufacturing capability. A major problem involves technical difficulties. ELVs are often difficult to dismantle, especially where the remanufacturers are not the OEMs. Thai REMs lack technical knowledge about design of complex auto-parts in particular, which obstructs efficient dismantling (Office of Industrial Economics: OIE, 2012).

4.5 Results: The significant factors influencing behaviour of automotive producers in Thailand to conduct remanufacturing businesses

The analysed results from secondary data collected and organised by Chaowanapong et al. (2017) reveal that influencing factors selected by literature reviews can differently affect respondents' decision-marking to initiate remanufacturing auto-businesses in Thailand. The analysed results in the form of an ordered list on average concerning scores of respondents on influencing factors are shown in Figure 4.7.

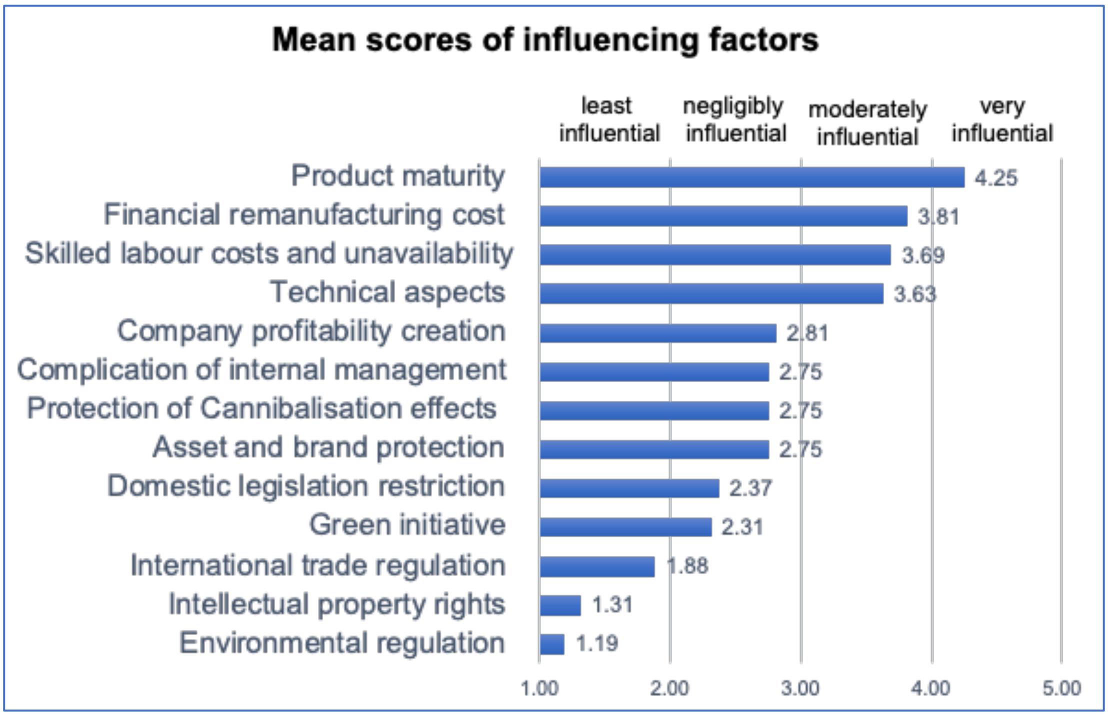

Figure 4.7 Mean scores of influencing factors
(Source: applied from by Chaowanapong et al., (2017))

According to the results shown in Figure 4.7, the influencing factors that affected automotive producers in Thailand to induce a remanufacturing auto-business can be ordered and grouped into four groups of influential levels. That is, the group of very influential factors ranging by their mean score of 4.00-5.00 is comprised of the factor of product maturity with the mean score of 4.25.

The second group is moderately influential factors ranging from their mean score of 3.00-3.99. This group comprises three influencing factors: 'Financial remanufacturing costs', 'Skilled labour costs and unavailability', and 'Technical aspects'. Their mean scores are 3.81, 3.69, and 3.63, respectively, as shown in Figure 4.7.

Thirdly, the group of negligibly influential factors, ranging the mean score from 2.00-2.99, comprises six influencing factors. They are the factors of 'Company profitability creation', 'Asset and brand protection', 'Protection of Cannibalisation effects', 'Complication of internal management', 'Domestic legislation restriction', and 'Green initiative'. They are prioritised by their mean scores of 2.81, 2.75, 2.75, 2.75, 2.37, and 2.31, respectively, as shown in Figure 4.7.

The final group of the least influencing factors ranges from 1.00-1.99 of the mean scores. This group includes the factors of 'International trade regulation' with 1.88, 'Intellectual property rights' with 1.31, and 'Environmental regulation' with 1.91, as shown in Figure 4.7.

4.5.1 Discussion

Factors inducing producers in Thailand’s automotive parts industry Initiate to conduct remanufacturing businesses. The key factors influencing the decision-making are based on secondary data by Chaowanapong et al. (2017). The results indicate that on average, ‘Product maturity factor’ is the most influential determinant that affects the decision-making of automotive companies in Thailand. This is followed by the factors of ‘Financial remanufacturing costs’, ‘skilled workers unavailability’ and ‘Technical barriers’, respectively.

Product maturity

The factor of 'product maturity' is ranked first as the most significant factor for an automotive producer in Thailand to engage in a remanufacturing automotive business. In the theory of Product Life Cycle (PLC) stages, during the maturity stage, a product begins to enter the most profitable stage after passing its introduction and growth periods. Sales of a product tend to drop or even stop when it becomes maturity reflecting a saturated market (Sraders, 2019).

The length of the product maturity stage is a crucial indicator to determine sales of a remanufacturing auto product. The target for producers in this stage is to maintain their sales and market share they have built up (Sraders, 2019). In other words, a significant question under the factor of 'product maturity' in producers' opinion is that will a remanufacturing auto product be demanded in the automotive market, and how long? The maturity period of a remanufacturing auto-product may be a short time or drawn out last a long time depending on perceptions of demands, product values, product lifespan or speed of technology innovation, and competitiveness with alternatives, especially competition from cheap new products (Chaowanapong et al., 2017; Matsumoto, 2010; Sraders, 2019).

Good perception of demands on remanufactured auto-products is a significant factor to maintain sales or prolong the maturity stage, in turn being a facilitator for auto-company to conduct remanufacturing (Chaowanapong et al., 2017; Sraders, 2019). Consumers in Thailand demand remanufactured products because of their competitive cheaper prices with at least as new condition and warranty offer (Chaowanapong, Jongwanich, & Ijomah, 2018). If a remanufactured products price is not attractive, the consumers in Thailand may select new and cheap imported products from China. Also, if the remanufactured product quality and warranty are unbeneficial, the consumers may choose used products instead (Chaowanapong et al., 2017, 2018). This results from the uncertainty of customer demand on remanufacturing acceptance depended on the perceived differences of the consumers between new and remanufactured products (Lundmark, Sundin, & Björkman, 2009).

However, consumers' negative perception about their misconception on quality of remanufactured products remains a crucial obstacle for operating remanufacturing businesses in many counties, including China, Japan and Thailand (Abdulrahman et al., 2015; Chaowanapong et al., 2017, 2018; Matsumoto et al., 2018).

To extend the period of product maturity for a remanufactured product, its product recovery value should high. Meanwhile, its product lifespan should long, and the speed of technology innovation should be stable. theoretically, remanufacturing is appropriate with products that their characteristics of products, recovery values, and technology trends are met. That is, the product is durable, high-value, factory-built and has reached end-of-use functionally. The restorable value-added has high enough value for recovery incentives relative to its market value. The product and process technologies are stable or at least do not change quickly. Fashion or demand trends in the product, also, do not change quickly (All-Party Parliamentary Sustainable Resource Group, 2014; Matsumoto & Ijomah, 2013).

The theoretical literature is affirmed by the empirical study of Chaowanapong et al. (2017, 2018) in case of Thailand automotive sector. They found that it is worth doing remanufacturing if the auto-product lifespan remains more than 80 to 100 per cent of the period of that of a brand-new alternative. Also, such the product still provides high added value in the market in addition to its stable technological change and involves a low level of technical complexity (Chaowanapong et al., 2017, 2018).

Financial remanufacturing costs

Financial issues of remanufacturing process were rated as the second most high score factor affecting an auto-company in Thailand to initiate a remanufacturing business. If the factor of product maturity acts as a critical indicator to determine revenues for remanufacturing businesses. In that case, the factor of financial remanufacturing costs acts as a key determinant for cost aspects.

In comparison with traditional linear manufacturing, remanufacturing has specific recovery costs to relief core components or end-of-use products back into at least as their original performance. There are particularly the costs core acquisition & reverse logistic, and product quality control. The costs of core management, especially, can determine success or failure to run auto-remanufacturing business (Subramoniam et al., 2010).

According to an empirical study in the Thailand automotive sector, Chaowanapong et al. (2017) found that two primary sources of core acquisition of remanufacturing auto-businesses in Thailand are domestic and imported markets. In the domestic market, direct-order based and credit-based approaches are used. By exchanging return cores for remanufactured auto-products is in the case of a direct-order based model. Also, there is to sell remanufactured auto-products at discount rates that include returned cores from the customers in the case of a credit-based approach. Meanwhile, the prices of the remanufactured auto-products depend on the conditions of the returned end-of-use products in both approaches. Remanufacturers in Thailand automotive sector also adopt a buy-back based approach through import markets, particularly from China, Japan, Taiwan, and Malaysia (Chaowanapong et al., 2017, 2018). However, imported cores have more uncertainties than domestic ones because of a lack of control in quality, quantity and timing (Chaowanapong et al., 2018; Junior & Filho, 2012, 2016; Östlin et al., 2009).

Skilled labour costs and unavailability

The finding can affirm that remanufacturing is a skilled labour-intensive activity. The factor of skilled labour costs and unavailability was ranked third in its significant influence on auto-producers in Thailand to conduct remanufacturing businesses.

Moreover, Chaowanapong et al. (2017, 2018) found that skilled labour aspects are a significant barrier to remanufacturing CE development in the auto industry on both quality and quantity issues. Significantly, the labour market situation in Thailand that the vocational education level workforce tends to inadequacy leads to a lack of technical skill labours to manage remanufacturing processes.

Original equipment remanufacturers (OERs) concern the workforce barrier more than Independent remanufactures (IRs). This could be because OERs selling both new and remanufactured products do so under their brand auspices. The skilled workers are needed even more when producing new products under their brands and meeting OERs' standards (Chaowanapong et al., 2017, 2018).

The high labour cost is also an obstacle for running remanufacturing auto-businesses in Thailand. this is because the incremental of the minimum wage from 222 baht (approximately £5) in 2013 to currently 330 baht (approximately £7.5) per day affects the remanufacturing cost as a labour-intensive activity.

Technical aspects

The factor of technical barriers was ranked fourth as being notably influential in making decisions to remanufacture in Thailand. The technical barriers comprise of a lack of product design for remanufacturing and a lack of technology and product knowledge.

Product design is a crucial obstacle to remanufacturing businesses because suitable product design for remanufacturing means the capability to easily disassemble, thoroughly clean, recover, and reassemble (Ridley, Ijomah, & Corney, 2019). They are vital procedures of remanufacturing that can determine success or failure for the businesses. In other words, suitable design for remanufacturing can effectively enhance production efficiency and drop labour costs (Chaowanapong et al., 2017). Furthermore, remanufacturing a product that is not designed for disassembly might require specific tools and machinery or even reverse engineering to complete the process. It is very costly and increases a huge of production costs (Karvonen et al., 2017).

Specific technology and product knowledge is also an essential issue of the technical barriers for remanufacturing business operations. This includes particular know-how, expertise, as well as and availability of testing machinery and tools. However, the difficulty is a barrier only for independent remanufacturers (IRs), but not for original equipment manufacturers (OEMs) and original equipment remanufacturers (OERs). Furthermore, automotive OEMs/OERs use product design, concerning the difficulty of disassembly and reassembly, and specific techniques and knowledge as instruments to protect IRs from remanufacturing their cores. Not surprisingly, these specific tools, techniques and know-how are required and possessed only by the OEMs/OERs. As a result, small-scale IRs cannot remanufacture their cores (Chaowanapong et al., 2017).

4.5.2 Contribution of the supply-side study

It can be seen from the results of the supply-side study that several factors influence automotive manufactures to induce remanufacturing auto-businesses in Thailand. The influencing factors are product maturity, financial remanufacturing costs, deficiency of skilled labour, and a lack of technical aspects.

The supply-side study of remanufacturing in the automotive sector in Thailand will contribute to a CE literature stream in developing counties. The study will also encourage R&D in CE, remanufacturing, and closed-loop supply chain in Thailand or even other countries where the development of the remanufacturing CE model is still in the preliminary stage.

Furthermore, the supply-side study is an empirical evidence to assist automotive entrepreneurs to make decisions whether to initiate involved in remanufacturing auto-businesses in Thailand. Also, the factors findings can lead to some strategic suggestions for remanufacturers to improve their business operation in Thailand.

That is, to prolong the product maturity stage or maintain sales for remanufactured auto-products in Thailand as long as possible, the study of consumers' behaviours of the auto-customers is needed. Moreover, strategic promotions to fulfil willingness to pay for remanufactured auto-products of the customers are needed to be initiated. Furthermore, the financial remanufacturing costs can reduce by minimising the costs of cores management. Strategic models to encourage cooperation from customers to willing to return their EoU/EoL products in the freshest or best condition are essential.

Finally, the findings of the supply-side study are also beneficial for policymakers in Thailand to promote CE transition in the big picture as a national agenda. There are some policy recommendations based on the findings.

The Thai government should encourage cooperation between stakeholders in the automotive industry and society. For instance, cooperation initiatives between producers and consumers can reduce asymmetric information and lemon market problems. The problems are a crucial cause of consumers' misconception consumers on remanufactured products leading to a barrier of the short product-maturity stage for remanufactured auto-product in the market. Also, cooperation of industrial players, especially between OEM/OERs and IRs, in the automotive and relevant industries is needed to reduce the technical barriers, in turn, to scale up the remanufacturing auto-market into a globally competitive level.

Also, the barriers of financial remanufacturing costs and a lack of some technical aspects, particularly product design suitably for remanufacturing, can be mitigated by financial schemes, including soft loans and tax incentives. The financial supports should provide based on increasing positive externalities of sustainability development from CE investments.

Strategic policies on human resource development (HRD) should develop remanufacturing curricula and promote vocational education to serve the demands of high-skilled labour in future CE activities. It can mitigate the bottlenecks of skilled labour insufficiency

Finally, laws and regulations that can clear and free the market failures in the automotive market should be established, such as End-of-Life vehicles (ELVs) directives, Extended Producer Responsibility (ERP). As well as hard infrastructure, policymakers should encourage establishing remanufacturing systems of product quality control, standards, testing & certification. Also, the government should support the initiation of intelligent centres to improve comprehensive remanufacturing CE activities.

4.6 Perspectives of the Thai government to a Circular Economy transition

The Thai Government has formally initiated CE development as a part of Bio-Circular-Green Economy Model (BCG) development. The promotion to the BCG economic model at the policy level started in October 2020 after establishing two national committees. Furthermore, in January 2021, the BCG model was approved to be a part of Thailand’s national agenda. At the same time, the BCG Economy Model Strategic Plan 2021-2026 was adopted to implement (Apisitniran, 2021).

The Thai government expects that economic activities initiated by implementation of the BCG five-year plan will contribute a new sustainable economic growth value of $137 billion by 2026 or one-fourth of current Thailand's GDP (Apisitniran, 2021; Bangkok Post, 2020). According to the BCG strategic plan (MHESI, 2021), four strategic areas for the BCG model development are (i) food and agriculture; (ii) medical and wellness; (iii) energy, material, and biochemicals; and (iv) tourism and creative economy. Based on Sufficiency Economy Philosophy (SEP) and Sustainable Development Goals (SDGs), these prioritised areas aim to achieve comprehensive security in the critical issue of sustainable well-beings: including food, health, energy, employment and sustainable natural resources and ecology.

A transition to a CE model under the BCG national strategic plan

According to the BCG five-year strategic plan, the principle of the CE is applied in and across these strategic areas throughout the plan. The CE concept is adopted to improve the cost-effectiveness of resources by reusing, remanufacturing, sharing, recycling, upcycling, and product designing to minimise or even eradicate waste in the production system to be environmentally friendly.

Furthermore, the CE development model (C in the BCG national strategic plan) is set as an engine to enhance sustainability and competitiveness of industrial manufacturing sectors. The aim of the strategic CE development is to focus on the CE transition with 3 Cs in three targeting industrial sectors. That is, the C1 represents ‘Closing the Loop’ by reducing resource use in economic system. The C2 represents ‘Creating New Economic Growth’ by creating new economic model. The C3 represents ‘Combating Climate Change and Pollution Reduction’ by reducing greenhouse gas emissions and pollution problem to initiate a transition to sustainable society. The three targeting industrial sectors are plastics industry, food and agricultures, and construction industry.

The achievement of the CE transition by the BCG national plan is also specified into four targets by 2026. The first indicator is a two-thirds reduction of raw resources compared to current use in these industrial sectors. The second indicator is to decrease greenhouse gas emission by at least 50 million tons of carbon dioxide equivalent. There is, also, to reduce pollution problems in the ecosystem. Expanding the CE market in both aspects of product quantity and variety is the last indicator.

Finally, the BCG Economy Model Strategic Plan 2021-2026 initiate measures and pilot programs for implementation.

Four strategic measures for the CE transition are identified. The first measure is to promote the CE development based on the cooperation of public, private, and public sectors (PPP). The second one is to encourage Digital Platform technology to propel the CE system. There is to promote the CE market in the consumption and production system through awareness and tax mechanisms. To enhance domestic and international competitiveness through the creation of new CE entrepreneurs is the final measure.

There are six pilot initiative programmes. The first CE initiative programme is developing circularity management eco-systems for plastics and food waste, which are effective at local levels, community levels and tourist area levels. The second programme is to develop digital platform technology to manage materials and resources in the construction industry to reduce greenhouse gas emissions. The third programme is financial and technological support for start-ups, SMEs and social enterprises to initiate CE businesses by technology and innovation.

The fourth one is to promote knowledge, awareness, and cooperation of consumers to the systemic waste separation in urban and rural communities. The fifth CE programme is the law and regulatory improvement programme to encourage and facilitate the private sector to invest in new CE businesses in order to support the growth of the CE market in the future. The last CE promotion is establishing a waste hub for sorting, collecting, and cleaning waste and recyclable materials. Label, certification and standardisation systems for material recovery are also initiated. This includes developing solution technology and platforms to manipulate the industrial material-flow database, analytical system and creation & utilisation of the circularity Index.

4.7 Conclusion

Thailand's automotive industry is a significant player not only in the development of the Thai economy, but also in the automotive supply chain of the world at large. The industry contributes about ten per cent to the Thai manufacturing GDP.

However, the growth trajectory of the industry in Thailand, as elsewhere, has been based on the traditional linear economic model, which allows producers to employ material and energy resources to 'make' (manufacture) auto-products; and customers to use the manufactured products until their end of life (EoL), whereupon the residual stuff would be disposed as waste. The 'make-use-dispose' linear model of industrialisation has limited the scope for the sustainability of the auto-sector in Thailand, as resource prices increase following increasing scarcity, thereby increasing production cost and making auto-products uncompetitive; and increased use of fossil fuel-based energy and discharge of the residual waste would result in environmental pollution. Moreover, the unsustainability problems in the automotive sector derive from dependency of automotive businesses on MNCs between large foreign companies and local SMEs, and End of life vehicles (ELVs) pollution.

Remanufacturing can decouple production growth and skilled-labour job creation from waste generation for the automotive sector, by doing more with less. This would create economic growth as well as employment, and reduce solid and chemical waste pollution arising from activities in the wider economic system. Moreover, the circular model supports local automotive SMEs, and encourages skill development and localisation of economic activities across regions. And energy, water and other resources will be utilised more effectively in the remanufacturing process.

The analysis results of the supply-side study find that the factors influencing automotive producers to induce remanufacturing auto-businesses in Thailand are product maturity, financial remanufacturing costs, deficiency of skilled labour, and a lack of technical aspects. Based on the supply-side findings, it can be implied that perception of customers is very essential to induce auto-manufacturers in Thailand to initiate remanufacturing auto-businesses. That is, acceptance and perception of consumers to purchase (willingness to pay) remanufactured auto-products determine sales, revenues and market share of the remanufactured products. While the sales, revenues and market share directly determine the period of product maturity, which in turn induce producers' intention to the remanufacturing CE market. As a result, the empirical finding confirms the statement that "the existence of a strong demand can bring forth supply in the market". However, how can we create the strong demand for CE remanufactured auto-products in Thailand.

On the Thai Government perspective, CE is currently approved to be a part of Thailand's national agenda formally since January 2021. A national strategic plan for promote a CE transition in Thailand also has adopted in a part of the BCG Economy Model Strategic Plan 2021-2026. However, this is just the first step in the early stage of CE development. Thailand economy still needs action plans and effective implementation in the real world.

Especially CE development in the automotive sector in Thailand, the transition of the sector to the remanufacturing circular economy model, however, depends in part on the switching behaviour of customers between new manufactured auto-products and 'like new' remanufactured auto-products. Hence the research question of this study: "What are the factors that bear on customers in the automotive sector to switch from linear to circular business models?

Chapter 5

Factors influencing the behaviour of customers to switch to remanufactured auto-products: data analysis and discussion of results

5.1 Introduction

This chapter is devoted to the investigation of the factors affecting consumers' switching behaviour in the auto-industry in Thailand. Thailand's automotive industry is a major player in the global automotive supply chain. It is also a strategic sector that is expected to propel Thailand industrial transformation through innovation and technological progress and the country's transition of Thailand to circular economy.

To date, the growth trajectory of the automotive industry in Thailand is based on the make-use-dispose traditional linear economic model. The linear economic pattern is unsustainable, however. Moreover, it has rendered the automotive sector in Thailand dependent on multi-national corporation (MNCs); increased income disparity between large foreign companies and local SMEs; and contributed to end-of-life vehicle (ELVs) pollution.

The CE system aims to eliminate waste pollution; and to maintain even improve the continual growth of economic activities. Also, it promotes local production and creates employment opportunities. Remanufacturing is sought as a circular economy option for the automotive market on grounds that remanufactured products are as good as, or even better, in terms of quality, reliability and robustness of functionality, than new manufactured products, not to mention the price competitiveness and environmental benefits of remanufactured products. However, the transition to circular economy through remanufacturing calls for changes in the behaviour of customers towards remanufactured automotive products. Hence the research question of this study: "what are the factors that bear on customers in the automotive sector to switch from new manufactured to 'like new' remanufactured auto-products?"

The remainder of this chapter is in eight parts. Following this brief introduction, the second part presents the analytical model adopted for investigation of the research question. In the third part, the survey data used for testing the hypotheses of the study are profiled. The correlation testing of the variables specified by the analytical model are tested for multi-collinearity in the fourth part of the chapter. The data corresponding to the variables of the model are analysed in the fifth part using the structural equation model (SEM). In the sixth part of the chapter, the results of the analysis are presented. The ramifications the results are discussed in the seventh part. The conclusion of the chapter is presented in the eighth part of the chapter

5.2 Analytical Model for Investigating the Research Question

Factors affecting customers' switching behaviour in the auto-industry in Thailand is investigated in this study based on the theoretical framework of the 'push-pull-mooring' (PPM) migration theory (Bogue, 1969, 1977; Lee, 1966; Moon, 1995). Within this framework, the analytical process is conducted through the application of the structural equation model (SEM).

Theoretical framework: Push-Pull-Mooring (PPM) migration theory

The PPM theory of migration can be applied to the analysis of customers' behaviour of switching between alternative products. According to the theory, switching behaviour is determined by the switching intentions of potential 'migrants'. Switching intentions, or individuals' willingness to act in specific ways, are results of three forces: push, pull and mooring forces, through direct and moderating effects.

In terms of customers' behaviour, the 'push' force derives from factors, which, in the eyes of consumers/customers, would count as the disadvantages or shortfalls of new manufactured 'linear' products when compared with 'circular' or remanufactured products. The theory is that these shortfall factors would push consumers to switch their preferences from new manufactured 'linear' products to their remanufactured alternatives. A major 'push' factor considered in the empirical analysis of this study is the price disadvantage of new auto-products compared with remanufactured alternatives (P_N)[19].

The 'pull force', which is considered to influence the switch of customer behaviour from new manufactured 'linear' auto-products to remanufactured 'circular' auto-products, derive from factors representing the advantages of circular remanufactured auto-products over new manufactured linear alternatives. These factors relate to the environmental benefits of remanufactured auto-products (EB_R)[20]; and the special feature benefits of remanufactured auto-products (SB_R)[21].

The 'mooring' force relates to factors that keep customers anchored to new manufactured linear auto-products, thus restraining them from switching to remanufactured circular auto-products. As such, the 'mooring' force delays customers' decision to switch to remanufactured products, and can thus influence the switching intention of consumers either directly, or indirectly by moderating the effects of the push and pull forces. Major 'mooring' factors considered in this study include customers' personal attitudes (perceived or misconceived) towards auto-remanufactured products (PA_R)[22]; and obsolescence risks or other perceived risks of remanufactured auto-products (OR_R)[23].

These relationships between the switching intentions of auto-customers in Thailand in preference for 'like new' remanufactured auto-products and the potential determinants of behaviour changes discussed above, (P_N, EB_R, SB_R, PA_R and OR_R),

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[19] The price disadvantage of new auto-products compared with remanufactured alternatives (P_N) include more expensive, less value-for-money, less reasonably priced, less worthy-for-money and less economical (See Table 3.2).

[20] The environmental benefits of remanufactured auto-products over new manufactured ones (EB_R) include reducing resource use, circulation of resources, reduction of landfill waste and more ecosystem friendliness (See Table 3.2).

[21] The special feature benefits of remanufactured auto-products over new manufactured ones (SB_R) include longer warranty, more durable materials, new upgrading technology, more features/functions and better services (See Table 3.2).

[22] The consumers' personal attitudes perceived or misconceived, towards auto-remanufactured products (PA_R) include feelings of bad experiences, second-hand products, defective products and unstandardised products (See Table 3.2).

[23] The obsolescence risks or other perceived risks of remanufactured auto-products (OR_R) include Old-fashioned too soon, a lack of newness feeling, without some exiting functionality, Unavailable via general retail channels and High maintenance costs (See Table 3.2).

are explored within the of PPM framework through the investigation of the following hypotheses, as shown in Figure 5.1.

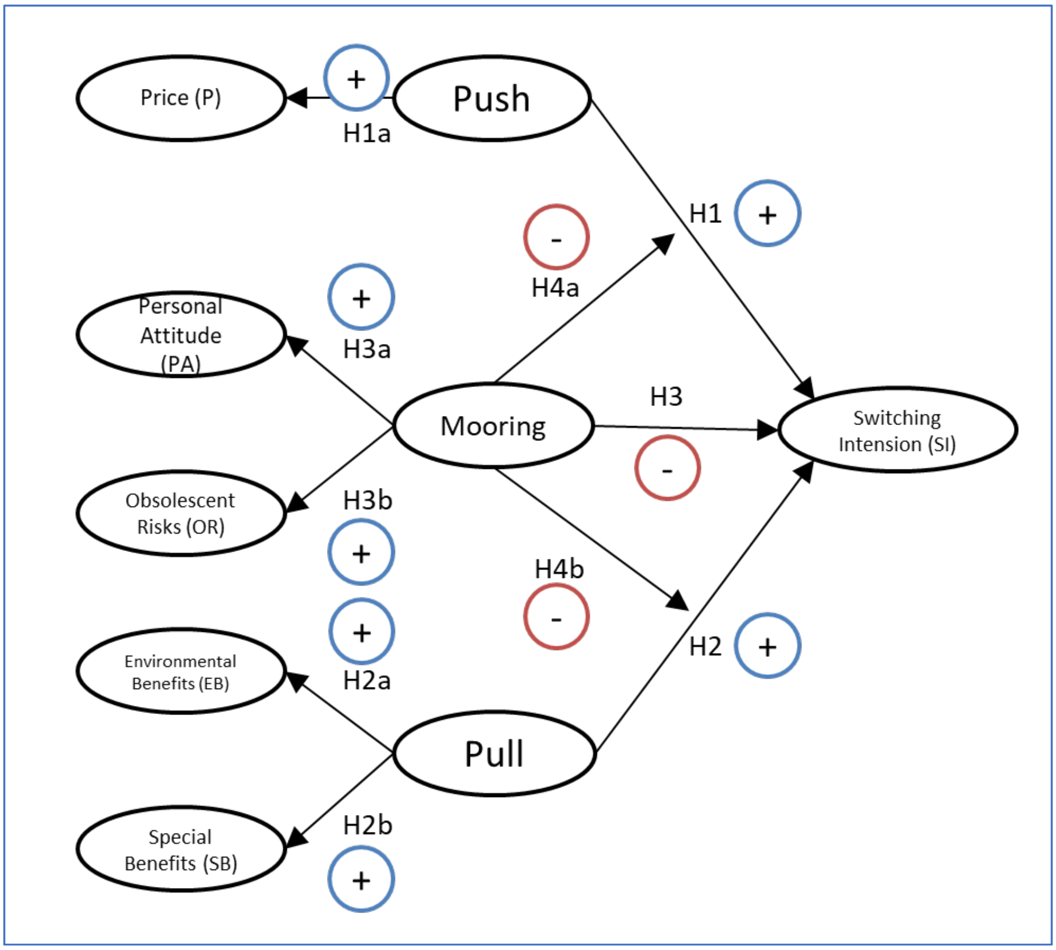

Figure 5.1 Proposed Hypotheses of relationships between variables in Path Analysis Model of the Research Framework (recalled Figure 3.6)

- *Hypothesis 1 (H1):* Push factors positively affect the switching intention of automotive customers to select remanufactured products.
    - *Hypothesis 1a (H1a):* Perception of consumers about the price disadvantages of new manufactured auto-products (P_N) positively affects the switching intention to switch remanufactured products.
- *Hypothesis 2 (H2):* Pull factors positively affect the switching intention of consumers in favour of remanufactured auto-products.
    - *Hypothesis 2a (H2a):* The perception of customers about the environmental benefits of remanufactured auto-products (EB_R)

positively affects the switching intention of customers towards remanufactured products.
    - *Hypothesis 2b (H2b):* The perception of customers about the special benefits of remanufactured auto-products (SB_R) positively affects their switching intention towards remanufactured products.

- *Hypothesis 3 (H3):* The direct effects of 'mooring factors' would be expected to negatively affect the switching intention of auto-customers to favour remanufactured products.
    - *Hypothesis 3a (H3a):* Misconceived personal attitudes of auto-customers that render the quality of remanufactured auto-products (PA_R) to be inferior to new manufactured products is inversely related to their switching intention to remanufactured products.
    - *Hypothesis 3b (H3b):* The perception of customers about obsolescence-related risks of remanufactured auto-products (OR_R) negatively affects their switching intention towards remanufactured products.
- *Hypothesis 4 (H4):* 'Mooring' factors have the effect of mitigating the influence of 'push' and 'pull' factors on the switching intention of customers to shift towards remanufactured products.
    - *Hypothesis 4a (H4a):* Mooring factors, including personal attitudes (PA_R) and obsolescence risks (OR_R), moderate the association between the push factor (P_N)) and the switching intention of customers to switch to remanufactured auto-products.
    - *Hypothesis 4b (H4b):* Mooring factors, including personal attitudes (PA_R) and obsolescence risks (OR_R), moderate the association between pull factors, including environmental benefits (EB_R) and special benefits (SB_R) of remanufactured auto-products), and the switching intention of customers to select remanufactured auto-products.

Analytical framework: The Structural Equation Modelling (SEM)

The structural equation model (SEM) is applied as the main analytical tool in this study because of its capability to address the complexities of latent variables and moderating variables in the PPM migration model. The latent variables are variables that cannot be directly measured but can be inferred from other observed variables.

These explanatory variables include: P_N, SB_R, EB_R, PA_R, OR_R, and SI. The moderating variables are the latent variables that have mooring effects on the other explanatory variables. PA_R and OR_R are the mooring factors that bear on to the push factors (P_N); and also have mitigating influence on pull factors (SB_R, EB_R) in the PPM migration model.

The structural equation model (SEM) is adopted for estimating coefficients ($\hat{\beta}$) which show the significance of factors that determine the switching behaviour of consumers in favour of remanufactured auto-products. It is also adopted for exploring the efficacy of the 'push-pull-mooring' (PPM) migration model to explain the behaviour of customers to switch to the adoption of remanufactured auto-products.

The SEM procedure involves testing of the measurement model and testing of the structural model.

(1) The technique of "confirmatory factor analysis" (CFA) is used to test the measurement model and to confirm that all observable indicators can suitably measure all unobservable latent factors. The suitable measurement or good fit means that all observable indicators can properly reflect the effects of all unobservable latent factors in the analysis (convergent validity), and also the latent factors that are different from each other in the model (divergent validity)[24].

(2) Test of the structural model is about the empirical relationships and paths between latent factors. SEM calculates the robustness and direction of the relationships between dependent and independent variables in terms of statistical p-values and estimated coefficients ($\hat{\beta}$). These numbers can identify the significant factors that determine the switching behaviour of customers in favour of remanufactured auto-products which is the first goal in the process of analysis.

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[24] *Convergent validity* is measured by the values of Initial and extraction communalities. The values of Initial communality indicate the capacity of the observable indicator to corporately explain an unobservable-latent-factor. While the values of extraction communality indicate the capacity of the observable indicator to extract explain an unobservable-latent-factor*.* *Divergent validity* is measured by the Eigenvalue Scree plot to show the number of different unobservable-latent-factors how many observable indicators can properly measure

Through the process of hypothesis testing, SEM can achieve a second goal of verifying the efficacy of the PPM migration model to explain the switching behaviour of individuals towards the adoption of remanufactured auto-products. To examine the efficacy of the proposed structural equation model based on the PPM model, the difference between the sample covariance matrix (S) (estimated by the survey data) and the implied covariance matrix ($\sum$) (reflected by the estimated coefficients ($\hat{\beta}$) and the proposed structural equation model) is tested (H0: $\sum = S$).

5.3 Description of Data Profiles

The fieldwork involving the questionnaire-based survey was conducted from November 2018 to January 2019 in Thailand. A sample of 401 Thai customers/users of automotive products were randomly selected to participate in the process. However, after cleaning ineffective responses, 342 responses (n=342) were used as basis for investigation of the research question.

The survey data relating to the personal features of respondents reflect on three aspects about the automotive market in Thailand as shown in Table 5.1. Firstly, there is no significantly apparent gender bias in the survey data. That is, about 52 per cent of the randomly selected respondents were males, which is not significantly different from the proportion of females (about 48 per cent). The age profile of all respondents ranges from 21 to 69 years. This means that all respondents were in the age range that would legally entitle them to be car owners and to have a driving license in Thailand. The largest group of respondents was in the 31-40 years old cohort.

Table 5.1 Descriptive statistical values of the surveyed data

Factors	N	Minimum	Maximum	Mean	Median	Mode	Standard Deviation	Skewness
<u>Control Variables</u>								
Demographic Data								
Education	342	1	5	3.65	4	4	0.693	-0.042
Age	342	21	69	35.67	36	36	7.376	0.960
Gender	342	1	2	1.52	2	2	0.500	-0.071

Factors	N	Minimum	Maximum	Mean	Median	Mode	Standard Deviation	Skewness
Income	342	1	7	4.17	4	3	1.947	0.158
Independent Variables								
Price (P_N)								
P_N1Expensiveness	342	1	5	3.96	4	4	0.755	-1.087
P_N3Unreasonableness	342	1	5	3.82	4	4	0.776	-0.442
P_N4Unworthiness	342	1	5	3.75	4	4	0.781	-0.277
P_N5Uneconomical	342	1	5	3.99	4	4	0.768	-0.924
Environmental Benefits (EB_R)								
EB_R1ResReduction	342	1	5	4.28	4	4	0.752	-1.006
EB_R2ResCirculation	342	1	5	4.33	4	4	0.692	-1.072
EB_R3WasteReduction	342	1	5	4.33	4	5	0.758	-1.209
EB_R4EcoFriendly	342	1	5	4.23	4	5	0.810	-0.966
Special Benefits (SB_R)								
SB_R1Warranty	342	1	5	4.16	4	4	0.844	-1.202
SB_R2Durability	342	1	5	4.13	4	4	0.809	-1.114
SB_R3Technology	342	1	5	3.96	4	4	0.838	-1.066
SB_R4Functionability	342	1	5	4.01	4	4	0.914	-1.141
SB_R5Serviceability	342	1	5	4.22	4	4	0.863	-1.479
Personal Attitude (PA_R)								
PA_R1Experience	342	1	5	2.86	3	3	0.884	-0.035
PA_R2SecondHand	342	1	5	3.24	4	4	1.060	-0.408
PA_R3Defect	342	1	5	2.84	3	3	0.960	0.087
PA_R4Unstandardisation	342	1	5	3.02	3	3	0.974	-0.162
Obsolescent Risks (OR_R)								
OR_R1Obsolescence	342	1	5	2.98	3	3	0.982	-0.146
OR_R2LackingNewness	342	1	5	3.21	3	4	0.983	-0.476

Factors	N	Minimum	Maximum	Mean	Median	Mode	Standard Deviation	Skewness
OR_R3Dysfunction	342	1	5	2.97	3	3	1.008	-0.229
OR_R5HighMaintenance	342	1	5	3.20	3	3	0.852	-0.234
Dependent Variables								
Switching Intension (SI)								
SI_R1Consideration	342	1	5	3.27	3	3	0.823	-0.369
SI_R2Feasibility	342	1	5	3.48	4	4	0.783	-0.253
SI_R3Acception	342	1	5	3.58	4	4	0.810	-0.682
SI_R4Recommendaion	342	1	5	3.54	4	4	0.775	-0.355
WTP	342	40	100	64.50	60	60	13.856	0.573
WTR	342	1	7	3.21	2	1	2.082	0.659

5.4 Correlation Testing

Before proceeding to inferential analysis, the study performed a correlation analysis to quantify the strength of the linear interrelationship between the independent variables of the analytical model. The testing was conducted by adopting the Pearson correlation coefficient, denoted by r. The correlation testing was in order to check whether any two independent variables strongly correlated in any direction, or if the absolute values of any Pearson correlation is more than 0.8 ($|r| > 0.8$). Strong correlation indicates the presence of the multi-collinearity problem in the process of inferential statistical analysis.

The results of the correlation analysis between independent variables are shown in Table 5.2. All values of correlation coefficient, values of Pearson correlation, are between -0.8 and 0.8 ($|r| < 0.8$), which confirms the absence of any strong interrelationship between the independent variables. This means that the study can proceed with inferential statistical analysis in the next part.

Table 5.2 Correlation analysis between independent variables (Pearson Correlation) (estimated by Programme of SPSS)

Factors/Variables	Control Variables				Independent Variables				
	Education	Age	Gender	Income	**Price (P_N)**	**Environmental Benefits (EB_R)**	**Special Benefits (SB_R)**	**Personal attitudes (PA_R)**	**Obsolescence Risks (OR_R)**
Education	1.000	0.260	-0.011	0.247	0.051	0.109	0.129	-0.092	-0.055
Age	0.260	1.000	0.105	0.330	0.034	0.053	0.076	0.007	-0.025
Gender	-0.011	0.105	1.000	0.175	-0.007	-0.085	-0.063	-0.018	-0.037
Income	0.247	0.330	0.175	1.000	-0.053	0.039	0.003	-0.034	-0.055
Price (P_N)	0.051	0.034	-0.007	-0.053	0.662	0.379	0.330	-0.039	0.089
Environmental Benefits (EB_R)	0.109	0.053	-0.085	0.039	0.379	0.775	0.336	-0.079	0.026
Special Benefits (SB_R)	0.129	0.076	-0.063	0.003	0.330	0.336	0.575	0.008	0.065
Personal attitudes (PA_R)	-0.092	0.007	-0.018	-0.034	-0.039	-0.079	0.008	0.567	0.306
Obsolescence Risks (OR_R)	-0.055	-0.025	-0.037	-0.055	0.089	0.026	0.065	0.306	0.614

5.5 Data Analysis

After Correlation testing, the main analysis was conducted by applying the structural equation method to determine the factors influencing the switching intention of customers to select remanufactured auto-products (SI). The analysis applied the theoretical framework of 'push–pull–mooring' (PPM) theory of migration, where 'push' factor (P_N), 'pull' factors (EB_R, SB_R), and 'mooring' factors (PA_R, OR_R) are considered. The SEM analysis was conducted in two steps: testing of the measurement model and testing of the structural model.

Testing of measurement model using CFA

Testing of the measurement model was performed using the technique of "Confirmatory Factor Analysis" (CFA). The CFA process is used to verify the 'goodness of fit' of the observed indicators in revealing the underlying unobserved variables to which they are supposed to be convergent - i.e. convergence validity. The CFA also helps to confirm the differences between underlying factors in the model: i.e. divergence validity (Garson, 2015; Schumacker & Lomax, 2010).

5.5.1 Testing of a minimum standard for factor-analytic purpose

Before processing the CFA, the survey data had to be tested for their adequacy to allow the procedures of factor analysis. The test was conducted using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, and the sphericity test of Bartlett.

Table 5.3 Kaiser-Meyer-Olkin (KMO) and Bartlett's Test (estimated by Programme of SPSS)

Testing		1st testing	2nd testing (Excluded PAR1Experience)
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.845	0.845
Bartlett's Test of Sphericity	Approx. Chi-Square	4712.010	4599.906
	df	300	276
	Sig.	0.000	0.000

The KMO statistic, initiated by Kaiser (1974), is a mathematical tool to measure adequacy of sampling or suitability of collected data for factor-analytic correlation matrices (Cerny & Kaiser, 1977). The KMO statistic is also referred to as measure of sampling adequacy (MSA). It is a measure of the proportion of variance among variables/indicators that is attributable to underlying factors (Glen, 2015; 2016). The KMO value ranges from zero to one - values closer to one suggests that the data is adequate for use in factor-analysis. A KMO value of less than 0.5 means that the collected data are unacceptable for factor analysis (Cerny & Kaiser, 1977), while a KMO value of 0.6 represents a mediocre baseline (Institute for Digital Research & Education, 2019). A KMO threshold value of 0.8 is used in this study to ensure the robustness of the collected data to be used in factor analysis (Glen, 2016).

Another measurement of the robustness of the survey data is Bartlett's test of sphericity. The Bartlett method statistically tests the hypothesis whether the (Pearson) correlation matrix of the collected data is an identity matrix (Glen, 2014a; Institute for Digital Research & Education, 2019). The null hypothesis (H_0) is that there is no difference between the correlation matrix of the survey data and the identity matrix. The alternative hypothesis (H_1) is that there is a difference between the correlation matrix of the survey data and an identity matrix.

Taken together as shown in Table 5.3, the KMO measure for the data used in this study is 0.845. (more than the threshold of 0.8). The KMO value thus shows that the data drawn from the sample survey are robust enough for use in factor analysis. Furthermore, the significance level of the Bartlett's test of sphericity is 0.000 (which is less than 0.01). The null hypothesis (H_0) is thus rejected at the 1 per cent level of significance, indicating that variables/indicators are related and are thus suitable for structure detection.

The KMO and Bartlett's tests show that the survey data are robust enough for use in factor analysis.

5.5.2 Convergent validity of factor analysis

Convergent validity, which is based on the principal component analysis, is measured by the value of communality in factor analysis. C*ommunality* is reflected by the sample variance, where an indicator correlating with all other indicators is accounted for by the factors or components (Härdle & Simar, 2007). In application to this study, communality estimates the extent the six unobserved selected factors that can explain the variance of the 25 observed indicators. High communality is better than low communality (Institute for Digital Research & Education, 2019).

There are two components to communality: initial and extraction communalities. Initial communality is estimation of the extent of the variance in each observed variable/indicator that is explained by all common unobserved factors (Härdle & Simar, 2007; IBM, n.d.). The value should be equal to 1.0 for correlation examination based on the principal components analysis. As shown in Table 5.4, all initial communality values are 1.000. It can be inferred that the indicators were perfectly fitted to cooperatively explain the selected factors.

Extraction communality is estimation of the extent of the variance in each observed indicator that is explained by an extracted unobserved factor (Härdle & Simar, 2007). Higher extraction communality of an indicator shows that the indicator is better represented by the extracted unobserved factors. This study adopted the level of 0.5 as the acceptable threshold. As shown in Table 5.4, only the extraction communality value of *PA_R1Experience* is 0.486, which is less than the minimum level of 0.5. That is, the indicator *PA_R1Experience* did not contribute to measuring the unobserved factors. As a result, the indicator of *PA_R1Experience* was removed from the analysis.

Because of the removal of the indicator, the testing procedure of CFA (the KMO and Bartlett's test), had to be rerun to check that the indicator was indeed omitted before proceeding to recalculate the value of communalities without the *PA_R1Experience,* as shown in Table 5.4.

Table 5.4 Values of Communalities
(estimated by Programme of SPSS)

Indicators/Variables	Included PA_R1Experience		Excluded PA_R1Experience	
	Initial Communality	Extraction Communality	Initial Communality	Extraction Communality
SB_R1Warranty	1.000	0.699	1.000	0.699
SB_R2Durability	1.000	0.590	1.000	0.597

Indicators/Variables	Included PA_R1Experience		Excluded PA_R1Experience	
	Initial Communality	Extraction Communality	Initial Communality	Extraction Communality
SB_R3Technology	1.000	0.585	1.000	0.587
SB_R4Functionability	1.000	0.576	1.000	0.583
SB_R5Serviceability	1.000	0.642	1.000	0.646
P_N1Expensiveness	1.000	0.610	1.000	0.601
P_N3Unreasonableness	1.000	0.740	1.000	0.754
P_N4Unworthiness	1.000	0.658	1.000	0.654
P_N5Uneconomy	1.000	0.684	1.000	0.685
EB_R1ResReduction	1.000	0.788	1.000	0.789
EB_R2ResCirculation	1.000	0.746	1.000	0.745
EB_R3WasteReduction	1.000	0.790	1.000	0.789
EB_R4EcoFriendly	1.000	0.800	1.000	0.799
PA_R2SecondHand	1.000	0.685	1.000	0.712
PA_R3Defection	1.000	0.687	1.000	0.773
PA_R4Unstandardisation	1.000	0.540	1.000	0.571
OR_R1Obsolescence	1.000	0.647	1.000	0.646
OR_R2NewnessFeeling	1.000	0.555	1.000	0.543
OR_R3Unfunctionality	1.000	0.717	1.000	0.727

Indicators/Variables	Included $PA_R1Experience$		Excluded $PA_R1Experience$	
	Initial Communality	Extraction Communality	Initial Communality	Extraction Communality
$OR_R5HighMaintenance$	1.000	0.663	1.000	0.664
$SI_R1Consideration$	1.000	0.689	1.000	0.681
$SI_R2Feasibility$	1.000	0.827	1.000	0.843
$SI_R3Acception$	1.000	0.822	1.000	0.828
$SI_R4Recommendaion$	1.000	0.770	1.000	0.771
$PA_R1Experience$	1.000	0.486	-	-

Source: estimated by Programme of SPSS

5.5.3 Divergence validity of factor analysis

The divergent validity of factor analysis was tested to confirm the optimal number of unobserved factors the 24 observed indicators explain after *$PA_R1Experience$* is removed. The process was tested using the Eigenvalue Scree plot. Eigenvalue is quality score of each component/latent factor. Higher Eigenvalue indicates statistical robustness of the represented real latent factors. Eigenvalues of more than one indicate robustness. As shown in Figure 5.2, the Eigenvalues of each component are plotted. The first six components have Eigenvalues or quality scores of more than one, which means that the six components are strong factors. There are thus six latent factors underlying the 24 observed indicators.

Figure 5.2 The number of generated components should be, analysed by Eigenvalue Scree plot (estimated by Programme of SPSS)

To identify the 24 indicators that enable estimation of one of the six latent components/factors precisely, rotated component matrix was applied as shown in Table 5.5. Theoretically, an underlying factor represents whatever its variables/indicators have in common. The rotated component matrix can be divided into two: component matrix and rotation or redistribution of factor loadings. Technically, the component matrix presents factor loadings estimated by Pearson correlations between the indicators and the latent components/factors. However, the problem of cross loadings means that a variable/indicator can have more than one considerable factor loading. The technique for solving this cross loading problem is rotation estimated by the method of variable maximization (varimax rotation) (Abdi, 2004).

Table 5.5 Rotated Component Matrix (estimated by Programme of SPSS)

Component	1	2	3	4	5	6
SI_R2Feasibility	0.893					
SI_R3Acception	0.848					
SI_R4Recommendaion	0.816					
SI_R1Consideration	0.793					
EB_R3WasteReduction		0.837				
EB_R4EcoFriendly		0.835				
EB_R1ResReduction		0.803				
EB_R2ResCirculation		0.759	0.316			
SB_R2Durability			0.745			
SB_R1Warranty		0.350	0.734			
SB_R5Serviceability			0.695			
SB_R3Technology			0.687			
SB_R4Functionability			0.666			
OR_R3Unfunctionality				0.813		
OR_R5HighMaintenance				0.794		
OR_R1Obsolescence				0.782		
OR_R2NewnessFeeling				0.633		
P_N3Unreasonableness					0.772	
P_N5Uneconomical					0.751	
P_N1Expensiveness					0.729	
P_N4Unworthiness					0.707	
PA_R3Defection						0.845
PA_R2SecondHand						0.766
PA_R4Unstandardisation						0.510

Source: estimated by Programme of SPSS

The rotated component matrix (Table 5.5) shows the first latent component/factor statistically measured by *SI_R2Feasibility*, *SI_R3Acceptance*, *SI_R4Recommendaion* and *SI_R1Consideration*. In comparison with the proposed conceptual model, the first component was the factor of switching intention (SI).

The findings of the confirmatory factor analysis are as follows:

- The second latent component/factor was statistically measured by *EB_R3WasteReduction*, *EB_R4EcoFriendly*, *EB_R1ResReduction* and *EB_R2ResCirculation*. In comparison with the proposed conceptual model, the second component was found to be the factor relating to the environmental benefits of remanufactured products (EB_R).
- The third latent component/factor was statistically measured by SB_R2Durability, SB_R1Warranty, SB_R5Serviceability, SB_R3Technology and *SB_R4Functionability*. In comparison with the proposed conceptual model, the third component was found to be the factor relating to the special benefits of remanufactured products (SB_R), including, for example, durability, functionality, better services and longer warranty.
- The fourth latent component/factor was statistically measured by *OR_R3Dysfunction*, *OR_R5HighMaintenance*, *OR_R1Obsolescence* and *OR_R2LackingNewness*. In comparison with the proposed conceptual model, the fourth component was found to be the factor relating to obsolescent risks of remanufactured products (EB_R).
- The fifth latent component/factor was statistically measured by *P_N3Unreasonableness*, *P_N5Uneconomical*, *P_N1Expensiveness* and *P_N4Unworthiness*. In comparison with the proposed conceptual model, the fifth component was found to be the factor relating to the price disadvantages of new products (P_N) *vis a vis* 'like new' remanufactured products.
- The last latent component/factor was statistically measured by *PA_R3Defection*, *PA_R2SecondHand* and *PA_R4Unstandardisation*. In comparison with the proposed conceptual model, the sixth component was found to be the factor relating to the personal attitudes of consumers towards remanufactured products (PA_R).

It can be seen from the above that the validity of the survey data with respect to the issue of their goodness of fit to the hypothesised factors proposed by the conceptual model is confirmed by the statistical test of Confirmatory Factor Analysis (CFA) (Figure 5.3). This means that the survey data were found to be robust enough to determine the correlation of the observed indicators (convergent validity). Furthermore, the observed indicators were able to measure the specific underlying unobserved factors that perfectly harmonised with the hypothesised factors of the proposed conceptual model of this study (i.e. divergence validity).

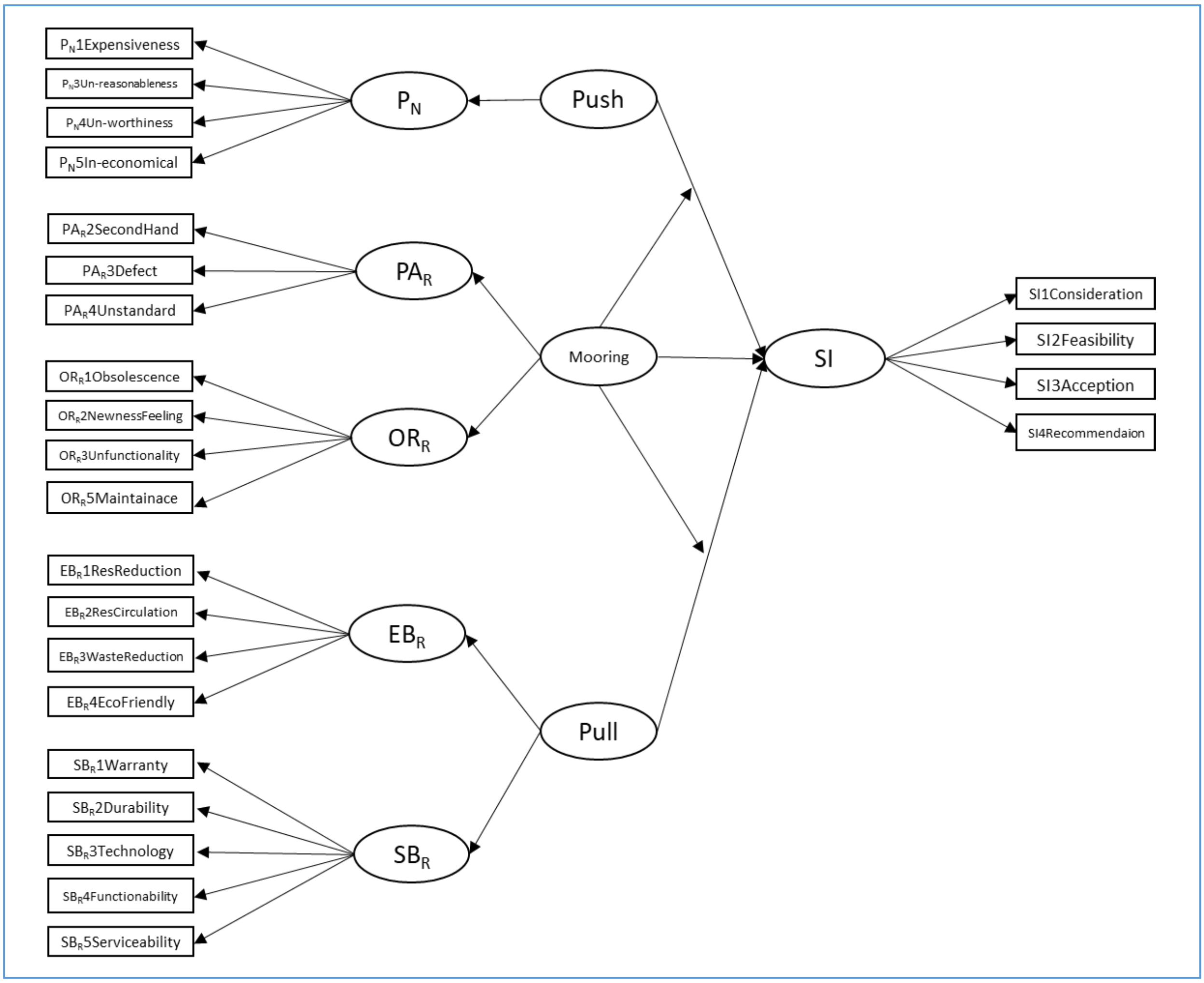


Figure 5.3 Adjusted Conceptual Model after Confirmatory Factor Analysis (CFA)

5.6 Analysis Results: Factors determining the switching intention of customers

After the measurement of model testing, there is the step of structural model testing, which is the main analysis.

Structural model testing (Main Analysis)

The main purpose of measurement of the adjusted conceptual model is to analyse the relationships among all underlying factors and the paths connecting them in the model. This analysis was conducted by using the structural equation model (SEM) in which the underlying hypothesised factors that determine SI, include a 'push' factor: P_N; 'pull' factors: EB_R and SB_R; and 'mooring' factors: PA_R and OR_R.

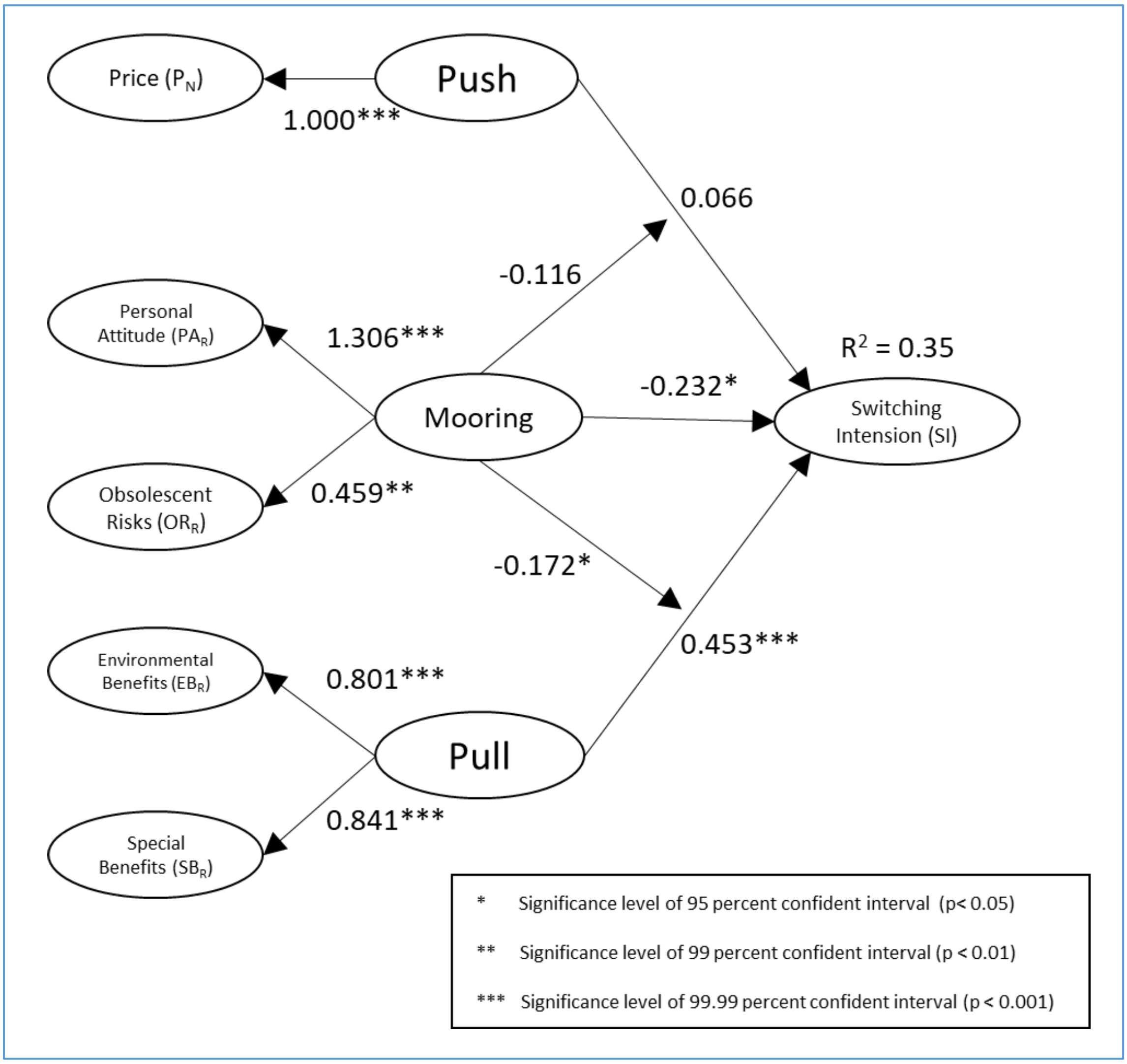
5.6.1 Testing the proposed hypotheses

The results of structural model testing identified the relationships and paths between all underlying factors as shown in Figure 5.4. The results are then compared with the proposed hypotheses.

First, regarding the 'push' factor, the 'push effect' had a positive impact on switching intention, thanks to the price disadvantage of new auto-products (P_N) *vis a vis* remanufactured products, even though the impact of it measured by the β coefficient was not found to be significant at the 5% level ($\hat{\beta}_1$= 0.066, p = 0.534 > 0.05) in Figure 5.4. Still, the evidence was sufficient as basis for accepting the hypotheses H1 and H1a.

Second, regarding the 'pull' factors, the 'pull effect' was found to have a significant positive influence on switching intention at less than the 1% level ($\hat{\beta}_2$= 0.453, p = < 0.001) in Figure 5.4. The 'pull effect' contained significant positive influences of the factors relating to environmental benefits of remanufactured auto-products (EB_R) ($\hat{\beta}_{2a}$= 0.801, p < 0.001) and the special benefits of remanufactured auto-products (SB_R) ($\hat{\beta}_{2b}$= 0.841, p < 0.001) in Figure 5.4. The evidence thus stands in support of the hypotheses H2, H2a and H2b.

Third, regarding the 'mooring' factors, the direct mooring effect is found to have a significant negative impact on switching intention at the 5% level ($\hat{\beta}_3$= - 0.232, p = 0.02 < 0.05) in Figure 5.4. The indirect mooring effect is found to have negative influence that would moderate the effect of the 'push' factor on switching intention, although estimate of the β coefficient in this regard does not reach the level that would make it significant at the 5% level ($\hat{\beta}_{4a}$= - 0.116, p = 0.053 > 0.05) in Figure 5.4. Also, the 'mooring' factor had a significant negative impact (significant at the 5% level) that would moderate the effect of the 'pull' factor on switching intention ($\hat{\beta}_{4b}$= - 0.172, p = 0.016 < 0.05) in Figure 5.4. The mooring effects consist of the significant positive impacts of the factors relating to customers' personal attitudes towards remanufactured auto-products (PA_R) ($\hat{\beta}_{3a}$= 1.306, p < 0.001) and obsolescence risk of remanufactured auto-products (OR_R) ($\hat{\beta}_{3b}$= 0.459, p=0.005 < 0.01) in Figure 5.4. Thus, the evidence deriving from the empirical analysis gives credence to hypotheses H3, H3a, H3b, H4a and H4b.



Notes: CMIN/DF = 1.500; RMSEA = 0.038; GFI = 0.931; AGFI = 0.901; CFI = 0.976; FMIN 0.924

Figure 5.4 Results of Structural Model Testing in a Form of Path Analysis (estimated by Programme of AMOS)

5.6.2 Testing effectiveness of the PPM theory to explain the switching behaviour of customers

To examine the effectiveness of the proposed structural equation model, the difference between the sample covariance matrix (S) and the implied covariance matrix (∑) is tested.

The null hypothesis (H0) is set to represent that the difference between the sample and implied covariance matrices is not significantly different (∑ = S). If the null hypothesis were found to be valid, the proposed model would be considered robust enough to fit the empirical data.

The implication of the alternative hypothesis (H1) in the event of rejection of the null hypothesis is that the proposed model would be considered to be not compatible with the observed data and the model is not empirically robust. However, the statistical indexes measuring the goodness-of-fit of the adjusted conceptual model proved that the hypothesised structural model was acceptable[25]. As a result, the alternative hypothesis (H1) is rejected in favour of the null hypothesis (H0). This indicates that the adjusted structural model based on the PPM theory of migration is able to explain customers' behaviour to switch from new auto-products to remanufactured auto-products. The test shows that 'push', 'pull' and 'mooring' factors, which constitute the inputs of the PPM model, explain 35 per cent of the total variance of switching intention (R^2 = 0.35).

- [25] The CMIN/DF ($\chi 2$/df) statistic at 1.5 satisfies by the critical baseline of CMIN/DF < 2. The minimum discrepancy to degrees of freedom ratios was found to be small enough, in the range of 2 to 1, to be indicative of acceptable similarity between the two matrices. In other words, the sample data matrix can be reasonably implied or predicted by the proposed model (Byrne, 1989; Marsh & Hocevar, 1985).
- The Root mean square error of approximation (RMSEA: $\sqrt{\max\{[\chi 2 - \mathrm{df}] \,/\, [(\mathrm{N}-1) \cdot \mathrm{df}]\,,0\}}$) was 0.038, which is satisfied by the baseline of RMSEA ≤ 0.05. This is also indicative of the goodness of fit of the proposed model to the sample data, because less error of parameter estimation than an acceptable level of fit means more accuracy of the implied covariance matrix. This, in turns, leads to be more likely to fit the observed covariance matrix (Hooper et al., 2008).
- Goodness of Fit Index (GFI: $1 - [\,\chi^2_{model} \,/\, \chi^2_{null}\,]$) was 0.931, which is satisfied by the baseline of GFI ≥ 0.90. This indicates that the implied covariance matrix (∑) of the proposed model can predict 93.1 per cent of the variance and covariance in the sample covariance matrix (S) (Schumacker & Lomax, 2010).
- Adjusted Goodness of Fit Index (AGFI: $1 - \{[\,\chi^2_{model} / \, df_{model}\,] \,/\, [\,\chi^2_{null} / \, df_{null}]\}$) was 0.901, which is satisfied by the baseline of AGFI ≥ 0.90. This indicates that the implied covariance matrix (∑) of the proposed model which is adjusted by degree of freedom can predict 90.1 per cent of the variance and covariance in the sample covariance matrix (S) (Schumacker & Lomax, 2010).

5.7 Discussion of Results

5.7.1 Factors determining the switching intention of auto-customers

In the investigation of customers' decision to switch to remanufactured auto-products, two components would need to be highlighted, as noted in the previous section of this chapter. The first one relates to the factors determining the switching behaviour of customers to switch to remanufactured auto-products. The second relates to the robustness of the push-pull-mooring (PPM model) to explain the switching behaviour of consumers in favour of remanufactured auto-products.

Regarding the factors influencing the switching intention of customers towards remanufactured auto-products, the results of the analysis based on the survey data were found to give support to all the hypotheses of the study. The 'pull' and 'mooring' constructs had significant direct effects on the switching intention of customers. The 'push' and 'pull' constructs had positive direct effects, while the 'mooring' construct had a negative direct effect on switching intention. The indirect mooring effect had negative significant impacts to moderate the direct effect of the pull effects on switching intention. The special benefits and environmental benefits of remanufactured auto-products had significant positive impacts on switching intention, while customers' attitudes and the risk of obsolescence with respect to remanufactured auto-products had significant positive impacts on the 'mooring' constructs, which, in turn, is found to have negative impact on switching intention.

Regarding path coefficients, the mooring construct are found to have the strongest total effect on the switching intention of customers, although the path coefficient of the direct effect of the 'pull' construct is greater than the direct effect of the 'mooring' construct on switching intention. This is because the 'mooring' construct affects switching intention both directly by itself and indirectly by moderating the effect of the 'push' and 'pull' constructs. With respect to the 'mooring' construct, the factor relating to personal attitudes of customers towards remanufactured auto-products had the highest significant coefficient. It is followed by the coefficient relating to the special benefits of remanufactured auto-products (longer warranty and better aftersales-service, in particular) within the 'pull' construct. The factors relating to environmental benefits and perceived obsolescence risks are also significant.

These findings contribute to the growing body of empirical literature on the complicated nature of customers' behaviour with respect to customers' decision to choose between new manufactured and 'like new' remanufactured auto-products. The findings also provide confirmation of the evidence about the influence of customers' attitudes towards auto-products.

As a 'mooring' construct, misconceived customers' attitude towards 'like-new' remanufactured auto-products does not only affect switching intentions, but also diminishes the influence of environmental and special benefits of remanufactured auto-products. It is apparent from the findings that auto-customers in Thailand rarely distinguish between remanufactured and second-hand auto-products with respect to the efficiency and effectiveness of product performance. This is akin to experiences elsewhere as reflected in the literature (Mugge et al., 2017; van Weelden et al., 2016). The findings also confirm the misconception of customers of auto-products that directly influences them to reject remanufactured products outright on grounds of perceived inferiority of product in terms of quality and robustness of performance (Hazen et al., 2012; van Weelden et al., 2016).

The study also found that the 'customer misconception' factor significantly moderates the relationship between perceived special and environmental benefits and poses a constraint on the switching intention of customers to shift towards remanufactured auto products. This notwithstanding, the findings extend the literature on the trend of 'environmentally-friendly' or 'green consumption' into the scope of remanufactured auto-products in Thailand. They also drive home the point that growing awareness about the social and private benefits of 'green consumption' (as in the use of remanufactured auto-products) would significantly heighten the level of switching intention in favour of remanufactured auto-products (Dokmai, 2018; Jiménez-Parra et al., 2014; Mugge et al., 2017); (Alqahtani & Gupta, 2017b; Lacy & Rutqvist, 2015; Otieno & Liu, 2016). On the other hand, the results reveal that the moderating impact of the 'mooring' factors, particularly the moderating effect of the personal misconception, which mitigates the motivating effect of the environmental and special benefits on the intention of customers to switch to remanufactured auto-products.

In unravelling the complex relationships of factors underpinning customer behaviour and customer intention to switch preference between products, it is found that the perception of customers about the quality and performance of 'like-new' remanufactured auto-products is a very important in determining switching decisions. Thus, the way remanufactured products are perceived by customers would directly or indirectly influence their decision to switch.

The individual attitude factor is contingent on macro-level factors that businesses and policymakers promote. First of all, the eco-friendliness of remanufactured products is often emphasized to promote the green initiatives of businesses. Moreover, rigorous quality control mechanisms exercised by businesses would add to the appeal of remanufactured products to customers. Also, enhancement of product performance reliability, innovative warranty offerings, and better after-sales services contribute to the favourable perception of customers about remanufactured auto products and their ability to perform better than new manufactured products.

5.7.2 Adequacy of the conceptual model based on the PPM theory

The structural equation model (SEM) was adopted to empirically test the efficiency of the proposed PPM model to analyse factors affecting the intention of customers to switch to 'like new' remanufactured auto-products. The statistical indicators of the goodness-of-fit proved a satisfactory fit ($\chi 2$/df = 1.5, RMSEA = 0.038, GFI = 0.931, and AGFI = 0.901), with R^2 = 0.35 , which is greater than 0.26, which is considered acceptable for social or behavioural sciences. (Cohen, 1988; Frost, 2018; Moksony, 1990). This indicates that the proposed model based on the PPM theory is able to explain customers' behaviour to switch from new manufactured auto-products to 'like-new' remanufactured auto-products. In addition, the model is shown to be capable of predicting the switching behaviour of customers. In this study, the model explained 35 per cent of the variance of customers' switching intention.

The predictive efficiency of a model (with $R^2 = 0.35 < 0.9$) may be considered weak. However, the satisfactory level of the relationship between exogenous and endogenous latent variables in respect of the variance accounting of structural models in social and behavioural sciences can be R^2 = 0.26 for substantial level; R^2 = 0.13 for moderate level; and R^2 = 0.02 for weak level (Rahman et al., 2013, p.123). The complexity of human behaviour cannot be understood or explained by any rigid laws that may duly apply to physical sciences. As a result, the application of regression models to studies in the social and behavioural sciences cannot be expected to explain or predict human behaviours with the same degree of efficiency as they can when applied to physical sciences (Yiannakoulias, 2016).

The usefulness of the PPM model and the SEM analysis is in its ability to expose the complexity of interrelationships between the factors influencing the switching behaviour of customers as between new remanufactured auto-products and 'like new' remanufactured auto-products in the context of the broader policy drive to promote transition of the automotive sector to circular economy.

5.8 Summary of the results of analysis and implications

The results summarised in Table 5.6 show that the 'pull' and 'mooring' constructs have a significant direct impact on customer switching intention. The environmental friendliness and the 'better-than-new' characteristic as well as the special benefits of remanufactured auto-products (i.e. longer warranty, more durable materials, upgradable technologies, more features/functions and better after-sales services) can influence automotive customers to opt for remanufactured auto-products. On the other hand, customers' misconceived attitudes towards remanufactured products and the perceived risk customers associate with remanufactured auto-products can, as a mooring force, moderate the 'pull' effects on the switching behaviour of customers. The moderating role of the 'mooring' factor was found to have an effect on the relationship between the 'pull' factor and the switching intention of customers. It may also be argued that the pull construct effect in the perceived attractiveness of the 'environmentally friendly' nature of 'like new' remanufactured auto-products, although can be mitigated by the effect of customers misconceived attitudes and perceived risks they associate with remanufactured auto-products, can reinforce customers' intention to switch to remanufactured products, thus making such products ever more popular.

Table 5.6 Summary of the results of analysis

Hypothesis	corresponding findings	Implication of the findings	Concordance with Hypothesis
The direct effect of the push factor			
H1	$\hat{\beta}_1$= 0.066	Push factor positively affects SI	Not significant at the 5% level
H1a	$\hat{\beta}_1$= 0.066	P_N positively affects SI	Not significant at the 5% level
The direct effect of the pull factor			
H2	$\hat{\beta}_2$= 0.453***	Pull factors positively affect SI	Accepted – significant at 0.1% level
H2a	$\hat{\beta}_{2a}$= 0.801***	EB positively affects SI	Accepted – significant at 0.1% level
H2b	$\hat{\beta}_{2b}$= 0.841***	SB positively affects SI	Accepted – significant at 0.1% level
The direct effect of the mooring factor			
H3	$\hat{\beta}_3$= - 0.232*	The direct effects of mooring factors negatively affect SI	Accepted – significant at the 5% level
H3a	$\hat{\beta}_{3a}$= 1.306***	PA negatively affects SI	Accepted – significant at 0.1% level
H3b	$\hat{\beta}_{3b}$= 0.459**	OR negatively affects SI	Accepted – significant at the 1% level
The indirect effect of the mooring factor			
H4a	$\hat{\beta}_{4a}$= - 0.116	The indirect effects of mooring factors moderate the association between the push determinant and SI	Not significant at the 5 % level
H4b	$\hat{\beta}_{4b}$= - 0.172*	The indirect effects of mooring factors moderate the association between the pull determinant and SI	Accepted – significant at the 5% level

Key:
* Significant at the 5% level
** Significant at the 1% level
*** Significant at the 0.1% level

Implications of results for research:

This study is among the few in the research literature that have adopted the PPM model from migration theory to investigate customers' switching behaviour. Remanufacturing is a sustainable solution for automotive industries, but only if the surrounding circular system or closed loop supply chain (CLSC) processes are appropriately configured (Stindt & Sahamie, 2014). This study will set a benchmark for research-based discussions on the role the remanufacturing industry, in general, and the automotive sector, in particular, as a strategy for transition to circular economy; and on factors that influence the propensity to switch to remanufactured auto-products of both customers and producers.

This study found that 'push effect' is the weakest driver among the three forces that impinge on the switching intention of customers of auto-products. In this respect, it is surprising that the price factor features as the weakest factor, whereas it stands out as a dominant variable in studies that do not consider the switching behaviour of customers (Agrawal et al., 2015; Hazen et al., 2017). On the other hand, 'pull factors', (including environmental and special benefits of remanufactured auto-products), and 'mooring factors', (including consumers' prejudice against remanufactured auto-products and their perceived risks towards such products), are found to have significant influence on customers' switching behaviour.

The findings suggest that the decision to switch to remanufactured auto-products is highly dependent upon micro-level factors of consumers' perception of remanufactured products via the 'mooring factors'. The 'mooring factors' not only directly affect consumers' switching intentions, but also indirectly affect switching intentions by moderating the influence of the 'pull' factor. Customers' personal attitude and perception towards remanufactured auto-products can directly and indirectly influence auto-customers to make to switch to 'like new' remanufactured auto-products. Overall, the results suggest as to which micro-level factors should be given more attention, and which significant factors have been ignored by other studies on the switching behaviour of customers.

Finally, it is worth noting that the empirical results of this study are broadly consistent with those of previous studies engaging the PPM model to examine the switching behaviour of customers (Bansal et al., 2005; Hazen, Boone, et al., 2017; Hazen, Mollenkopf, et al., 2017; Jung et al., 2017; Yacan Wang & Hazen, 2016).

Implications for policy and business decisions in the automotive sector:

The findings of this study provide the basis for some useful suggestions for remanufacturing circular enterprises in the automotive industry in Thailand. The factor relating to the special benefits of remanufactured auto-products (operating through the 'pull' factor) is, for example, found to have the strongest facilitating effect on switching intention. The special feature benefits include longer warranty, more durable materials, upgradable technologies, better functionality, and better after-sales services than is the case with new manufactured auto-products. This means that auto-remanufacturers should seek to increase their appeal to auto-customers through marketing strategies, such as better customer service, longer warranty offer, and selection of more durable materials.

Eco-efficient remanufactured auto-products (operating through the pull factor) is also a significant facilitating factor influencing consumers' switching intentions. This suggests that remanufacturing auto-enterprises would do better to develop green initiative strategies to hammer home to potential customers the environmental friendliness of their remanufactured auto-products.

In addition, the factor relating to consumers' possibly misconceived attitudes towards auto-remanufactured products (operating via the 'mooring' factor) is found to have the strongest inhibiting effect on customers' switching intentions. The factor can also have a moderating influence on the facilitating force of the 'pull' factor, including the special benefits and environmental benefits of remanufactured auto-products. This means that remanufacturing enterprises should, as a matter of priority, seek to resolve the prevailing misunderstanding of remanufactured auto-products among potential customers, and to clear all social resistance militating against the uptake of remanufactured auto-products in the market. Remanufacturers would also benefit from communicating aspects of the remanufacturing process, demonstrating the reliability and the price and quality competitiveness of remanufactured auto-products (Hazen, Mollenkopf, et al., 2017). That is Moreover, it would help remanufacturers to conduct surveys on customers' awareness and perception about the significance of circular businesses to obtain information and data underpinning market trends and customer profiles, including their knowledge about remanufacturing; their environmental awareness; their perceptions about the quality remanufactured products; and factors affecting their switching behaviour.

Policy makers, too, (at local, regional and national government levels) should seek to promote circular remanufacturing activities through support of public procurement of remanufactured products. Government should also initiate policy and regulatory measures to facilitate the development of remanufacturing enterprises.

Such initiatives include, among other things, a clear legal definition of remanufacturing; standard specification and quality certification of remanufactured products; and establishment of laboratories for testing and screening core components before they are put through the remanufacturing process. A mechanism should also be put in place that would facilitate the collection of end-of-life vehicles.

5.9 Conclusion

The factors that bear on customers in the course of switching to remanufacturing auto-products were empirically investigated in this chapter based on the PPM analytical model. The structural equation modelling (SEM) was adopted to analyse the survey data within the PPM framework.

The SEM was processed in two steps. The first step involved testing of the PPM analytical model for its adequacy. The process of "confirmatory factor analysis" (CFA) was conducted to verify the capacity of observable indicators and their fitness for measuring all unobservable factors in the proposed conceptual framework. The statistical techniques of communality and Eigenvalue scree plot were also used. Before conducting the CFA process, the Kaiser-Meyer-Olkin (KMO) and Bartlett's tests were conducted. The results of the tests confirmed the adequacy of the survey data for the purpose of conducting factor analysis. It was subsequently found through the CFA process that the 24 observed indicators (PA_R1Experience removed) are good fit for measuring all six unobservable factors (i.e. SI, P_N, EB_R, SB_R, PA_R and OR_R). Thus, the conceptual analysis based on the PPM framework of this study is confirmed by the CFA for its convergent and divergence validity.

The second step in the application of SEM involved testing of structural modelling of the relationships among all factors affecting switching intentions and the paths connecting them in the model. The results of the analysis identified the significant factors influencing the switching behaviour of customers in favour of remanufactured auto-products.

The findings of the study show that the decision of customers to switch to remanufactured products is significantly related to the special benefits (especially offers of better after-sales services, longer warranties and durability and functionality of products), and environmental benefits deriving from the use of these auto products.

Also, significant as factors explaining the switching behaviour of customers towards remanufactured auto-products are customers' attitudes towards such products; and the risk of obsolescence customers would attach to remanufactured auto-products. In particular, customers' misconceived attitudes towards the so-called 'like-new' remanufactured auto-products were found to have significant direct and indirect influence on customers' switching intentions. Furthermore, the findings show that the PPM theory is able to explain customers' behaviour to switch from new manufactured auto-products to 'like new' remanufactured ones, as it was empirically established that PPM is capable of predicting 35 per cent of the variance of customers' switching intention.

Chapter 6

Implications of the results of the empirical analysis for the responsiveness of remanufacturing enterprises to the challenges of transition to circular economy in the automotive sector

6.1 Introduction

Analysis of the behaviour of auto-customers to switch to remanufactured options (see Chapter 5) suggests that there is evidence of viable market for remanufactured auto-products in Thailand. But what would it take for auto-businesses to respond to the demands of the emerging market in remanufacturing? Transition to remanufacturing requires a period of adjustment for auto-businesses as it involves a whole raft of changes in their supply chain management. And businesses would need to appraise whether production shift towards remanufacturing is commercially as well as environmentally worth the while. Auto-businesses would therefore need a framework within which they could implement the shift towards producing remanufactured products on a sustainable basis. This chapter proposes such a framework in the form of a sustainable business model (SBM) for auto-businesses in Thailand to transition to circular economy through a switch towards remanufacturing. The questions to be addressed through the proposed SBM are derived from the results of the empirical analysis discussed in Chapter 5, which relate to the key factors influencing the switching behaviour of customers of auto-products.

6.2 SBM as framework for transition of auto-businesses to circular economy through remanufacturing

The SBM framework is developed based on sustainable business model archetypes of Bocken et al. (2014) and the business model canvas of Sterwalder & Pigneur (2004, 2010). It is also based on analysis of the factors that determine demand for remanufactured auto-products, as discussed in the previous chapter. As such, it is constructed as a matrix with four main pillars and ten sub-elements as shown in Figure

6.1. The four pillars are: value proposition, value creation, value delivery and value capture. These are discussed below.

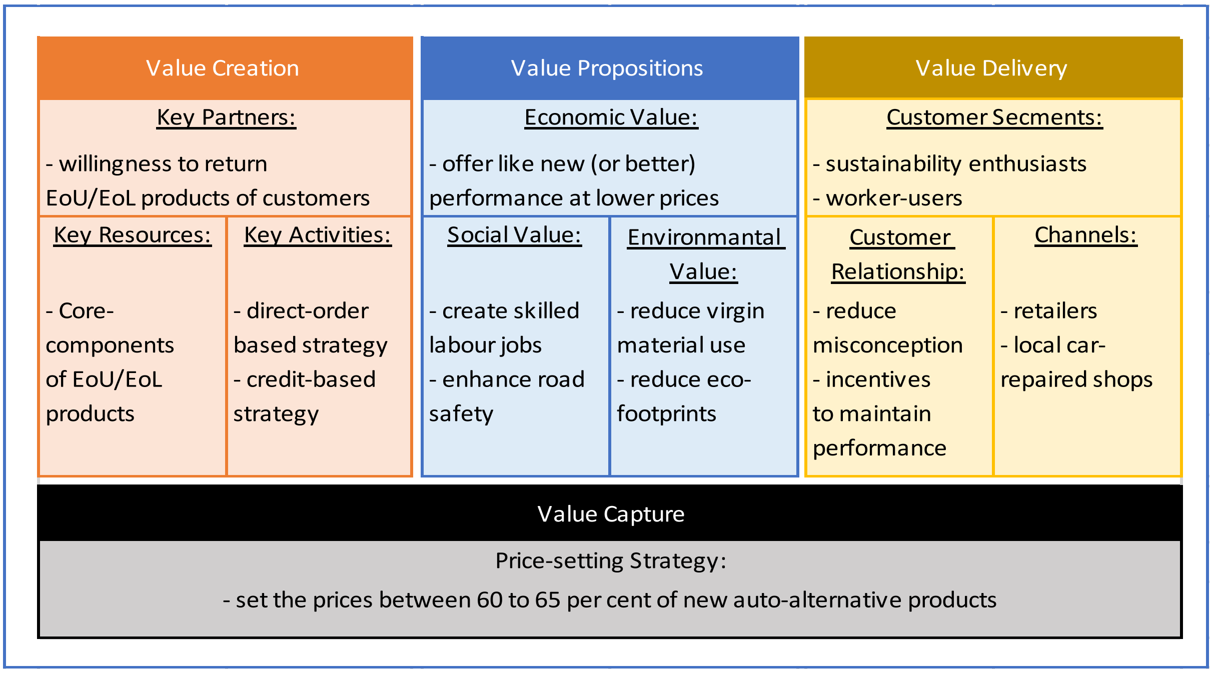


Figure 6.1 The initiated sustainable business model for automotive remanufacturing businesses in Thailand

6.2.1 Value Proposition

The value proposition is based on the hypothesis that an automotive remanufacturing business would offer higher values than linear economy competitors.

There is growing evidence to suggest that remanufacturing in the automotive industry would offer the maximum value of automotive parts and vehicles with at least 'like-new' functional conditions and life-time warranties, while also contributing to the minimum depletion of natural resources (Automotive Parts Remanufacturers Association: APRA, 2015; Osterwalder & Pigneur, 2010; Stahel, 2008). This gives remanufactured 'like new' auto-products a competitive edge over the products of traditional linear businesses. The revenue streams of the businesses would depend on resource efficiency whether the businesses can contribute to slowing, cascading, closing, or narrowing resource loops (Ellen MacArthur Foundation, 2015b). As a result, there needs to be systematic thinking around the design of products as well as collaboration with stakeholders to operate circular activities effectively, reverse logistics included. In turn, the businesses are in a position to distribute the created and delivered values to multiple incorporated stakeholders through circular supply chains (Bocken et al., 2018).

In other words, remanufacturing auto-businesses would offer not only automotive products and services, but would also participate as customers and stakeholders in a sustainable system of circular economy supply chain. The value proposition of remanufactured auto-products constitutes the economic, environmental and social elements of sustainability.

The remanufacturing business would be in a position to offer lower prices than what would be charged for new manufactured auto-products; but the quality, functionality and safety standard of remanufactured auto-products are expected to be the same or even better than that of the new manufactured auto-products. Also, customers are at advantageous position with remanufactured products as the suppliers are by design least vulnerable to supply chain problems, whereas availability of spare parts is a problem in case of new manufactured products when they cease to be manufactured in the event of technological obsolescence. Furthermore, remanufacturing businesses can provide a faster solution at higher uptime and lower out-of-service time than other circular activities. These economic values embedded in remanufactured products can be offered at prices 40 per cent lower than new manufactured products (Parker et al., 2015, p.37).

The environmental aspect of value proposition is recognised to be more significant in the case of remanufacturing businesses than it is for new manufactured products. Remanufacturing businesses offer high productivity of resources by reducing the use of virgin materials, waste, footprint, CO_2 emission, and water and energy consumption. Thus by remanufacturing end-of-use vehicles, and transforming waste into value, circular businesses in the automotive industry can reduce the environmental cost of production.

The social aspect of value proposition in remanufacturing activities is reflected in the creation job opportunities through engagement with the local partners and stakeholders. Remanufacturing requires input of skilled labour. Promoting remanufacturing therefore requires investment in training to add to the stock of relevant skills. Moreover, remanufactured auto-products can enhance road safety because the lower prices of remanufactured auto-products mean lower barrier to access high-quality equipment.

Thus, the sustainable value proposition of the SBM framework would allow businesses engaged in the remanufacturing of auto-products to discharge their responsibilities of corporate social responsibility (CSR).

6.2.2 Value delivery

Value delivery is the process of providing maximum value to customers using the product (Bhasin, 2017). The value delivery that the SBM framework enables remanufacturing businesses to achieve depends for its effectiveness on customer segments, customer relationships, and communication channels of businesses to access their customers (Osterwalder & Pigneur, 2010).

(i) Customer Segments

The factor relating to customer segments specifies the groups of customers that a business targets to reach and serve (Osterwalder and Pigneur, 2010, p.20). The proposed SBM, which is based on the findings of the empirical study in the previous chapter, suggests that the customer groups, including ‘sustainability enthusiasts’ and ‘business-users’, are potential target groups for businesses engaged in the remanufacturing of auto-products in Thailand.

It is established in the empirical analysis in Chapter 5 that environmental benefits constitute a significant factor influencing customers’ behaviour to switch to remanufactured auto-products. The customer group of ‘sustainability enthusiasts’ can be prospected to be the most promising customer target groups as they would be expected to promote environmentally friendly issues, thus enhancing their motivation to support sustainable products. Accordingly, it can be safely argued that features of the new manufactured auto-products are of less importance to them than the environmental benefits to be had from the remanufactured alternatives (Mugge et al., 2017).

Price competitiveness is another factor that gives remanufactured auto-products an edge over new manufactured alternatives, thus making remanufactured auto-products attractive to both potential customer target groups and casual supporters. Customers would normally look for vehicles and auto-products of competitive quality that deliver standard functions and can be purchased at competitive prices. It is apparent from the literature that remanufacturing businesses have the potential to achieve a 'win-win' position in that they can produce at reduced costs without compromising the quality and performance of the final product (Mugge et al., 2017).

Yet another significant influence on customers' switching behaviour is the factor of special benefits (including offers of better after sales services, longer warranties and use of more durable materials) that give remanufactured auto-products an edge over new manufactured alternatives. It is apparent from the survey discussed in the previous chapters that the incentives related to remanufactured products are more effective in attracting customers than the multi-function and high-technology based incentives embedded in new manufactured products. The survey data show respectively 86.6%, 85.4% and 84.8% of the respondents indicating incentives of 'better services', 'longer warranty period', and 'more durability' as factors that would influence them to switch to remanufactured auto-products. Meanwhile, 80.1% and 79.8% of the respondents selected the incentives of 'robust functionality', and 'higher manufacturing technology', respectively. While 'high manufacturing technology' is often associated with new manufactured products, albeit not necessarily, there is no good reason to presume that 'robust functionality' can only be had through the application of 'high manufacturing technology'. In other words, the newest models or most advanced technologies may not be able to meet the needs of auto-customers (Mugge et al., 2017).

The evidence obtained from the survey data suggests that customers whose choice of remanufactured auto-products derives from their concern about the issue of maintaining or continuing the performance of auto-products' are potential customers of remanufactured auto-products. This group of customers is also referred to as 'business-user' group (Kohpaiboon, 2011). This includes customers who use cars as an essential equipment for work and are chiefly concerned about the objective of maximising mobility performance subject to budget constraint. Such category of customers includes commuters, taxi drivers, carriers or delivery companies (Kohpaiboon, 2011).

The business-user group can be regarded as need-driven group in comparison with the group of sustainability enthusiasts. Initially, their evaluation with circular products might be negative, but would not reject the option if they can perceive that remanufactured auto-products can deliver the same or even better performance than new manufactured auto-products (Mugge et al., 2017).

(ii) Customer relationship

The element of customer relationship in the SBM framework addresses how circular remanufacturing businesses should establish good relationships with customer segments (Osterwalder and Pigneur, 2010, p.28). In remanufacturing economy, customers are essential stakeholders playing two roles as customers who purchase the remanufactured products, and as suppliers who return or 'reverse-logistic' the core components to complete the circularity remanufacturing loop.

Customers relationship with remanufacturing businesses is crucial for value delivery as they play a dual role as customers, who buy the remanufactured auto-products, and as suppliers of core-components or end-of-use auto-products. The question of customer relationship raises two issues for remanufacturing businesses: asymmetric information and special benefits. These issues are important for remanufacturing businesses to design marketing strategies that would encourage customer segments to switch to remanufactured auto-products, and also to maintain good relationship with them.

- *The issue of asymmetric information*

Results of the empirical analysis in Chapter 5 show personal attitude based on customers' misconception of the quality of remanufactured auto-products to be a significant barrier against initiatives to promote remanufacturing activities in Thailand. The misconception directly obstructs the switching intention of customers. Also, it indirectly diminishes the positive effects of other facilitating factors on the intention of customers to switch to remanufactured auto-products. This misconception is a result of information asymmetry. Information asymmetry is a major cause for the prevalence of unawareness of the benefits of remanufactured products. Hence the misconception of customers, in general, about the quality and performance of remanufactured auto-products and their contribution to sustainability (Hazen et al., 2017). The problem of asymmetry of knowledge about the quality, reliability and robustness of functionality of remanufactured products has implications for supply-chain productivity and sustainability (Hazen et al., 2017).

To resolve the information asymmetry problem, remanufacturing businesses would need to raise awareness. This would help reduce the misunderstanding of remanufactured auto-products among potential customers. The following two strategies can help remanufacturing businesses to resolve the information asymmetry problem by increasing awareness about remanufactured auto-products.

The first strategy is about communicating aspects of the remanufacturing process to customers. This is important as lack of knowledge about the remanufacturing process is a cause for the prevalence of misconceived views among customers – namely, that remanufactured products are inferior in performance to new manufactured products (Hazen et al., 2012). In the survey conducted for this study, more than half of the total respondents (51.8 per cent) would consider remanufactured products as second-hand products; and only less than one-third (29.2 per cent) could differentiate the performance between remanufactured products and second-hand products.

However, the fact is that to reach at least to the 'like-new' condition, remanufactured products have to be thoroughly treated, going through various stages, including grading or inspection, disassembly, cleaning, component reprocessing, reassembly and testing (Andrew-Munot & Ibrahim, 2013). There are two measures to reduce the perceived performance risk caused by the misconception of remanufactured products (Hazen et al., 2017). One suggestion is initiating a classification system based on transparency and traceability of the remanufacturing process. Such a system can help bring to light the condition of every product for potential customers to see before making any switching decisions (van Weelden et al., 2016). Another suggestion is to inform customers that as a circular economy activity, the remanufacturing process is in keeping with sustainability and environmental imperatives. This would inform customers about what to expect from specific remanufactured products - not only about the outer appearances but also about the history of the core components that make up the product, and the under-realised environmental benefits of remanufactured products (Hazen et al., 2017; Hazen et al., 2012; van Weelden et al., 2016).

The Second strategy for resolving the problem of information asymmetry is monitoring the contents of marketing and promotional activities with the view to enhancing the awareness and knowledge of customers about the 'like-new' condition of remanufactured products (van Weelden et al., 2016). This involves building profiles of consumers' experiences with respect to remanufactured auto-products (Mugge et al., 2017). According to the survey conducted for this study, more than two-thirds of the total respondents said that they did not have a good experience with remanufactured auto-products. This shows that remanufacturing auto-businesses in Thailand would need to redouble their efforts to raise the awareness of their customers and mitigate the problem of information asymmetry. This involves, for instance, offering customers longer trial periods as this would help to counter misconceived views about the performance risks of auto-products (van Weelden et al., 2016). It also involves offering customers access to utilisation of the services rather than ownership of products upon purchase. This is in keeping with business models based on the principle of sharing or performance economy (Bocken et al., 2016; Stahel, 2010).

Remanufacturing businesses could also offer customers marketing incentives, especially offering long warranty periods, which can enhance consumers' knowledge about evaluations of product quality (Alqahtani & Gupta, 2017b; Srivastava & Mitra, 1998). The principle underlying long warranty period is based on the recognition that only those remanufacturing businesses who are very confident about the quality of their auto-products would offer the incentive (Alqahtani et al., 2017; Noh & Borges, 2015). Moreover, performance standards and certifications can solve the misconception problem regarding the quality of remanufactured products (van Weelden et al., 2016). This is significant in view of the widespread misconception of customers about the quality and performance standard of remanufactured products. For example, the survey data used in this study show that almost 70 per cent of the total respondents would not consider remanufactured auto-products to have reliable performance standards. Certification of high-performance standards for remanufactured auto-products can reduce the problem of misconception about the quality and unreliability of auto-products. It would also reduce the problem of information asymmetry.

- *The issue of special benefits*

The second issue arising from business strategies for maintaining and strengthening the relationship of remanufacturers of auto-products with their customers is creating awareness of the special benefits deriving from remanufactured products among potential customers. These ‘special benefits’ refer to such factors as offers of better after-sales services, longer warranties and durability of products.

The empirical analysis of this study (see Chapter 5) has established special benefits of remanufactured goods as a factor that has significant influence on auto-customers to switch to remanufactured auto-products. According to the survey data, 86.6 per cent of the total respondents indicated the offer of ‘better services’ of remanufactured auto-products to be the most effective aspect of special-benefit that would persuade customers to switch to remanufactured auto-products.

The ‘better services’ that remanufactured products offer are contingent on the specific needs of customers. Normally, remanufacturers would consult their customers to build portfolio of needs customers would like to see served by remanufactured auto-products. The customer feedback would enable them to customise auto-products to fit the needs of their customers; but that depends on whether they have the skills and technological flexibility to cannibalise components from end-of-life products based on the customers' needs. Technological constraints on remanufacturers notwithstanding, customers would like to buy products that match their needs; and remanufacturers will gain customers’ loyalty as a result of their ever closer relationship with their customers. This can result in better material flows for the remanufacturers, which, in turn, can lead to reducing total costs because the materials used for remanufacturing can be re-customised and used by more customers (Sakao & Sundin, 2019).

According to the survey conducted for this study, the sources of special benefits associated with remanufactured auto-products vary in their appeal to customers: 86.6 percent of the respondents saw the special benefits of remanufactured auto-products in ‘better after-sales services’; 85.4 per cent in the ‘longer warranty period’ and 84.8 per cent in the ‘more durability’ of re-manufactured auto-products; 80.1 per cent in the ‘better functionality’ of auto products; and 79.8 per cent in the reliability and robustness of the technologies employed by remanufacturers of auto-products. These observations are in agreement with that of Mugge, Jockin and Bocken (2017) in the literature. The potential customer target groups of remanufactured products (‘sustainability enthusiasts’ and ‘business-user’) are said to be influenced by product-related incentives (Mugge et al., 2017). Moreover, these product-related incentives, the warranty incentive in particular, can indirectly signal to customers the ‘quality and reliability’ of the remanufactured auto-products (Alqahtani & Gupta, 2017b; Noh & Borges, 2015; Srivastava & Mitra, 1998). However, other groups of consumers, such as the group of ‘conservative critics’ (elder consumers) and the ‘expert technologists’, who do not normally promote circular-products, appear to be attracted to incentives due to the ‘functionality’ of remanufactured products (as in the former case), and due to the ‘technologies’ used in the remanufacturing of products (as in the case of the latter) (Mugge et al., 2017).

(iii) Channels of communication with customers

The channels of communication in the SBM framework represents the method as to how companies reach out to their customer segments to promote remanufactured products, and so to deliver value (Osterwalder and Pigneur, 2010, p.26). The absence of channels of communication with customers is a major cause of customers’ misconception about remanufactured products, as customers would not be able to have proper knowledge about and experience with remanufactured products (van Weelden et al., 2016).

According to the survey conducted for this study, more than half of the total respondents (51.8 per cent) were unsure about their experiences with remanufactured auto-products. Furthermore, 74.3 per cent of the total participants agreed that the remanufactured auto-products are not available via general retail channels. Because of their unawareness, there is the risk that consumers may neglect ‘like-new’ remanufactured auto-products as an alternative to new manufactured products (van Weelden et al., 2016).

An effective channel of communication can solve the problem of lack of demand for remanufactured auto-products by enabling businesses to promote awareness of customers about the advantages of 'like new' remanufactured auto-products over new manufactured alternatives (van Weelden et al., 2016). The existence of communication channels would thus enhance customers' perception of remanufactured auto-products and could influence their decisions to switch to remanufactured products (Matsumoto et al., 2018). In the development of the auto-remanufacturing industry in Japan in the early 2000s, retailers in repair shops were important players in shaping customers' perception of remanufactured auto-products. They offered the availability of remanufactured auto-products as an option, informed their customers what in essence remanufactured auto-products are, and provided them with cases of true self-experiences (Matsumoto et al., 2018). Moreover, the General Insurance Association of Japan found that almost three-fifths of Japanese consumers (58.5 per cent) who opted for remanufactured auto-products, were influenced by the recommendations of car-repair shops (General Insurance Association of Japan: GIAJ, 2014).

This means that encouragement of retailers and local car-repair shops to offer their communication channels is an important factor to consider to promote consumers' awareness and perception of remanufactured auto-products. This is particularly important at least in the preliminary stage of the marketing promotion of remanufactured automotive products.

6.2.3 Value creation

Value creation is a process that provides management of resources to be of greater utility to customers (Jorgenson, 2015). In this research, the value creation the SBM framework enables is mainly focused on the process of reverse logistics, because a successful strategy of reverse logistics directly relates to the efficiency of recovery of EoU/EoL products. Successful reverse logistics close the circular loop within the remanufactured circular supply chain (Alamerew & Brissaud, 2020).

The process to create values through the remanufacturing process needs collaboration between several stakeholders along the supply chain. The essential stakeholders in the remanufacturing supply chain are customers, (not only as customers, but also in their role as material suppliers); and business enterprises involved in manufacturing and remanufacturing activities (Jansson et al., 2017). The value creation in the SBM framework adopted in this study involves three key elements: key resources; key partners; and key activities.

(i) Key Resources

Core-components from end-of-use (EoU)/end-of-life auto-products (EoL) are the key resources featuring in the SBM framework, and represent the most important assets required circular businesses engaged in the remanufacturing of auto-products (Osterwalder and Pigneur, 2010). A major objective of remanufacturing enterprises is to offer to the market products that are reliable and robust in terms of quality and performance, that are cost saving and reduce waste to the minimum on a sustainable basis. The viability of this objective of remanufacturing depends on the conditions of the core components obtained through the reverse logistic mechanism, and also on the reconditioning process in the closed-loop supply chain (Casper & Sundin, 2018; Wei et al., 2015).

In the reverse logistic process, material flows of the core-components, especially those between businesses and customers (C2B), pose a major challenge for the circularity of remanufacturing supply chains. For instance, inefficiency of the C2B material flows leads to low quality and unusable core-components. This is because local customers would mishandle the disposal of core-components if they did not realise the value of their EoU/EoL products. Often, such customers would not make the effort to access structured approaches they would trust to earn them fair value for EoU/EoL products. In such cases, EoU/EoL products are immediately abandoned as waste and good-for-nothing (Jansson et al., 2017).

Returned core components with varying defects and conditions, which may be encountered in the reverse logistic process, have implications for the costs of the remanufacturing process (Kin, Ong, & Nee, 2014).

(ii) Key Partners

The key partners in the value creation process within the SBM framework are the customers who also play the role of suppliers of core-components (Osterwalder and Pigneur, 2010, p.38). Remanufacturing businesses would thus need to forge close links and build social capital with their customers to ensure not only the continuity of the C2B material flows, but also the return of core-components in good condition. Without any management mechanisms, the core-components extracted from EoU/EoL products returned by customers are often in poor condition, thus adding cost to the remanufacturing process. Yet another challenge for remanufacturing businesses is envisaged when, as often is the case, the C2B process of material flows is dispersed with unknown locations of EoU/EoL products (Jansson et al., 2017).

(iii) Key activities

The key activities in the value creation process within the SBM framework are central to the strategy for the development of remanufactured auto-businesses in Thailand (Osterwalder and Pigneur, 2010, p.36). The key activities are underpinned by mechanisms for forging win-win relationships between customers (as cores suppliers) and remanufacturers. This would require customers to be willing to return their EoU/EoL products for a fair compensation or incentive, on the understanding that remanufacturers would receive core-components in the best of conditions. Moreover, the incentives offered to customers can signal to customers that the remanufacturing business is driven by environmental issues and are therefore engaged in activities that would reduce waste form ELVs.

In this respect, it is 'direct-order-based' and/or 'credit-based' relationship mechanisms that are adopted in the case of auto-remanufacturing business in Thailand. According to the survey conducted for this study, it was found that the most common approaches that encourage customers to be willing to return their end-of-use auto-products is the 'direct-order-based' relationship (26 per cent). It was closely followed by the 'credit-based' relationship (25 per cent). The distribution of the sources of core-components that survey respondents most prefer are shown in Figure 6.2.

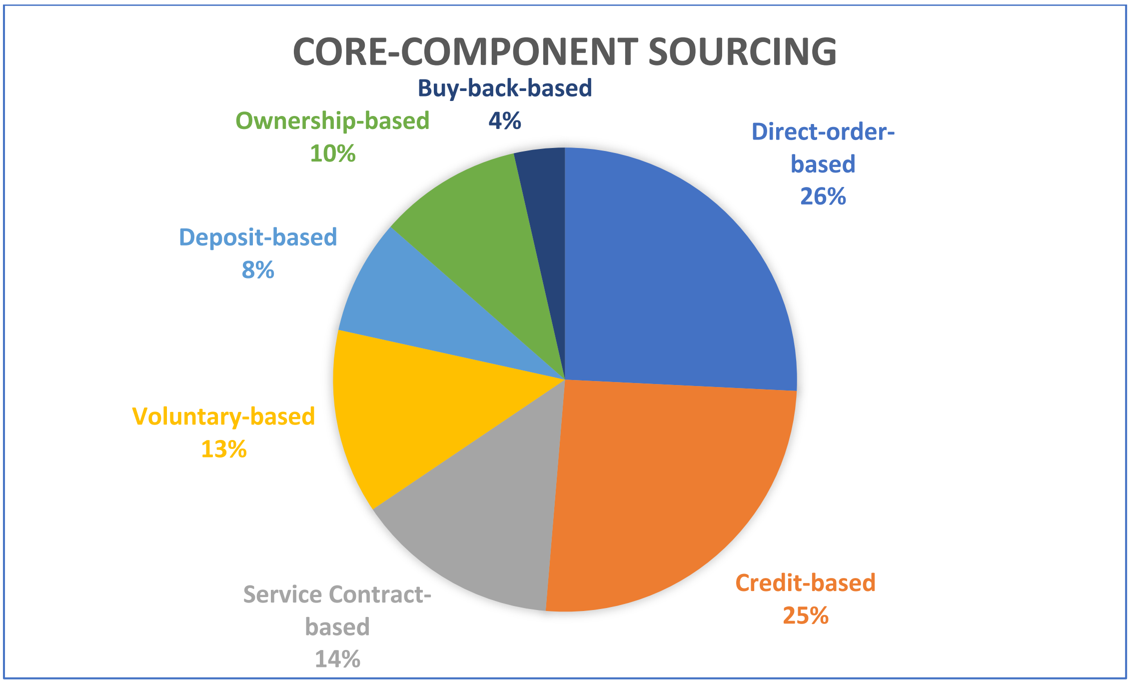


Figure 6.2 Core-component sourcing that can encourage customers' willingness to return end-of-life products (Survey data)

The 'direct-order-based' relationship is adopted by Mercedes Benz, one of the well-known companies, who uses the approach to run its worldwide remanufacturing businesses. In this approach, the customer places an order for end-of-use auto-products. This approach does not require remanufacturers to keep a huge inventory of core-components, because the cores will be directly supplied by their customers (Östlin, Sundin, & Björkman, 2008). Application of this model can help tackle problems due to the lack of cores and spare parts in the remanufacturing process (Östlin et al., 2009).

The order price of remanufactured auto-products depends on the quality of the core-components used. Thus, remanufacturers would need high quality-inspection capability to be able to evaluate the value of cores being returned. Also, remanufacturers would need to build trust with their customers to avoid conflicts with customers in the process of core valuation. Fixed price strategy can reduce the difficulty involved in the valuation process, but this has the effect of transferring risks associated with the quality of the core-components to the remanufacturers (Östlin et al., 2008).

The credit-based relationship is adopted by Volvo, one of the well-known automotive companies, which uses the approach to drive its worldwide remanufacturing businesses. In this approach, customers gain credits when they supply core-components to remanufacturers. The credits will be used for some discounts when ordering new remanufactured auto-products. The credit system does not limit the one-for-one principle as in the direct-order-based relationship; so customers are able to return their core-components or end-of-use auto-products in as large number as they possibly can (Östlin et al., 2008). This will allow remanufacturers to receive a high diversity of core-components.

There are two key variables in the calculation of proper credits. The first one is the quality level of the core-components. The system requires a quality inspection to assess re-manufacturability of the cores before providing credits. A low credit level is given for returned cores that are of low re-manufacturability; while high credit level is given for cores that are of high re-manufacturability. The mechanism will thus incentivise customers to maintain the functionality of products to be able to obtain high credit compensation upon return of EoU products (Östlin et al., 2008). This ensures remanufacturers to receive high-quality cores.

The second key variable in the calculation of proper credits is the type of the cores, which depends on the demand for the cores. Low demand for cores means that low credits will be given to customers for the EoU products they return to remanufacturers, while high credit level is given for highly demanded cores. The aim is for remanufacturers to incentivise customers to return their EoU/EoL products in good condition. This would allow remanufacturers to receive good quality cores on regular basis. Moreover, it provides an opportunity for remanufacturers to balance their demand for core-components with their supply of remanufactured products, thus reducing their inventory costs (Östlin et al., 2008).

The complexity of the system can cause uncertainty about returned credits from the customers' point of view; and the customers could be reluctant to return their cores or end-of-use auto-products (Sundin et al., 2016). The credit-based model would nonetheless be efficient over the long-term period, although this depends on remanufacturers maintaining fair deals for customers (Yuliawati, Pratikto, Sugiono, & Novareza, 2018). Thus, in the credit-based system, trust would bind remanufacturers to their customers, so that the transaction between them would result in win-win situations.

It is apparent from the above, and also from what can be elicited from the survey data used in this study, that auto-remanufacturing businesses in Thailand could possibly apply both models of relationship. The credit-based model is prominent for its ability to keep relationship and cooperation with customers on long-term basis. As such, it allows remanufacturers to receive core-components that are in good condition. On the other hand, the direct-order-based model of relationship is noted for its capacity to control the demand for and supply of core-components, especially in the case of remanufactured auto-products for which spare parts are not readily available (Östlin et al., 2008).

6.2.4 Value Capture

Value capture is a crucial point of concern for remanufacturing businesses as it can influence the switching behaviour of customers in favour of remanufactured products. It is a process through which remanufacturers seek to retain a certain proportion of the price/market value of 'like new' remanufactured auto-products similar to new manufactured products, without, however, compromising the quality-competitiveness of the remanufactured products on offer. Thus, the more the value remanufacturers seek to capture, the less attractive their offer becomes to customers. So, by moderating their profit margins, remanufacturers can persuade customers – particularly price-sensitive customers - to switch to remanufactured products, all other factors remaining constant. This is significant since price (as a push factor) is found to be a major factor that can influence the switching intention of customers.

Customers, in general, are, however, unduly sceptical, particularly about the quality of remanufactured auto-products; and do not often consider that remanufactured auto-products can be a good replacement for new manufactured alternatives (Neto et al., 2016). Consequently, their willingness to pay (WTP) for remanufactured products is generally lower than it is for new products. In the circumstances, price incentives and quality certification are mitigating factors that remanufacturers would resort to in order to persuade customers to switch to remanufactured products (Aras, Güllü, & Yürülmez, 2011; Frota Neto et al., 2016; Ovchinnikov, 2011). In other words, the drive of remanufacturers to maximize value capture is inversely proportional to the reluctance of customers to switch to remanufactured products.

According to the results of the survey conducted for this study, the average price that would induce most of the respondents to switch to remanufactured auto-products is 64.5 per cent of the prices of new products. This is consistent with most findings in the empirical literature, which establish that for remanufacturers to optimize their 'value capture objective', they would offer their products at prices which generally range between 45 and 80 per cent of the prices of new manufactured alternatives. This is, however, too wide a range; so to provide a more practical guideline, it is narrowed down to the 45 – 65 per cent range (Frota Neto et al., 2016; Y. Jin, Muriel, & Lu, 2007; Sundin et al., 2016; Lund & Hauser, 2010). The finding derived from the survey conducted for this study sets the average customer-desired value capture price at 64.5 per cent. Thus, to persuade customers in Thailand to switch to remanufactured auto-products, the prices of remanufactured auto-products would need to be set at levels, which as proportion of the prices of new manufactured auto-products, fall within the 60 to 65 per cent range. The distribution of respondents covered in the survey conducted for this study is concentrated in this range.

6.3 Discussion of untethered risks of product warranty to reality

A greater warranty strategy for remanufactured products is an effective promotion technique to appeal to customers (See 6.2.2 (ii)). According to the survey conducted for this study, the top three sources of special benefits associated with remanufactured auto-products in their appeal to customers are 'better after-sales services', 'longer warranty period' and 'more durability materials' with 86.6, 85.4, and 84.8 per cent of the respondents, respectively.

On the one hand, a greater warranty not only directly refers to more excellent customer protection, but it is also an indirect key message to signal the better quality of products. Customers can suppose that a great warranty indicates better product quality and reliability from remanufacturers. As a result, customers can ensure that the remanufacturer is good and well-reputed. It can also concordantly affect marketing demand (Liao et al., 2015; Liu, 2015; Otieno & Liu, 2016).

On the other hand, a greater warranty means a higher cost. In fact, remanufacturers would like to minimise the warranty costs. The remanufacturers have to bear more costs to ensure quality through assurance. Meanwhile, remanufacturers still have to maintain the relatively low price of remanufactured products compared with a new alternative as a significant characteristic and to be competitive. Therefore, a better warranty may decrease the profitability of remanufactured products. That is, a double-sided challenge of cost-quality-warranty trade-off has taken place (Alqahtani & Gupta, 2017b; Yuxi Liu, 2015).

It seems that a greater warranty for remanufactured products is likely to be untethered to practicable reality. Remanufacturers are, as a result, forced to create solutions to promise and assure their customers about good quality at relatively accessible prices of their remanufactured products. At the same time, the solutions can maximise the remanufacturer's profit. Therefore, an optimal combination strategy between profitability and costs of warranty for remanufactured products is needed. The optimal combination strategy should maximise the remanufacturer's profit, minimise the warranty and other relevant costs. Yet, the strategy remains to maximise the customers' confidence toward purchasing a remanufactured product and the attractiveness of the remanufactured product's price (Alqahtani, Surendra, & Gupta, 2018). There are several suggestions to initiate the optimal combination strategy of warranty for remanufactured products.

Firstly, the warranty is a must-have marketing strategy for remanufactured products, especially in term of a strategy to enhance market demand and profitability. Although offering a warranty on remanufactured products incurs a higher cost, it is an effective strategy to improve profits for remanufacturers by creating a higher demand (Alqahtani et al., 2018; Liao et al., 2015). A greater warranty is significantly related to a higher willingness to pay (WTP) for the remanufactured products, while the customers' WTP for a brand-new alternative product decreases (Liao et al., 2015). Liao et al. (2015) also found that remanufacturers have the highest profit in case the remanufacturer offers a warranty, but new manufacturers do not. However, new manufacturers have the highest profit in case that no warranty service is provided by both producer types of products (Liao et al., 2015, p.556). According to an empirical study by Alqahtani et al. (2018), offering a warranty affects 8.94 per cent of total costs but can increase at least 19.59 per cent of total profit (Alqahtani et al., 2018).

Therefore, better after-sale services as an approach of product warranty can offer a win-win situation to customers and remanufacturers. Consumers cannot assess the performance of remanufactured products before their purchase; a warranty in the form of better after-sale service is an effective strategy to drop the quality risk for customers. Also, the strategy enhances customers' perceived value encouraging sales of remanufactured goods. Moreover, better after-sale services mean an opportunity for remanufacturers to keep a good relationship with their customers to generate brand loyalty and a chance to monitor and collect their cores in the best condition.

Secondly, a preventive maintenance action is a complementary approach to warranty-marketing promotion to reduce warranty costs for remanufacturers (Alqahtani et al., 2018). The strategy can predict the best warranty approach and warranty period to offer customers specific remanufactured components and products. Remanufacturers can provide the action of preventive maintenance by facilitating embedded sensor technology implanted into the components and products to monitor and estimate their conditions and remaining lives. The activity that can effectively control warranty costs is based on the fact that a lower remaining products' life implies a higher expected warranty cost, while a higher remaining products' life indicates a lower warranty cost. As a result, remanufacturers can decrease the number of claims in warranty periods which, in turn, eradicate avoidable costs (Alqahtani & Gupta, 2017a). The preventive maintenance provision, together with a warranty offer, can enhance remanufacturers' profitability to become statistically significantly. The combined marketing promotion can drop the total cost by 18.27 per cent and improve profits by 10.99 per cent compared to providing a warranty without a preventive maintenance action (Alqahtani et al., 2018).

As a result, providing more durable materials is an approach of preventive maintenance activities to extend the remaining products' lives. It, in turn, can reduce the number of claims and decrease warranty costs for remanufacturers. Therefore, remanufacturers can combine more durable materials and warranty services to mitigate their remanufacturing costs and increase sales.

However, the analysis of optimal warranty length for remanufactured products is complicated in comparison to new-manufactured ones owing to the variable levels of usage and maintenance history. According to Otieno & Liu (2016), they found that a one-year warranty is the optimal choice for the remanufactured products that the sale price ranges between 737 to 30,000 US dollars. Arguably, Zhu & Yu (2019) found that the optimal warranty length for remanufactured products depends on the warranty efficiency of each entity that meets some conditions. For example, if the warranty cost of remanufacturers is lower than of manufacturers, the remanufacturers should provide a longer warranty period than manufacturers.

Therefore, providing a longer warranty period than one year is still questionable. The strategy is an effective promotion to attract customers' switching behaviours to select remanufactured products, but the more extended warranty period means exponentially increasing warranty costs (Otieno & Liu, 2016).

6.4 The quality challenge facing remanufactured auto-products

Ambiguity about the performance of auto-remanufacturing products is a significant source of personal misunderstanding of 'like-new' remanufactured products. This makes strategies for quality control of remanufactured products essential to ensure that the performance of remanufactured products is no less – indeed, if not even be better – than the performance of new manufactured products.

The empirical analysis in this study is based on assumptions about remanufacturers' value capture decisions that reflect on the prices of remanufactured auto-products, and about the quality of these products. That is, the price ratio of remanufactured auto-products to new manufactured products would need to be favourable from the vantage point of customers; and remanufacturing products have to be reconditioned to be at least 'like-new', if not even better, than new manufactured alternatives. Should these assumptions fail to hold, customers would be expected to have no confidence to switch to remanufactured products. In fact, any remanufactured auto-products that do not reach the 'like-new' quality level and the long warranty to back this, they cannot qualify to compete with new manufactured auto-products. This is a problem that is commonly observed where there are skill, information and technology shortfalls, as is the case in many developing countries. The problem is exacerbated in the absence of a third-party in terms of international standard certification of remanufactured auto-products[26] (Zhang & Chen, 2015).

Remanufacturers, especially individual SMEs, can be impeded from entry into the remanufacturing market because they cannot access the full knowledge set and specifications about the origins of EoU/EoL products obtained through the mechanism of reverse logistics. As a result, they need to conduct reverse engineering to understand the way how to remanufacture the product efficiently. This involves the processes of dismantling, reassembling, reconditioning the cores and remanufacturing products to quality levels that are at least as good as 'like-new' (Karvonen et al., 2017).

Customer suspicion about the quality and reliability of remanufactured products as a result of information asymmetry can cause what is known as 'the lemon market dilemma' that leads to ambiguity about the quality of remanufactured auto-products in the eyes of customers, and can even wreak havoc to the whole remanufacturing auto-market, thus downgrading the remanufactured products to be considered as second-hand or shoddy products (Akerlof, 1970; Kim, 1985).

6.5 The way forward for remanufacturing through collaboration

This problem can be mitigated through collaboration and knowledge sharing between independent re-manufacturers (IRs) and original equipment manufacturers (OEMs) (Kamigaki et al., 2017). The level collaboration in the auto-remanufacturing market between IRs and OEMs can produce a range of results that may provide the basis for the sustainable remanufacturing of auto-products (Kamigaki et al., 2017). According to Kamigaki et al. (2017), there are four cases of relationship schemes for

[26] According to Zhang and Chen (2015), remanufactured diesel engines in China achieved only the China-2 emission standard, while a new one in similar specifications reached the China-4 standard during their use phase in a life-cycle assessment. Indeed, the authors argue, considering the principles governing the remanufacturing process, the market would not even recognise China-2 standard engines as remanufactured products.

collaboration between IRs and OEMs that have implications for the environment, the economy and the society, as shown in Table 6.1 below.

Table 6.1 The implications of OEMs-IRs collaboration for sustainable remanufacturing of auto-products

Relationship cases	Environment		Economy		society	
	Resource saving	Pollution Risk	Job Creation	Income Allocation	Accessibility (Reasonable price)	Quality of life (Products' quality)
Collaboration (baseline)	O	O	O	O	O	O
No collaboration	O	X	OO	O	O	X
OEMs-Majority	O	OO	X	X	X	OO
IRs-Majority	O	X	OO	O	OO	X

Note: OO: good effects; O: relatively good effects; X: risks of not good effects

Source: Kamigaki et al. (2017)

Collaboration between enterprises in the auto-remanufacturing industry, especially between OEMS and IRs sharing knowledge and information about remanufacturing, is essential in order to maintain quality of remanufactured products at 'like-new' level, and also to achieve the best sustainability performance of remanufacturing activities (Kamigaki et al., 2017). Knowledge sharing through cooperation is considered to be more effective than enterprises going it alone to engage in reverse engineering which can't guarantee the required 'like-new' quality of remanufactured products (Karvonen et al., 2017). Sustained corroboration, however, calls for the application of appropriate business models; appropriate responses of remanufacturers to market pressures; and the provision of effective government support.

(i) Business models for collaboration

Business models for collaboration between original equipment manufacturers (OEMs) and independent remanufacturers (IRs) aimed at promoting remanufacturing enterprises would need to address the following points. First, conflicting business interests may arise, especially between OEMs and IRs. However, this potential conflict can be mitigated by the common vision to be found in the larger picture that features remanufacturing at the centre of the sustainability agenda of the automotive industry in which both OEMs and IRs have stakes.

Secondly, the business model would be expected to provide strategic options to address the social, economic, environmental and technological challenges facing the development of the remanufacturing industry. These challenges have significant bearing on both the demand and supply sides of the remanufacturing business. On the demand side, the question is how far customers are aware of and are willing to switch to remanufactured products. This has been discussed at length in Chapter 5. On the supply side, the challenge is one of achieving the best quality standard. This calls for access to technological and technical knowledge, including product designs and the dismantling and assembling of core-components. However, cooperation may be curtailed when manufacturers, particularly OEMs, are reluctant to share such knowledge with independent remanufacturers (IRs). What is therefore required is a new business model for win-win collaboration, taking into consideration the common advantages of remanufacturing accruing to both parties in the collaboration scheme. For example, Cisco (a well-known Information-Communication-Technology (ICT) enterprise) permits independent remanufacturers to remanufacture their EoU/EoL ICT equipment. Cisco benefits from this arrangement by charging customers who switch to the remanufactured ICT-products internet signal license fees (Xia & Zhang, 2019).

Decentralised strategies for remanufacturing could possibly reduce adverse impacts on the environment, while increasing supply chain revenues. According to Zhou *et al.* (2013), auto-manufacturers or OEMs do not directly engage in remanufacturing themselves, but adopt a decentralised approach by authorising others (IRs) on the supply chain to remanufacture auto-products, as this would reduce cost for them. That is, once an OEM authorises the remanufacturing of the parts it uses to independent remanufacturers, its component suppliers will strategically react by cutting their remanufactured component price to maintain their market share against competitors (Zhou et al., 2013).

Furthermore, the presence of IRs may actually be helpful to OEMs, especially in cases of production of high-quality brand products (Agrawal et al., 2015). According to Agrawal, Atasu and Van Ittersum (2015), if OEMs opt to remanufacture the parts themselves, they can adversely affect the perceived value of their 'like new' products by about eight per cent of consumers' willingness to pay (WTP) for these products, mainly due to cost of cannibalisation and its price implication for the remanufactured auto-product. If, however, the remanufacturing task is undertaken by IRs, the arrangement would have a positive effect on the perceived value of their products by around seven per cent of consumers' WTP for the products, because IRs produce remanufactured auto-parts at competitive prices (Agrawal et al., 2015). Thus, ignoring IRs instead of collaborating with them, would run against the commercial interests of the OEMs.

(ii) Market and policy drivers of collaboration initiatives

Marketing pressures can be effective in promoting collaboration between OEMs and IRs. There should be a two-way communication mechanism that would allow manufacturers (OEMs) to share technical knowledge to independent remanufacturers of auto-products. Remanufacturers can also share information to develop product designs for promoting remanufacturing activities (Jansson et al., 2017).

Policymakers would also be expected to encourage cooperation between OEMs, IRs, product designers and associated organisations. Policymakers facilitate remanufacturers to access technical information about quality standards, product designs and assembly, which OEMs are often reluctant to share to independent remanufacturers. Policymakers can also provide remanufacturers support services, including workshops and other training programmes, as well as legal and regulatory mechanisms that incentivise collaboration between OEMs and IRs. They can also set up information networks that would facilitate collaboration between remanufacturers, OEMs and academia; help improve product designs; and promote the diffusion of remanufactured auto-products. Policymakers can also initiate collaboration between designers, OEMs and EoL stakeholders, as in the case of the EU initiated project of universal chargers for smart phones that is promoted with the over-riding aim of reducing e-waste (European Parliament and Council, 2020).

6.6 Conclusion

This chapter has sought to shed light on challenges on the supply side of remanufacturing as a strategy for transition to circular economy. This analysis is conducted within the framework of a sustainable business model (SBM) for the development of remanufacturing activities in the automotive industry of Thailand. However, insofar as supply cannot be expected to create its own demand, this study has principally concerned itself with the market for remanufacturing, and, particularly, factors influencing the switching behaviour of customers towards remanufactured auto-products (Chapter 5). The study finds that there are economic, social and environmental factors that come into play when customers choose between 'like new' remanufactured auto-products and new manufactured auto-products. Remanufacturing businesses would be expected to address these factors to have a clear picture of the remanufacturing market, and make supply-side decisions regarding issues about remanufacturing value proposition, value delivery, value creation and value capture in the context of the sustainable business model (SBM) discussed in this chapter.

Thus, given demand for remanufactured outputs, the question for remanufacturing businesses becomes how best to tap the market without compromising their commercial interests; the interests of customers regarding the price and quality of auto-products; and the common social interest regarding environmental sustainability. While customers have the options to switch between 'like new' remanufactured and new manufactured auto-products, it remains for remanufacturers to settle the remanufacturing market by deciding on their 'value capture' at levels that are consistent with the 'willingness to pay' of customers. For instance, the empirical results of this study based on survey data show the average customer-desired value capture price for remanufactured auto-products at 64.5 per cent of the market price of new manufactured auto-products. Thus, to persuade customers in Thailand to switch to remanufactured auto-products, the prices of remanufactured auto-products could be set at levels, which as proportion of the prices of new manufactured auto-products, fall within the 60 to 65 per cent range.

It is also important that individual remanufacturers (IRs) engage with original equipment manufacturers (OEMs) and EoL stakeholders in collaborative initiatives to keep them informed about remanufacturing markets and about the technologies and skills that would be required for improving the remanufacturing of automotive products.

Chapter 7

Summary and Conclusions

7.1 Introduction

The major findings of this study, which are reported in Chapter 5, relate to changes in the behaviour underlying customers' decisions in the course of transition to a circular economy in the Thai automotive sector. There are two aspects to the discussion of the remanufacturing market, which is central to the bigger issue of transition to a circular economy. The first aspect relates to the factors determining the decision of customers to switch to remanufactured auto-products. This is an empirical question which is investigated using the 'push-pull-mooring' (PPM) model of migration. The model is tested for its adequacy and relevance to the switching behaviour of customers in favour of remanufactured auto-products through the application of the structural equation model (SEM). The second aspect of the discussion of the demand side of remanufacturing is the implication of customers' switching behaviour for the response of remanufacturing enterprises in terms of remanufacturing value proposition, value delivery, value creation and value capture, which are discussed within the framework of the sustainable business model (SBM).

The empirical analysis of this study is based on survey data elicited through the administration of online and paper-based questionnaires. A sample of 401 Thai customers of automotive products were randomly selected to participate in the survey process. However, after cleaning out ineffective responses, 342 responses (n=342) were used as basis for data analysis.

The survey data were used to test the hypotheses of the study based on the PPM conceptual framework through the application of the SEM. for addressing the factors that influence the switching behaviour of customers of auto products. This method was adopted for its merit of capturing the complexities of switching behaviour of customers due to the effects of the 'push' and 'pull' factors and the direct & moderating effects of 'mooring' factors in the PPM migration model.

The remainder of this chapter is in three parts. In the part following this introduction a summary of the major findings of this study is presented and their contribution to the body of knowledge about the role of customers in the wider strategy of transition to circular economy discussed. This is followed by a discussion of the policy implications of the findings of the study. In the third and last part, the limitations of the study and suggestions for future studies are presented.

7.2 Summary of findings and contribution to knowledge

7.2.1 The Supply-side Study

In the supply-side study, the factors influencing automotive manufacturers in Thailand's to develop remanufacturing businesses are investigated by using collected data in Thailand's automotive industry of Chaowanapong et al. (2017). Results of the analysis on the supply-side show that on average, 'Product maturity factor' is the most influential determinant affecting the decision-making of automotive companies in Thailand. This is followed by the factors of 'Financial remanufacturing costs', 'skilled workers unavailability' and 'Technical barriers', respectively.

The supply-side findings contribute to reinforcing a literature stream on empirical knowledge on the complex factors influencing products' behaviour on decisions to develop a 'like new' remanufactured auto-business. The importance of product maturity in the findings as to the most influential factor affecting supply-creation also empirically confirms the efficacy of a strong demand creating its supply, even in an emerging market in a developing country like the auto remanufacturing market in Thailand.

The findings point out some prioritised issues that have to be borne in mind before initiating a new remanufacturing business in Thailand. This is not just the issue of customers' behaviour affecting the length of the product maturity period, but also the capacity to manage cores and reverse-logistics, which are essential issues behind the remanufacturing financial costs. As a result, some marketing and promotion strategies are needed to encourage these relevant CE activities.

Cooperation between remanufacturers and prosumers (consumers + producers) is essential to prolong the mutuality stage of the remanufactured auto products. It is the role of the prosumers as customers to create sustainable demand. Simultaneously, the prosumers have another role to be suppliers to return cores in the best condition into the CE cycle to complete the closed-loop system. The willingness to return the cores is essential for remanufacturers to reduce their remanufacturing costs in the long run.

Also, cooperation between automotive producers is needed, especially between OEMs/OERs and IRs. To promote sustainability through a transition of the automotive industry to the remanufacturing CE model on a sustainable competitive scale, OEMs/OERs should share their product design, specific technical knowledge and equipment. While IRs should distribute their remanufacturing experiences and local market demand conditions in exchange. This process will effectively mitigate technical barriers in the market.

7.2.2 The Demand-side Study

Moving on to the demand-side study, results of the analysis of factors influencing the switching intention of customers in favour of remanufactured auto-products based on the survey data were found to give support to all the hypotheses of the study.

The 'push' and 'pull' constructs are found to have positive direct effects, and the 'mooring' construct to have negative direct and indirect effects on the switching intention of customers. The indirect 'mooring' effect is significant for its negative impacts by moderating the direct effect of 'pull' effects on the switching intention of auto-customers. The special benefits (especially offers of better after-sales services, longer warranties and more durable materials), and the environmental benefits of remanufactured auto-products had significant positive impacts on switching intentions, while customers' attitudes and the risk of obsolescence with respect to remanufactured auto-products had significant positive impacts on the 'mooring' constructs, which, in turn, are found to have indirect negative impacts on switching intentions.

Regarding path coefficients, the 'mooring' constructs are found to have the strongest total effect on switching intentions, although the path coefficient of the direct effect of the 'pull' construct on switching intentions is greater than the direct effect of the 'mooring' construct. This is because the 'mooring' construct affects switching intentions both directly by itself and indirectly by moderating the effect of the 'push' and 'pull' constructs. With respect to the 'mooring' construct, the factor relating to personal attitudes of customers towards remanufactured auto-products had the most significant coefficient. It is followed by the significant coefficient of the special benefits of remanufactured auto-products within the 'pull' construct, longer warranty and better after-sales services. The factors of environmental benefits and perceived obsolescence risks are also found to be significant.

These findings contribute to the growing body of empirical knowledge on the complicated nature of customers' behaviour with respect to decisions to choose between new manufactured and 'like new' remanufactured auto-products. The findings also provide empirical confirmation of evidence about the influence of customers' attitudes on transition to the closed-loop circular economy of the automotive market in Thailand.

The stigma customers usually attach to 'like-new' remanufactured auto-products does not only affect switching intentions, but also diminishes the influence of environmental and special benefits. It is apparent from the findings that automotive customers in Thailand rarely distinguish between remanufactured and second-hand auto-products with respect to the efficiency and effectiveness of the performance of auto-products. This is akin to experiences elsewhere reflected in the relevant literature (Mugge et al., 2017; van Weelden et al., 2016). The findings also confirm the misconception of customers of auto-products that would directly prompt them to reject remanufactured products outright on grounds of perceived inferiority of product quality and performance (Hazen et al., 2012; van Weelden et al., 2016).

The study also found that the 'customer misconception' factor significantly moderates the relationship between the perceived special and environmental benefits of 'like new' remanufactured auto-products, and poses a constraint on the switching intention of auto-customers to shift towards remanufactured auto-products. It is apparent from the findings that remanufacturing of automotive products has a good chance of facing a thriving market in Thailand on grounds of its environmental appeal to customers. The findings also suggest that growing awareness about global environmental concerns would significantly heighten the level of switching intention in favour of remanufactured auto-products. This is consistent with the findings of other studies (Jiménez-Parra et al., 2014; Mugge et al., 2017; Dokmai, 2018; Lacy and Rutqvist, 2015; Otieno and Liu, 2016; Alqahtani and Gupta, 2017). On the other hand, the results reveal the moderating impact of the 'mooring' constructs, particularly the moderating effect of the 'personal misconception' factor, which mitigates the motivating effects of the environmental and special benefits of 'like new' remanufactured auto-products on the switching intention of auto-customers.

In unravelling the complex relationships in customers' behaviour and their intention to switch to remanufactured auto-products, it is found that the perception of customers about the quality and performance of 'like-new' remanufactured auto-products is a very important factor in determining switching decisions. Thus, the way remanufactured products are perceived by customers would directly or indirectly influence their decision to switch.

Customers are normally sensitive to changes in the relative prices of 'like new' remanufactured and new manufactured auto-products; and all other factors relating to 'pull', 'push' and 'mooring' constructs remaining constant, customers would be inclined to switch to 'like new' remanufactured auto-products when the price advantage of these over the new manufactured alternatives becomes clearly apparent. However, the results of the empirical analysis in this study do not show price as a push factor to have a significant influence on the switching decisions of customers. This has implications for the decision of remanufacturers of auto-products with respect to the 'value capture' practice, which is represented by the ratio of the price of remanufactured products to the price of new manufactured products. However, no significant evidence has been found in this study to suggest that customers would switch to remanufactured auto-products if remanufacturers reduce the rate at which they seek to capture value. As a result, price promotion may not be a good strategy in this case. On the other hand, the empirical analysis of this study based on survey data (see Chapter 6) found the average customer-desired 'value capture' price for remanufactured auto-products to be 64.5 per cent of the market price of new manufactured auto-products. This means, to persuade customers in

Thailand to switch to remanufactured auto-products, the prices of remanufactured auto-products could be set at levels, which as a proportion of the prices of new manufactured auto-products, fall within the 60 to 65 per cent range.

The individual attitude factor is contingent on macro-level factors that businesses and policymakers promote. First of all, the eco-friendliness of remanufactured auto-products is often emphasized to promote the green initiatives of businesses. Moreover, rigorous quality control mechanisms exercised by businesses would add to the appeal of remanufactured products to customers. Also, enhancement of the reliability of product performance, innovative warranty offerings, and better after-sales services contribute to the perception of customers about 'like new' remanufactured auto-products and their ability to perform better than new manufactured products.

The switching behaviour of customers between 'like new' remanufactured and new manufactured auto-products is a major influence on the decision of automotive enterprises to engage in the remanufacturing of auto-products. As discussed in Chapter 6, the responses of automotive enterprises to shift the automotive market towards 'like new' remanufactured auto-products are best managed in the framework of the sustainable business model. This would enable them to appraise the value of remanufacturing activities not only from their own commercial vantage point, but also in terms of the implications of such ventures for the wider objective of sustainability, and more particularly, for transition of the automotive industry in Thailand to a circular economy through the engagement of auto-enterprises in remanufacturing activities.

A major contribution of this study consists in the findings of the empirical analysis of the factors influencing customers' switching decisions as between new manufactured auto-products and 'like new' remanufactured alternatives, and also on how enterprises in the automotive industry would respond to customers' switching behaviour through evaluation of remanufacturing activities in terms of value proposition, value delivery, value creation and value capture. As noted above, the findings central to this study show that the decision of customers to switch to remanufactured products is contingent upon the special benefits (especially offers of better after-sales services, longer warranties and more durable materials), and environmental benefits deriving from the use of remanufactured auto products, customers' attitudes towards remanufactured auto-products, and the risk of obsolescence customers would attach to such products. In particular, customers' misconceived attitudes towards the so-called 'like-new' remanufactured auto-products were found to have a significant direct and indirect influence on customers' switching intentions.

This study is predicated on the presumption that supply activities, market trends and even innovative activities are generally demand-driven. Hence, corporate decisions and government policy on such issues as, for example, research and product development, marketing strategies and environmental protection, would be expected to benefit from the empirical findings of this study.

7.3 Policy implications and recommendations

It is worth noting that remanufacturing auto-businesses are at an early stage of development in Thailand. Moreover, remanufactured auto-products are not yet widely adopted, and, indeed, most customers would recognise remanufactured products to be no different from second-hand products, and hence putatively inferior to new manufactured products in terms of quality and performance. This is because of misunderstanding of customers', lack of awareness and misconceived perception of 'like new' remanufactured auto-products due to the asymmetric distribution of information and knowledge about such products. The findings of this study suggest that there is scope for policy intervention to raise stakeholders' awareness about the importance of remanufacturing activities as part and parcel of the broader strategy for transition to circular economy, and about the robustness of remanufactured products in terms of quality, safety and environmental impact. Thus, based on the results of the study, the following policy recommendations are suggested.

7.3.1 Measures for increasing customers' awareness of the significance of remanufacturing and of the quality and performance merits of remanufactured products.

Insofar as unawareness about remanufacturing is a result of asymmetric distribution of information across market segments, policy should seek to adopt control and regulatory measures, so that more and more people would come to know about remanufactured products and the advantages of switching to such products. The focus of policy should be – albeit not exclusively – on the demand side of the remanufacturing issue, because it is widely recognised that businesses often respond to customers.

Thus, for customers to be attracted to 'like new' remanufactured auto-products, they would need to be informed about what remanufacturing activities involve, and about remanufactured auto-products regarding questions about their quality, 'value for money', safety and environmental impact. In this respect, policy would do well to start with a clear legal definition of remanufacturing in the Thai automotive market, so that potential customers would not confuse remanufactured auto-products with second-hand products. The definition of remanufacturing should also be consistent with the international definition, as this would help customers to distinguish between waste and end-of-life (EoL) or end-of use (EoU) products, which constitute the core-components for remanufacturing.

Policy should also engage in the enhancement of customer perception of remanufactured auto-products through standard specification and warranty for quality certification. These official marks of standards and certification would confirm to customers that the products have been thoroughly tested and have fully satisfied the requirements of international standards.

Policymakers should also seek to contribute to the 'reputational capital' of the remanufacturing industry by increasing awareness of the public about the advantages of remanufactured auto-products in terms of quality, functionality, price competitiveness, safety and environmental impact. Thus, they should promote skill development through training programmes including workshops to encourage remanufacturing auto-businesses to reduce end-of-life vehicle (ELV) waste and create local jobs, and create the framework for the development of 'performance economy' to encourage customers of auto-products to shift from being owners of auto-products to being users of the services of such products (Stahel, 2010). Public organisations should take the lead in the procurement of remanufactured products and comply with the 'reverse logistics' arrangement concerning EoL/EoU materials as an activity of corporate social responsibility (CSR), thus paving the way for private sector organisations and households to follow suit. For remanufacturing to flourish, the government would be expected to espouse a circular economy, in general, and remanufacturing, in particular, to feature as part and parcel of industrial and environmental policy.

7.3.2 Measures to improve the environmental and economic appeal of remanufactured auto-products to customers

The manufacturing of new auto-products based on the linear economic model involves externalisation of costs due to the disposal of EoL/EoU materials into landfills. Environmental policy would penalise polluters - i.e. the manufacturers of new auto-products, who would shift the tax burden to customers. On the other hand, remanufacturing removes the externalisation of costs through the mechanism of reverse logistics that would keep EoL/EoU materials in the circular production system for as long as possible, leaving little or nothing for waste disposal. This would give 'like new' remanufactured auto-products a competitive edge over new manufactured auto-products and enhance their economic and environmental appeal to customers, so that they would decide to switch their custom to remanufactured products.

Based on the principle of extended producer responsibility (EPR) that shift the responsibility for end-of-life products from customers back to the producers (OECD 2001), policymakers would need to play the 'carrot and stick role', not simply by taxing the producers as polluters, but more importantly, by incentivising them to improve the quality and functionality of environmentally friendly products through effective utilisation of materials and resources (Jacobs & Subramanian, 2012). This incentive will increase positive externalities to induce private companies to invest more in CE development. This would require the creation of effective institutional mechanisms and regulatory frameworks to bring pressure to bear on original equipment manufacturers (OEMs) to eco-design for the remanufacturing of auto-products according to set standards comparable to the EPR and ELV directives used in developed counties (Aroonsrimorakot & Akaraj, 2010; Karagoz et al., 2020).

Finally, to avoid trade-offs in the process of a CE transition, comprehensive benefits and costs of CE initiatives should be assessed, compared and prioritised in any significant criteria of inclusive sustainability and its relevant issues. Cooperation between interdisciplinary academics, participation of all societal, economic and environmental stakeholders, and governmental agencies with influence on broader socio-economic systems and global value chains are essential (Schroeder et al., 2018).

7.3.3 Measures to facilitate remanufacturing

It is important for policy to provide mechanisms to facilitate product-recovery operations not only for remanufacturing, but also for other circular activities. However, the facility should not be unduly extended to support the greenwashing of new products (Jin, Nie, Yang, & Zhou, 2017). The promotion of product recovery will increase the quantity and diversity of cores available for remanufacturing. Also, through its Pollution Control Department, the Government of Thailand should set targets and incentivise the collection of EoU/EoL products. This policy can improve the return rates of core-components in the short-run and increase resource productivity in the long-run.

Additionally, the Thai Government should set up a Centre of Excellence for Remanufacturing to promote engineering skills to improve remanufacturing product designs, remanufacturing processes and maximise the value of resources and EoL/EoU materials for remanufacturing through efficient management of the system of reverse logistics. In this respect, a major task of the centre of excellence to engage in research and development that would enable the various processes involved in remanufacturing to benefit from the application of advanced technologies. The following are some suggestions for promoting the application of high technologies to enhance remanufacturing in the Thai automotive industry in terms of process and product development, and the marketing of remanufactured auto-products.

One option for remanufacturing businesses is the development of software that can furnish customers with the information they need to explore appropriate personal customer experiences before deciding to switch to remanufactured auto-products, so that the decision to switch to remanufactured auto-products is not casual but informed. Electronic information and big data also provide remanufacturers the opportunity to customise and re-customise products to fit their customers' needs (Sebastian Kempf et al., 2018).

Secondly, the adoption of electronic automation technologies in remanufacturing can help improve the quality and functionality of remanufactured auto-products by enhancing the product design process. Moreover, automation technologies can efficiently detect the conditions of EoU/EoL materials, which labour-intensive options would find difficult to achieve. To maximise the values of core-components that are being returned to remanufacturers, technologies that support non-destructive evaluation (NDE) are needed (Rochester Institute of Technology, 2017). NDE technology, which uses digital sensors, digital tab testing, x-rays and infrared thermography, is applied for testing and inspecting the inside of the cores without the need for disassembling them to determine their suitability as throughput for remanufacturing. Also, remanufacturing would benefit from the adoption of electronic and robotic technologies as this would increase labour productivity, particularly in tasks involving the streamlining of throughputs, where the core-components are diverse in their conditions and quality upon return to remanufacturers. However, there is still need for more research and development to adapt automation technology to the needs of remanufacturing (ReMaTec, 2018). For example, cooperation between the University of Birmingham, Caterpillar and Meritor is expected to deliver dismantling robot technology by 2021 to disassemble water pumps in combustion engines of EoU/EoL products (Pham, 2016).

Thirdly, ICT, internet of things (IoT) and electronic systems have for long been part and parcel of vehicle manufacturing technologies, and, although auto-remanufacturers are more used to mechanical than electronic systems, protocols or algorithms for the evaluation of core-components to be used in remanufacturing can be facilitated by the adoption of these advanced technologies. Software technologies can help not only in the assessment of the condition of EoU/EoL materials, but also in determining the remaining functional life in core-components (Rochester Institute of Technology, 2017).

The above are some of the major policy-related issues arising from the findings of this study, which is based on analysis of a survey data exploring the factors influencing customers' decision to switch to remanufactured auto-products, and on analysis of the responses of remanufacturers to customers' switching behaviour. However, the policy measures that derive from the results of this study has to be qualified by the limitation of the study, which is discussed below.

7.4 Limitations of the study and suggestions for future research

This research has some limitations, which would provide opportunities for further studies in the future. The study is principally focused on the demand-side of the remanufacturing market on the assumption that remanufacturers would respond to trends in customers' switching behaviour between new manufactured auto-products and 'like new' remanufactured auto-products. Based on this, the study investigated perceptions of customers about automotive products in Thailand through the administration of questionnaires. However, since customers of auto-products are varied – i.e. those like motor garages and SMEs who would use auto-products to cover their intermediate demand, and those like individuals and households who would use auto-products as consumer durables – the sample used for this study, though big in size, does not stratify respondents according to their demand for auto-products as intermediate capital goods and consumer durables, and according to the technical specifications of automotive products. A larger study with a larger research budget is required for this. Moreover, future studies could survey remanufacturing businesses to determine empirically their market and technological responses to the switching behaviour of customers between new manufactured auto-products and 'like new' remanufactured auto-products. In this respect, the sustainable business model (SBM), which is used to indicate, albeit in broad terms, the response of remanufacturers to the switching behaviour of customers, can be empirically verified in the context of the experiences of the automotive industry in Thailand.

The overarching goal of this study is to test the viability of transition to circular economy through the expansion of the market for remanufactured products. This would require extending the empirical analysis of this study, which is limited in its scope to the automotive industry in Thailand, to cover a wide range of activities and markets across the economic spectrum.

7.5 Conclusion

Notwithstanding its limitations, this study draws its significance from being the first of its type addressing the issue of transition to circular economy in Thailand through remanufacturing activities. The study is focused on both demand and supply sides of the remanufacturing market.

The findings on the supply-side study indicate that the factors influencing auto-manufacturers in developing remanufacturing auto-businesses in Thailand are product maturity, financial costs, lack of skilled labour and technical aspects.

Meanwhile, the results deriving from this demand-side study show that the decision of customers to switch to remanufactured products is significantly related to the special benefits (especially offers of better after-sales services, longer warranties and more durable materials), environmental benefits deriving from the use of these auto products, customers' attitudes towards such products, and the risk of obsolescence customers would attach to remanufactured auto-products. In particular, the suspicious attitude of customers towards the so-called 'like-new' remanufactured products were found to have a significant direct and indirect influence on their switching intentions. Furthermore, the findings show that the PPM theory is able to explain customers' decision to switch from new auto-products to 'like new' remanufactured ones.

Finally, a sustainable business model (SBM) for remanufacturing and 'circular' practices in the Thai automotive industry is developed as a policy and decision framework based on the empirical findings of the study. The SBM is developed as a practical business model for remanufacturers to launch 'circular' businesses in the auto sector in Thailand. But the model has yet to be tested for its empirical validity in the light of the experiences of the automotive industry in Thailand. This is one possible area for future research, in which remanufacturing can be comprehensively explored as a strategy for transition to a circular economy by looking into how switching intentions of customers (on the demand side) feed into the supply side of the market through value proposition, value delivery, value creation and value capture.

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Appendix A : Structural Problems of Thailand's Economy

Structural Problems of Thailand's Economy

The structural macro-economic problems of Thailand lead to decreasing economic growth in last two decades. The structural problems include the stumbling of Thailand's industrialisation, middle-income trap, the stagnation in technological sophisticating level, and slow productivity growth.

The recession of Thailand's economic growth can be a result of a slowdown of industrialisation of Thailand (World Bank Thailand, 2016). That is, GDP grew rapidly in 1986-1996 when industrial sector annually expanded at 11.9 per cent on average. While the rates of service and agricultural sectors were 9.1 and 3.9, respectively (World Bank Thailand, 2016). Moreover, in 1986-1996 the proportion of industrial sector in GDP increased at an average expansion of 1.48 per cent annually from 31.84 per cent of GDP in 1985 to 37.32 per cent of GDP in 1996. While the shared rates in the same period were an increasing rate of average 0.29 per cent per year for service sector, and a decreasing rate of average 4.12 per cent annually for agricultural sector (Table A.1).

*Table A.1 Average annual growth rates in GDP and its components (excluding crisis periods, 97-00 and 2008-10) (World Bank Thailand, 2016; *calculated from World Bank Indicators in The World Bank, 2017)*

Periods	GDP growth rates	Average annual growth of sectors (%)					
		Agricultural Sector		Industrial Sector		Service Sector	
		Average annual growth	Growth in share of GDP*	Average annual growth	Growth in share of GDP*	Average annual growth	Growth in share of GDP*
1986-1996	9.4	3.9	-4.12	11.9	1.48	9.1	0.29
2000-2007	5.4	2.8	0.69	6.3	1.00	5.1	-0.81
2010-2015	2.9	1.2	-1.52	1.2	-0.99	4.6	1.10

The stumbling of Thai industrialisation is due to several reasons such as, middle income trap, stagnation in technological sophisticating level**,** internal and external shocks, and stagnation of labour reallocation.

First of all, Thailand's economy is falling into a **middle-income trap**. Similar to some upper-middle income countries including Argentina, Brazil, and Mexico, Thailand attained the economic level of upper-middle income in 2010, but has not been able to enhance to become a high-income economic level. The middle-income countries, Thailand included, confront with difficulties to enhance their economic growth which are not the same as economic problems that they used to struggle. That is, in period of rapid expansion to climb from low-income to middle-income level, these developing countries propel their economy by exporting labour-intensive products, and accumulating capital from infrastructural investments. However, when they step in the middle-income tier, their increase of incomes and wage will impact their competitiveness especially with labour-intensive exports. They will be challenged by competitors not only from lower-cost exports in other low-income countries, but also from high-quality exports in high-income countries (World Bank Thailand, 2016). The phenomena have threatened some industries in Thailand, including garments, food products, and electronic components. Thai exporters have to compete with neighbour manufacturers in Cambodia and Vietnam who gain from their lower wage. In the same time, Thai manufacturers have to compete with export goods from other higher-up income countries, especially from China.

Also, **the Stagnation in technological sophisticating level** is a factor influence discontinuance of industrial development and the slowdown of Thailand's export. The level of technological sophistication of Thailand's export products have been stagnated since the second-half of the 2000s.

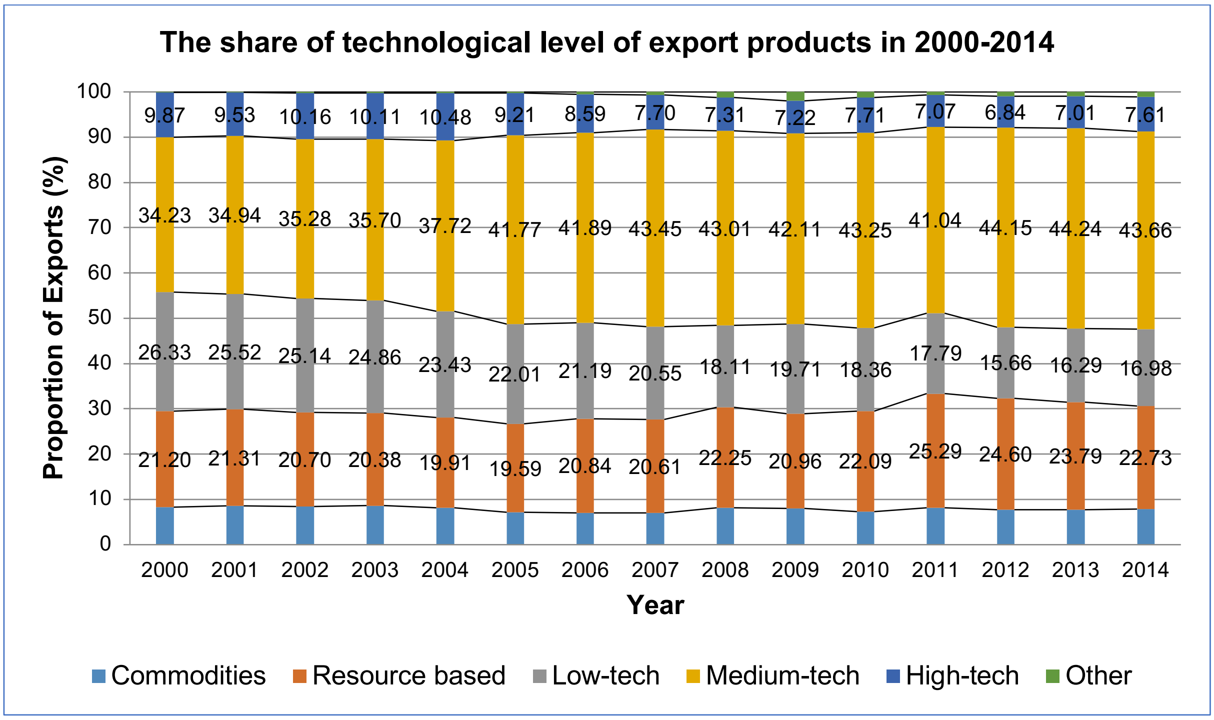

Figure A.1 The share of technological level of export products in 2000-2014 (World Bank Thailand, 2016)

That is, as shown in Figure A.1 Thai export goods had an enhancing trend in technological sophistication in the first-half of the 2000s. This can be indicated from the growing share of medium and high technological products in exports from 44.10 per cent (34.23 per cent for medium-tech and 9.87 per cent for high-tech) of exports in 2000 to 50.98 per cent (41.77 per cent for medium-tech and 9.21 per cent for high-tech) of exports in 2005.

However, the proportion has stayed the same at the level of around 50 per cent of exports over the last 8 years (Figure A.1). In fact, the composition of technological sophistication of Thailand's exports has not much changed for almost the last decade. That is, Thai exports are dominated by medium-technological manufacturing products are the majority of Thai exports at around 43 per cent of total exports. The proportion is followed by resource-based manufacturing and low-tech manufacturing of around 21 and 18 per cent, respectively.

The technological stagnation of Thai exports not only obstructs technological improvement in Thai industrial sector, but also misses an opportunity for enhancing Thailand's competitiveness and profitability of Thai exports. In general, products which are embedded more technological sophistication can create higher value-added leading to greater prices in world markets. Moreover, enhancing quality and content of export products by applying higher technology can be a sustainable source of export expansion. Undoubtedly, countries where their products are manufactured by more technologically sophisticated are likely to reach greater levels of future economic expansion (World Bank Thailand, 2016).

In case of Thailand's export, it has a good signal that low-technological manufacturing has slightly decreased its share in the export composition from 20 to 16 per cent of exports. Unfortunately, the more important part is not medium or high technological manufacturing, but there is the weight of resource-based manufacturing from 20 to 23 per cent of exports (Figure A.1). Worse, according to World Bank Thailand (2016), Thailand has been losing world market shares in commodities, resource-based manufacturing, and low-tech manufacturing since 2011.

Furthermore, the recession trend of Thailand's economy in 2010-2015 was a result of **external and internal shocks**. Firstly, the external problems were the degeneration of world economy and environment. This included the global financial crisis in 2008 and the tsunami disaster in Japan in 2011. Finally, several domestic difficulties included political deadlock in 2010, the great flood in 2011, and extensive political concerns leading to overthrowing a government in 2014.

According to a study of Qureshi, Diaz Sanchez, & Varoudakis (2014), the impact of the global financial crisis in 2008 caused around annual 2 percentage-points of GDP depression in developing countries in crisis period in comparison with the pre-crisis period. In case of Thailand's economy, Thai GDP growth dropped around annual 3 percentage-points on average in 2008-2009. That is, it decreased from the growth of 5.43 per cent in 2007 to 1.73 and -0.69 per cent in 2008 and 2009, respectively. Furthermore, economic slowdowns in developing countries are about two-thirds results from a linkage of slow economic recovery in developed countries. While another one-third was a result of sluggish productivity growth (World Bank, 2014).

The final reason is **slow productivity growth** because of stalling of labour reallocation in Thailand. Investments (including FDI, private and public investment) were an important engine of Thai economic expansion in economic boom period during 1986-1996. As a result of the investments, more capital-intensive manufacturing was installed in Thai economy. This, in turn, leaded to rapid enhance of Thai labours' productivity. That is, the noticeable extension of the investments supports the greater role of technology and machines in industrial sector leading to a growth of Thai labours' productivity in the sector in comparison with other sectors. Undoubtedly, Thai labours' productivity in industrial sector has been more than five times greater than the productivity in agricultural sector (Figure A.2).

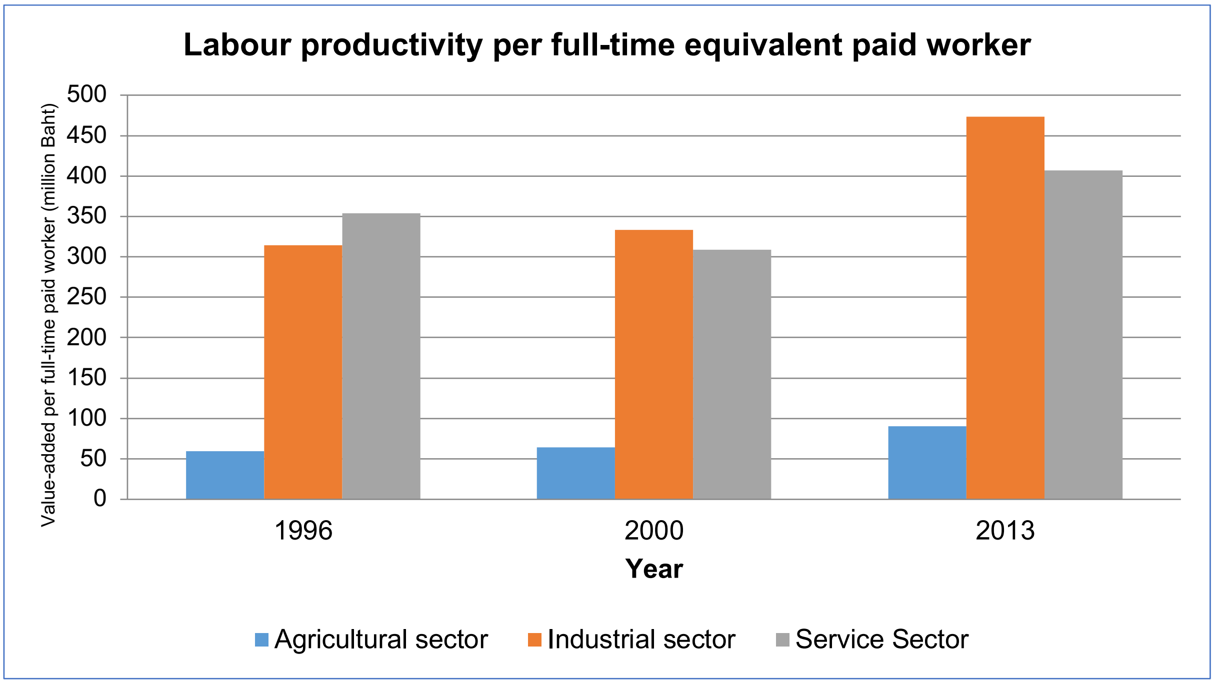

Figure A.2 Labour productivity per full-time equivalent paid worker (World Bank Thailand, 2016)

In addition to the increase of machinery application in manufacturing sector, overall labour productivity of Thailand grew because of labour reallocation or labour structural transformation. In other word, Thai labours moved from agricultural sector which uses resource-based production into industrial sector which uses more capital-intensive, especially in Thailand's economic boom period. As shown in Figure A.3, the cross of Thai labours from low capital-intensive sectors to higher capital-intensive sectors was a significant of total productivity extension in Thailand, particularly in the economic boom period (Figure A.3). In Thailand, this transformation created 1.3

percentage points of GDP expansion toward total productivity growth of 7.1 per cent in 1987-1996 (World Bank Thailand, 2016).

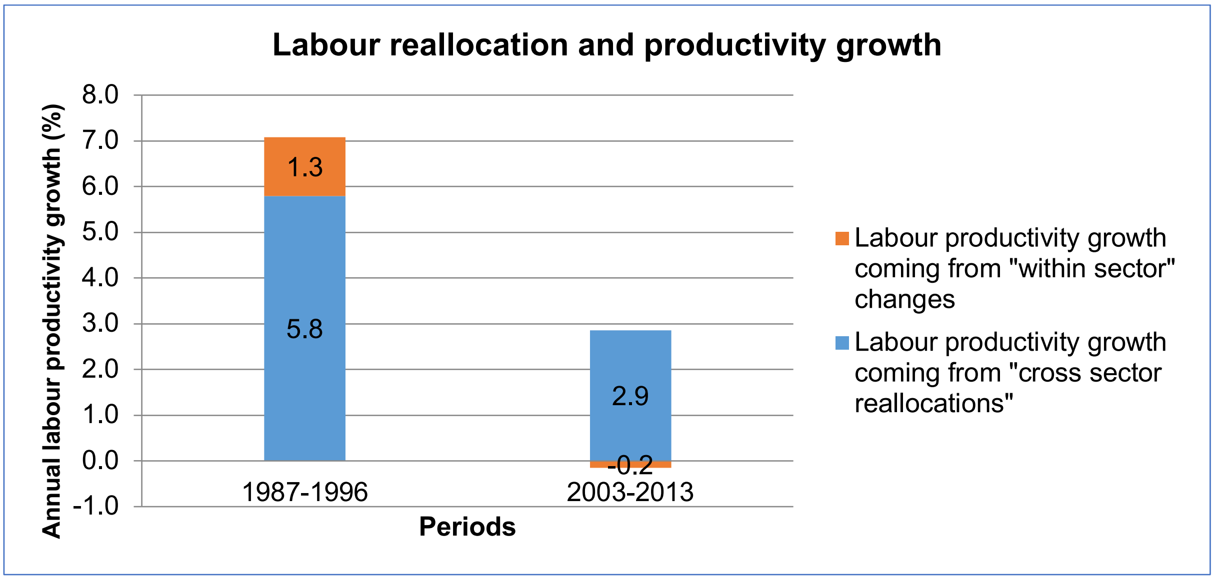

Figure A.3 Labour reallocation and productivity growth (World Bank Thailand, 2016)

However, the labour structural transformation halted after 2004 when Thai labour forces stopped crossing from the low capital-intensity agricultural sector into the industrial sector. The structural transformation which was as the engine of total productivity enhancement in Thailand halted working. As a result, labour productivity development had been discontinued. Furthermore, labours crossing back into the agricultural sector. Consequently, the productivity creation of the labour reallocation dropped in 2003-2013 (Figure A.3).

In fact, the stop of structural transformation was because of three significant reasons. Increasing agricultural prices in world market in the 2000s is the first reason. Agricultural prices rapidly increased up to 157 per cent of index point from 2002 to 2011 (Figure A.4). As a result, the real wages of labours in agricultural sector increased more than 70 per cent in 2001-2013, although their productivity little increased (Lathapipat, 2015). The agricultural wage was close to the wage premium between non-agricultural and agricultural employments. Therefore, the incentive of the wage premium for labours to cross sector was almost eliminated. This led to the reallocation flow. Furthermore, there was a backward flow crossing from non-agricultural into agricultural sector, even secondary and post-secondary educated labours crossed back into the farm jobs (World Bank Thailand, 2016). However, the growing trend of agricultural prices has finished since 2011. Moreover, World Bank Commodity Markets Outlook (2017) forecasted that agricultural prices in world market will have remained a going down trend throughout the 2010s.

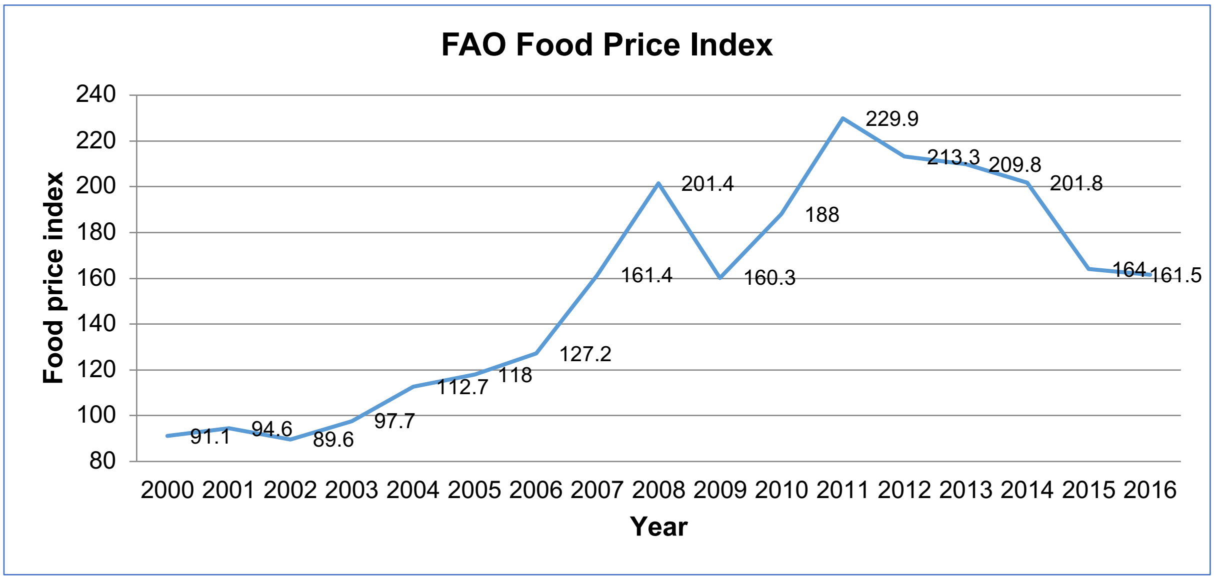

Figure A.4 FAO Food Price Index
(Food and Agriculture Organisation: FAO, 2017)

Slow Job growth in Thailand is also a factor affecting structural transformation to stop. This causes more difficult to find jobs even highly-educated labours (World Bank Thailand, 2016). Finally, government policies to support some agricultural products, rice and natural rubber in particular, can make incentives for Thai labours to maintain in farm sector, although their productivity are still low (World Bank Thailand, 2016).

Appendix B : Research Questionnaire

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

University of Strathclyde Engineering

Survey Questionnaire

Research Title

Switching Behaviour of Consumers for Transition
to Circular Economy with Particular Reference to the Automotive Sector in Thailand

Background

Remanufacturing is a series of industrial process which restores end-of-life products or components for reviving them to original working 'like-new or better performance' condition, with a warranty that is equivalent or better than that of the newly manufactured product.

As a circular economy business model, remanufacturing is a best practice of product life-extension. It is considered to be a powerful model to enhance sustainable development at macro- and micro-levels. Macro-level advantages include economic growth, enhancement of knowledge & innovation, ecological enhancement, and encouragement of localisation and Local SMEs. In the automotive industry, remanufacturing also economically benefits automotive manufacturers and customers; creates high-skilled labour jobs; reduces resource requirement and GHG emission by resource efficient improvement; and provides 'like-new' quality products at reasonable prices.

In spite of these benefits, remanufacturing in a circular economy is at the preliminary stage in Thailand. It still needs cooperation from producers and consumers. The cooperation is based on a lot of key factors, which have varied influences under specific conditions in different countries.

Research overview

To promote greater remanufacturing activities, and a move towards a circular economy in Thailand in the automotive sector, this research aims to empirically study what it takes to switch behaviour of Thai producers and consumers in the sector for transition to circular economy. This leads to the following objectives:

- To investigate the factors encouraging the market opportunity of circular economy based remanufacturing in the automotive sector in Thailand
- To introduce the conceptual framework underlying business models for circular economy-based remanufacturing in the automotive sector in Thailand
- To examine the dynamics of transition of the Thai Automotive Sector to circular economy

Research survey (Demand side)

The intention of the survey is to investigate key factors influencing switching behaviours of automotive consumers in Thailand to select remanufactured products.

The data and information you provide will be used with data and information on supply side of another part of the study for generating integrated spaces between demand and supply sides of the remanufacturing market in Thailand.

The findings will be expected to shed light on the remanufacturing market in Thailand's automotive market. This can help in providing quality automotive products at cheaper prices in Thailand. Furthermore, it can contribute to the development of a knowledge and innovative economy; increase local employment; and improve waste pollution control in Thailand.

This questionnaire can be divided into three parts of questions and ought to take less than 5 minutes to accomplish.

- Part 1: Personal demographic data
- Part 2: Switching behaviour factors
- Part 3: Switching intention

All data and information that are acquired in this survey will be secured and confidential. Furthermore, it will be anonymised and compound in the analysis process.

Proposal for the survey has been ethically cleared by the Departmental Ethics Committee of the Department of Civil and Environmental Engineering at the University of Strathclyde, Glasgow.

If you have any queries concerning this survey, please not hesitate to directly contact Bancha Dokmai via:

Mr. Bancha Dokmai
PhD student in the Department of Civil & Environmental Engineering
University of Strathclyde

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Telephone in Thailand: +66 (0) 8 1694 2099
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e-mail: bancha.dokmai@strath.ac.uk

Part 1: Personal demographic data

1. Highest level of acquired educational qualification:

☐ Less than or High school ☐ Vocational certificate ☐ High vocational certificate
☐ Bachelor's degree ☐ Master's degree ☐ Doctoral degree or higher

2. Age (Please fill): _ _ _ _ _ _ _ _ years old

3. Gender:

☐ Male ☐ Female

4. Monthly income level:

☐ < 15,000 ฿ ☐ 15,001 – 25,000 ฿ ☐ 25,001 – 35,000 ฿
☐ 35,001 – 45,000 ฿ ☐ 45,001 – 55,000 ฿ ☐ 55,001 – 65,000 ฿
☐ 65,001 – 75,000 ฿ ☐ > 75,000 ฿

Part 2: switching behaviour factors and switching intention

1. Do you **agree/disagree** with these statements

Factors	Perspective				
	Extremely Disagree	Disagree	Neutral	Agree	Extremely Agree
Perceived price of new auto-products compared with like-new remanufactured alternatives					
• New auto-products are expensive than like-new remanufactured auto-products.					
• New auto-products do not provide more valuable for money than like-new remanufactured auto-products.					
• New auto-products are not more reasonably priced than like-new remanufactured auto-products.					
• Other more expensive auto-products are not more worthy than like-new remanufactured alternatives.					
• New auto-products are not more economical than like-new remanufactured auto-products.					
Perceived environmental benefits of like-new remanufactured auto-products compared with new alternatives					
• Switching to a like-new remanufactured auto-product will help save finite resources					
• Switching to a like-new remanufactured auto-product will help increase use more reusable/recyclable resources					
• Switching to a like-new remanufactured auto-product will cause minimise landfill waste pollution					

Factors	Perspective				
	Extremely Disagree	Disagree	Neutral	Agree	Extremely Agree
• Switching to a like-new remanufactured auto-product will minimize negative effects on natural ecosystems					
Consumers' attitudes towards like-new remanufactured auto-products					
• I have a bad experience with using like-new remanufactured auto-products					
• I feel that like-new remanufactured auto-products are second-hand products					
• I feel that like-new remanufactured auto-products are defective products					
• I do not rely on remanufacturing process and care less for the standard of like-new remanufactured auto-products even if they are the same or better than new alternatives					
Perceived filling of obsoleteness to like-new remanufactured auto-products compared with new alternatives					
• Like-new remanufactured auto-products will become old-fashioned too soon					
• Like-new remanufactured auto-products do not inspire confidence of newness (at least their core components)					
• Like-new remanufactured auto-products are without exiting functionality which new products can give					
• Like-new remanufactured auto-products are not available via general retail channels					
• The price advantage like-new remanufactured auto-products have over new products is attractive					
• Like-new remanufactured auto-products involve high maintenance compared with new alternatives					

2. Does these statements are **significant/insignificant** to motivate your decision-making to select like-new remanufactured auto-products

Factors	Perspective				
	Extremely Significant	Significant	Neutral	In-significant	Extremely In-significant
Perception of **special benefits/promotions** with respect to like-new remanufactured auto-products compared with new alternatives					
• Like-new remanufactured auto-products offer **longer warranties** than new alternatives					

Factors	Perspective				
	Extremely Significant	Significant	Neutral	In-significant	Extremely In-significant
• Like-new remanufactured auto-products offer **more durable materials** than new alternatives					
• Like-new remanufactured auto-products offer **new upgrading technology** than new alternatives					
• Like-new remanufactured auto-products offer **more features/functions** than new alternatives					
• Like-new remanufactured auto-products offer **better services** than new alternatives					

Part 3: switching intention

3. Do you **agree/disagree** with these statements

Factors	Perspective				
	Extremely Disagree	Disagree	Neutral	Agree	Extremely Agree
The switching intention for like-new remanufactured auto-products					
• I'm considering switching from a new auto-part to a like-new remanufactured auto-part					
• The prospect of switching to like-new remanufactured auto-parts is high					
• I willing to switch to buy a like-new remanufactured auto-part					
• I would recommend like-new remanufactured auto-parts to friends and relatives					

4. "Based on at least like (or better than) new condition, remanufactured auto-products are more environmentally friendly and sustainable than traditional auto-products. However, the remanufactured auto-products are made by used core-components of other end-of-used products." "You may consider to switch your selection to the 'like-new' (or better than new) remanufactured auto-products, if the prices of the remanufactured auto-products are cheaper than new auto-alternatives."
   According to these statements, how much is the price of the 'like-new' remanufactured auto-products compared with new alternatives that can induce your willingness to decide to switch to the 'like-new' remanufactured ones?

   cheaper than new products — Equivalent to new products

40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%

5. Which strategy has the most potential encouraging you to be willing to return your end-of-used

auto-products promptly when you do not need them anymore?

- ☐ You will get the same remanufactured product back, when return the end-of-used product to the remanufacturer (Direct-order-based).
- ☐ You will receive a number of credits when return an end-of- used product. These credits are used as a discount when buying a remanufactured product (Credit-based-based).
- ☐ The product is owned by the remanufacturer and operated by the customer, including rental, leasing or product-service offer (Ownership-based).
- ☐ The strategy is based on a service contract between you and a remanufacturer (Service Contract-based).
- ☐ The remanufacturer buys your end-of-used products from you directly, or through a supplier or a core dealer (Buy-back-based).
- ☐ When you buy a remanufactured product, you are obligated to return a similar end-of-used product for your deposit money back (Deposit-based).
- ☐ You return or donate an end-of-use auto-product by voluntary. (Voluntary-based).

- - - End of questionnaire; Thank you for your participation - -

Appendix C : Ethic Clearance

OFFICE USE ONLY
UECREF
Date
Paper

Ethics Application Form

Please answer all questions

1. Title of the investigation
Switching Behaviour of Producers and Consumers for Transition to Circular Economy with Particular Reference to the Automotive Sector in Thailand
Please state the title on the PIS and Consent Form, if different: -

2. Chief Investigator (must be at least a Grade 7 member of staff or equivalent)

Name: Dr. Girma Zawdie

- ☐ Professor
- ☐ Reader
- ☒ Senior Lecturer
- ☐ Lecturer
- ☐ Senior Teaching Fellow
- ☐ Teaching Fellow

Department: Civil and Environmental Engineering
Telephone: +44(0)1415483275
E-mail: g.zawdie@strath.ac.uk

3. Other Strathclyde investigator(s)

Name: Mr. Bancha Dokmai
Status (e.g. lecturer, post-/undergraduate): postgraduate
Department: Civil and Environmental Engineering
Telephone: +44(0)7719822682
E-mail: bancha.dokmai@strath.ac.uk

4. Non-Strathclyde collaborating investigator(s) (where applicable)

Name: -
Status (e.g. lecturer, post-/undergraduate): -
Department/Institution: -
If student(s), name of supervisor: -
Telephone: -
E-mail: -
Please provide details for all investigators involved in the study:

1) Chief Investigator (Dr. Girma Zawdie):
- To co-design the research proposal, including framework, methodology, and questionnaires of this research
- To monitor all procedures of the research
- To be the key consultant of the research
- To edit reports and publications of the research findings

2) Other Strathclyde investigator (Mr. Bancha Dokmai):
- To initiate and co-develop the research proposal
- To conduct and follow up the process of data collection in the field work
- To analyse the collected data and interpret the results
- To write the report and publish the findings

5. Overseas Supervisor(s) (where applicable)
Name(s): - Status: - Department/Institution: - Telephone: - Email: - I can confirm that the local supervisor has obtained a copy of the Code of Practice: Yes ☐ No ☐ Please provide details for all supervisors involved in the study: -

6. Location of the investigation
At what place(s) will the investigation be conducted Automotive-part factories, and Automotive-product shops in Thailand
If this is not on University of Strathclyde premises, how have you satisfied yourself that adequate Health and Safety arrangements are in place to prevent injury or harm? The Strathclyde investigator has passed training workshops of project and risk management contributed by the Researcher Development Programme (RDP) of the university of Strathclyde.

7. Duration of the investigation
Duration(years/months) : 0/3 Start date (expected): 01 / 10 / 2018 Completion date (expected): 31 / 12 / 2018

8. Sponsor
Please note that this is not the funder; refer to Section C and Annexes 1 and 3 of the Code of Practice for a definition and the key responsibilities of the sponsor.
Will the sponsor be the University of Strathclyde: Yes ☒ No ☐ If not, please specify who is the sponsor: -

9. Funding body or proposed funding body (if applicable)
Name of funding body: - Status of proposal – if seeking funding (please click appropriate box): ☐ In preparation ☐ Submitted ☐ Accepted Date of submission of proposal: / / Date of start of funding: / /

10. Ethical issues
Describe the main ethical issues and how you propose to address them: The main issue is the confidentiality of the collected data form the survey, especially, commercial data of the responding automotive firms. To address the issue, the collected data will be strictly used only for the purposes of the research project. Also, the data will be not made in duplicate copies. Finally, the data will be destroyed at the end of the research project.

11. Objectives of investigation (including the academic rationale and justification for the investigation) Please use plain English.

There are three objectives of the research project. The first objective is to investigate the factors that bear on consumers and producers in the course of transition to circular economy in the automotive sector in Thailand. The second objective is to examine how a circular economy business model relates to the development of circular economy market in the automotive sector in Thailand. Finally, the third objective is to examine the dynamics of transition of the automotive sector in Thailand to circular economy in terms of the interplay between the behaviour of consumers (on the demand side of the auto-product market) and producers (on the supply side of the market)..

12. Participants

Please detail the nature of the participants:
This research focuses on both sides of the automotive-product market in Thailand; producer and consumer sides. The participants on the producer side are automotive manufacturers in Thailand who have the potential to be remanufacturers in the Thai automotive industry. The participants on the consumer side are the general consumers of auto-products in Thailand.
Summarise the number and age (range) of each group of participants:
Number: not less than 82 firms and 400 consumers Age: All respondents expected to be adults

Please detail any inclusion/exclusion criteria and any further screening procedures to be used:
The targeted respondents in the survey of the producer behaviour study are automotive firms who have the potential to be remanufacturers in Thai automotive industry - particularly, the auto-part manufacturers in the first tier of the Thai automotive industry who have responsibility to deliver completed auto-parts to the motor-vehicle assemblers or consumers. Furthermore, the individual respondents should understand their overview business, and have a role in strategic decision-making of the firms. Their positions in the organisations should be at least chief engineers or business unit managers.
While, the targeted respondents in the survey of the consumer behaviour study are general consumers of auto-products in Thailand.

13. Nature of the participants

Please note that investigations governed by the Code of Practice that involve any of the types of participants listed in B1(b) must be submitted to the University Ethics Committee (UEC) rather than DEC/SEC for approval.

Do any of the participants fall into a category listed in Section B1(b) (participant considerations) applicable in this investigation?: Yes ☐ No ☒
If yes, please detail which category (and submit this application to the UEC):
-

14. Method of recruitment

Describe the method of recruitment (see section B4 of the Code of Practice), providing information on any payments, expenses or other incentives.
The investigator will ask local organisations in Thailand for their support to the surveys targeted at producers and consumers of auto products. This includes asking the Automotive Cluster Programme, a department of Thailand National Science and Technology Development Agency of Thailand (NSTDA), to give the researcher access to its network in the Thai automotive industry for connections with relevant manufacturers. Also, NSTDA will be solicited for support through the provision of facilities for transport and communication in Thailand. However, there are no monetary incentives provided by the researcher to facilitate the process of data collection by the administration of questionnaires.

15. Participant consent

Please state the groups from whom consent/assent will be sought (please refer to the Guidance Document). The PIS and Consent Form(s) to be used should be attached to this application form.

The targeted respondents, including the automotive companies to be surveyed (the auto-part manufacturers in the first tier of the Thai automotive industry); and the randomly selected public who are users of auto products.

16. Methodology

Investigations governed by the Code of Practice which involve any of the types of projects listed in B1(a) must be submitted to the University Ethics Committee rather than DEC/SEC for approval.

Are any of the categories mentioned in the Code of Practice Section B1(a) (project considerations) applicable in this investigation? ☐ Yes ☒ No

If 'yes' please detail: -

Describe the research methodology and procedure, providing a timeline of activities where possible. Please use plain English.

The research methodology comprises of two parts for analysing determinants influencing the switching behaviours of producers and consumers of auto-products towards preference for remanufactured products.

The first part is the producers' behaviour study, which will make use of the Barrier Analysis model (Davis Jr., 2004; Kittle, 2013). Application of the model involves seven procedures: (1) defining the aim, behaviour and target group; (2) creating behaviour screening questions; (3) creating questions about factors influencing behaviour; (4) creating suitable methods for collecting data; (5) collecting survey data; (6) organising and analysing the results; and (7) using the results.

The fifth procedure (the collection of data), involves a survey based on the administration of questionnaires. The producer sample will cover around 80 potential remanufacturers in the automotive industry in Thailand. These sampled companies will be invited via letter, Participant Information Sheet (PIS), consent form, and the questionnaires will be sent out to them together with a covering letter in Thai language. Meanwhile, the participant firms can respond to the survey though channels of Qualtrics online survey, mails, e-mails, and/or telephone calls.

Furthermore, around ten firms will be randomly selected for in-depth investigation in form of semi-structured interviews (see sample interview format). These will be conducted via face to face interviews, telephone calls, or video conference systems. Permission for recording the interviews will be sought before starting the interviews.

The survey for data collection from target companies is expected to cover the period from October – December 2018.

The second part of the survey will elicit data and information for the consumer behaviour study. The theoretical framework of this part is based on the Push–Pull–Mooring (PPM) theory of migration (Bogue, 1969, 1977; Lee, 1966; Moon, 1995). To analyse the pull, push, and mooring factors influencing switching behaviours to select the products, data will be elicited relating to personal perception of randomly selected 400 auto-consumers of remanufactured auto-products. The quantitative primary data will be acquired from online survey based on the administration of questionnaires (as shown in sample questionnaires (2)) though channels of Qualtrics online survey. The data collection process is expected to take the period from October – December 2018.

What specific techniques will be employed and what exactly is asked of the participants? Please identify any non-validated scale or measure and include any scale and measures charts as an Appendix to this application. Please include questionnaires, interview schedules or any other non-standardised method of data collection as appendices to this application.

The main point of the survey will focus on the decision-making factors to enter remanufacturing businesses in case of the producers, and to select remanufacturing products in case of the consumers. As a result, in the questionnaire, the Five-point Likert-type scales will be applied to help individual participants to express how much they agree or disagree with any factors.

In the procedure of data analysis, the econometric regression analysis of ordinal logit model, and/or descriptive statistical analyses will be used to determine the level of significance of factors influencing the switching behavior of manufacturers.

Also, the collected data will be analysed by using the econometric technique of the hierarchical regression analysis to find out the significance of factors determined the switching behavior of consumers.

For data analysis the Statistical Package for the Social Science (SPSS) programme will be used.

Where an independent reviewer is not used, then the UEC, DEC or SEC reserves the right to scrutinise the methodology. Has this methodology been subject to independent scrutiny? Yes ☐
No ☒
If yes, please provide the name and contact details of the independent reviewer:
-

17. Previous experience of the investigator(s) with the procedures involved. Experience should demonstrate an ability to carry out the proposed research in accordance with the written methodology.

As a research staff in division of policy research at the National Science and Technology Development Agency (NSTDA) in Thailand, the investigator acquired research experiences. The experiences include practical skills to conduct and achieve a research survey through administration of questionnaires. Furthermore, at Strathclyde University, as a student on the MSc course in sustainability and environmental studies, the investigator gained knowledge about electronic data collection by Qualtrics online survey, which he used while conducting a survey for his MSc dissertation (Dokmai, 2018).

18. Data collection, storage and security

How and where are data handled? Please specify whether it will be fully anonymous (i.e. the identity unknown even to the researchers) or pseudo-anonymised (i.e. the raw data is anonymised and given a code name, with the key for code names being stored in a separate location from the raw data) - if neither please justify.

The data collected will be used only for the purposes of the research project. Furthermore, the data acquired from participants will be anonymised and used in the analysis without indicating the names of respondents, companies or interviewees. Where needed, case numbers will be used to show the subject the data is referring to.

Explain how and where it will be stored, who has access to it, how long it will be stored and whether it will be securely destroyed after use: The collected data will not be distributed to any person who is not associated with the study. The data will be securely stored in the personal computer of the investigator. Also, any duplicated copies of the collected data will not be made. Finally, the data will be destroyed at the end of the research project.
Will anyone other than the named investigators have access to the data? Yes ☐ No ☒ If 'yes' please explain: -

19. Potential risks or hazards
Briefly describe the potential Occupational Health and Safety (OHS) hazards and risks associated with the investigation: The potential OHS hazards and risks with the data collection processes are only hazards and risks relating to travels across companies in different areas. Therefore, if not virtually insignificant, the hazards and risks are minimal.
Please attach a completed OHS Risk Assessment (S20) for the research. Further Guidance on Risk Assessment and Form can be obtained on Occupational Health, Safety and Wellbeing's webpages

20. What method will you use to communicate the outcomes and any additional relevant details of the study to the participants?
If the participants are keen to be informed about the research findings of the study, communication with them will be made by e-mail.

21. How will the outcomes of the study be disseminated (e.g. will you seek to publish the results and, if relevant, how will you protect the identities of your participants in said dissemination)?
The researcher intends to publish the results and findings in international journals and conferences. Furthermore, this research will show the analysed data on website or book in Thai language. All publications based on the research will ensure that the specific sources of information used are anonymised.

Checklist	**Enclosed**	**N/A**
Participant Information Sheet(s)	☒	☐
Consent Form(s)	☒	☐
Sample questionnaire(s)	☒	☐
Sample interview format(s)	☒	☐
Sample advertisement(s)	☐	☒
OHS Risk Assessment (S20)	☒	
Any other documents (please specify below)	☐	☒

22. Chief Investigator and Head of Department Declaration
Please note that unsigned applications will not be accepted and both signatures are required

I have read the University's Code of Practice on Investigations involving Human Beings and have completed this application accordingly. By signing below, I acknowledge that I am aware of and accept my responsibilities as Chief Investigator under Clauses 3.11 – 3.13 of the Research Governance Framework and that this investigation cannot proceed before all approvals required have been obtained.

Signature of Chief Investigator	
Please also type name here:	Dr.Girma Zawdie

I confirm I have read this application, I am happy that the study is consistent with departmental strategy, that the staff and/or students involved have the appropriate expertise to undertake the study and that adequate arrangements are in place to supervise any students that might be acting as investigators, that the study has access to the resources needed to conduct the proposed research successfully, and that there are no other departmental-specific issues relating to the study of which I am aware.

Signature of Head of Department	
Please also type name here	Professor Zoe Shipton
Date:	/ /

23. Only for University sponsored projects under the remit of the DEC/SEC, with no external funding and no NHS involvement

University of Strathclyde Glasgow

Head of Department statement on Sponsorship

This application requires the University to sponsor the investigation. This is done by the Head of Department for all DEC applications with exception of those that are externally funded and those which are connected to the NHS (those exceptions should be submitted to R&KES). I am aware of the implications of University sponsorship of the investigation and have assessed this investigation with respect to sponsorship and management risk. As this particular investigation is within the remit of the DEC and has no external funding and no NHS involvement, I agree on behalf of the University that the University is the appropriate sponsor of the investigation and there are no management risks posed by the investigation.

If not applicable, tick here ☐

Signature of Head of Department	
Please also type name here	Professor Zoe Shipton
Date:	/ /

For applications to the University Ethics Committee, the completed form should be sent to ethics@strath.ac.uk with the relevant electronic signatures.

24. Insurance

The questionnaire below must be completed and included in your submission to the UEC/DEC/SEC:

Is the proposed research an investigation or series of investigations conducted on any person for a Medicinal Purpose? Medicinal Purpose means: ▪ treating or preventing disease or diagnosing disease or ▪ ascertaining the existence degree of or extent of a physiological condition or ▪ assisting with or altering in any way the process of conception or ▪ investigating or participating in methods of contraception or ▪ inducing anaesthesia or ▪ otherwise preventing or interfering with the normal operation of a physiological function or ▪ altering the administration of prescribed medication.	No

If "**Yes**" please go to **Section A (Clinical Trials)** – all questions must be completed
If "**No**" please go to **Section B (Public Liability)** – all questions must be completed

Section A (Clinical Trials)

Does the proposed research involve subjects who are either: i. under the age of 5 years at the time of the trial; ii. known to be pregnant at the time of the trial	Yes / No

*If "**Yes**" the UEC should refer to Finance*

Is the proposed research limited to: iii. Questionnaires, interviews, psychological activity including CBT; iv. Venepuncture (withdrawal of blood); v. Muscle biopsy; vi. Measurements or monitoring of physiological processes including scanning; vii. Collections of body secretions by non-invasive methods; viii. Intake of foods or nutrients or variation of diet (excluding administration of drugs).	Yes / No

*If "**No**" the UEC should refer to Finance*

Will the proposed research take place within the UK?	Yes / No

*If "**No**" the UEC should refer to Finance*

Title of Research	
Chief Investigator	
Sponsoring Organisation	
Does the proposed research involve:	
a) investigating or participating in methods of contraception?	Yes / No
b) assisting with or altering the process of conception?	Yes / No
c) the use of drugs?	Yes / No
d) the use of surgery (other than biopsy)?	Yes / No
e) genetic engineering?	Yes / No
f) participants under 5 years of age(other than activities i-vi above)?	Yes / No
g) participants known to be pregnant (other than activities i-vi above)?	Yes / No
h) pharmaceutical product/appliance designed or manufactured by the institution?	Yes / No
i) work outside the United Kingdom?	Yes / No

If **"YES"** to **any** of the questions a-i please also complete the **Employee Activity Form** (attached).
If **"YES"** to **any** of the questions a-i, and this is a follow-on phase, please provide details of SUSARs on a separate sheet.
*If "**Yes**" to any of the questions a-i then the UEC/DEC/SEC should refer to Finance (insurance-services@strath.ac.uk).*

Section B (Public Liability)

Does the proposed research involve :	
a) aircraft or any aerial device	No
b) hovercraft or any water borne craft	No

c) ionising radiation	No
d) asbestos	No
e) participants under 5 years of age	No
f) participants known to be pregnant	No
g) pharmaceutical product/appliance designed or manufactured by the institution?	No
h) work outside the United Kingdom?	Yes

*If **"YES"** to any of the questions the UEC/DEC/SEC should refer to Finance (insurance-services@strath.ac.uk).*

For NHS applications only - Employee Activity Form

Has NHS Indemnity been provided?	No
Are Medical Practitioners involved in the project?	No
If YES, will Medical Practitioners be covered by the MDU or other body?	No

This section aims to identify the staff involved, their employment contract and the extent of their involvement in the research (in some cases it may be more appropriate to refer to a group of persons rather than individuals).

Chief Investigator		
Name	**Employer**	**NHS Honorary Contract?**
	The University of Strathclyde	No
Others		
Name	**Employer**	**NHS Honorary Contract?**
Mr Bancha Dokmai	The University of Strathclyde (PhD Student)	No

Please provide any further relevant information here:

Participant Information Sheet for the automotive firms who have potential to be remanufacturers in the automotive industry and auto-product consumers in Thailand

Name of department: **Civil and Environmental Engineering**
Title of the study: Switching Behaviour of Producers and Consumers for Transition to Circular Economy with Particular Reference to the Automotive Sector in Thailand

Introduction

As a circular economy business model, remanufacturing is a best practice of product life-extension. It is considered to be a powerful model to enhance sustainable development at macro- and micro-levels. Macro-level advantages include economic growth, enhancement of knowledge & innovation, ecological enhancement, and encouragement of localisation and Local SMEs. In the automotive industry, remanufacturing also economically benefits automotive manufacturers and customers; creates high-skilled labour jobs; reduces resource requirement and GHG emission by resource efficient improvement; and provides like-new quality products at reasonable prices.
In spite of these benefits, remanufacturing in a circular economy is at the preliminary stage in Thailand. Its development is conditional on the behaviour of producers and consumers. The aim of this study is to identify key factors that bear on the decision of producers and consumers to switch to circular economy mode in terms of preference for remanufactured auto products.
The research is a part of the doctoral study of Bancha Dokmai, a PhD student in the Department of Civil and Environmental Engineering, University of Strathclyde, the U.K.

What is the purpose of this investigation?

To promote greater remanufacturing activities, and a move towards a circular economy in the automotive sector in Thailand, this research aims to empirically study what it takes to switch behaviour of producers and consumers in the sector for transition to circular economy in Thailand.
The intention of the survey is to investigate key factors influencing switching behaviours of automotive producers and consumers to participate in remanufactured automotive market in Thailand.

Do you have to take part?

Your participation is very essential for the research. Your cooperation can contribute to the development of the remanufacturing market in the automotive market in Thailand. However, your participation to take part in the investigation is voluntary. Participants have a right to withdraw at any time of their choice.

What will you do in the project?

To investigate key factors influencing switching behaviours of automotive producers and consumers to participate in remanufactured automotive market in Thailand, your experiences and opinions on the remanufacturing and traditional automotive market are very essential.
That is, these your information and data will provide us to understand and generate integrated spaces between the supply and demand sides of the market in Thailand. The findings will be expected to shed light on the remanufacturing market in Thailand's automotive market. This can help in providing quality automotive products at cheaper prices in Thailand. Furthermore, it can contribute to the development of a knowledge and innovative economy; increase local employment; and improve waste pollution control in Thailand
We can achieve the aspiration together, but the research needs your cooperation on the both sides of the market to provide your information and data. That is, on the automotive producer side, you can pass us your experiences and opinions about the industry through survey based on the administration of questionnaires. Furthermore, you can provide us in-depth information through semi-structured interview based on the administration of a list of interview questions, and meeting observation are required.

On the automotive consumer side, you can also transfer your experiences and viewpoints on conventional and remanufacturing auto-products through survey based on the questionnaire administration.

Why have you been invited to take part?

As mentioned above, this research investigates both sides of the automotive market in Thailand; participants on producer and customer sides of the market are required to participate in the investigation.

The required participants on the automotive producer side are automotive firms who have potential to be remanufacturers in the automotive industry in Thailand. Particularly, the auto-part manufacturers in the first tier of the Thai automotive industry who have responsibility to deliver completed auto-parts products to the motor-vehicle assemblers or consumers. The data collection tools on the supply side are both survey and in-depth interview. That is, the targeted participants for survey are around 80-100 volunteers of the potential remanufacturers in the automotive industry in Thailand based on the administration of a list of interview questions based on the administration of questionnaires. Moreover, the targeted participants for the semi-structured in-depth interview are around ten potential remanufacturers in the industry based on the administration of a list of interview questions.

Meanwhile, the required participants on the automotive consumer side are general automotive-product consumers in Thailand. The targeted respondents are around 400 voluntary automotive-product users.

What are the potential risks to you in taking part?

None.

What happens to the information in the project?

All data and information that are acquired in this survey will be kept confidential, and securely saved. The collected data and information will be strictly used only for the purposes of the research project. They will not be distributed to any person who is not associated with the study. Also, they will be stored separately from individual identification information or any documents which can refer to personal information of participants. Furthermore, the collected data and information will be securely stored in the personal computer of the investigator. Also, any duplicated copies of them will not be made. Finally, the data will be destroyed at the end of the research project

Furthermore, the collected data and information will be anonymised and compound in the analysis process. All research results and findings are presented without indicating the name of respondents, companies or interviewees. Finally, if necessary, the case numbers will be used to represent the collected data and information to the respective sources.

The proposal for the survey has been ethically cleared by the Departmental Ethics Committee of the Department of Civil and Environmental Engineering at the University of Strathclyde, Glasgow.

The University of Strathclyde is registered with the Information Commissioner's Office who implements the Data Protection Act 1998. All personal data on participants will be processed in accordance with the provisions of the Data Protection Act 1998.

Thank you for reading this information – please ask any questions if you are unsure about what is written here.

What happens next?

If you are happy to give your information, please sign the consent form that shows the detail in the below to make sure that you have read and understood the information about this research.

Then, please complete a questionnaire which would take less than 15 minutes. Also, we hope you to agree to a follow-up interview to find out more about the activities of your company.

In the course of data analysis, the investigator will consider the data and information you provided in combination with data from other sources. That is, your data and information will be anonymised.

The results and finding of this research will be published in the form of journal articles and presentations at conferences. Please ignore questions, which you think may not be of any concern to you. Thank you for your attention and hope to have your corporation in the future.

Researcher contact details:

If you have any queries concerning this survey, please not hesitate to directly contact the investigator via:

Mr. Bancha Dokmai

PhD student, The department of Civil & Environmental Engineering, University of Strathclyde,

Address in the U.K.: James Weir Building, Level5, 75 Montrose Street, Glasgow, Scotland, The U.K., G1 1XJ.

Address in Thailand: 3, Soi Rat-Burana 5, Khwaeng Bang-Pakok, Khet Rat-Burana, Bangkok, 10140
Telephone number in the U.K.: +44 (0) 7719 720682
Telephone number in Thailand: +66 (0) 8 1694 2099
e-mail: bancha.dokmai@strath.ac.uk

Chief Investigator details:

The chief investigator of this project: Dr.Girma Zawdie
Senior Lecturer, The Department of Civil and Environmental Engineering
James Weir Building, Level5, 75 Montrose Street, Glasgow, Scotland, The United Kingdom, G1 1XJ.
Telephone number: +44 (0) 1415 483275
e-mail: g.zawdie@strath.ac.uk.

This investigation was granted ethical approval by the University of Strathclyde Ethics Committee.
If you have any questions/concerns, during or after the investigation, or wish to contact an independent person to whom any questions may be directed or further information may be sought from, please contact:
Secretary to the University Ethics Committee
Research & Knowledge Exchange Services
University of Strathclyde
Graham Hills Building
50 George Street
Glasgow
G1 1QE
Telephone: 0141 548 3707
Email: ethics@strath.ac.uk

Consent Form for the automotive firms who have potential to be remanufacturers in the automotive industry and auto-product consumers in Thailand

Name of department: **Civil and Environmental Engineering**

Title of the study: Switching Behaviour of Producers and Consumers for Transition to Circular Economy with Particular Reference to the Automotive Sector in Thailand

- I confirm that I have read and understood the information sheet for the above project and the researcher has answered any queries to my satisfaction.
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, up to the point of completion, without having to give a reason and without any consequences. If I exercise my right to withdraw and I don't want my data to be used, any data which have been collected from me will be destroyed.
- I understand that I can withdraw from the study any personal data (i.e. data which identify me personally) at any time.
- I understand that anonymised data (i.e. data which do not identify me personally) cannot be withdrawn once they have been included in the study.
- I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available.
- I consent to being a participant in the project
- I consent to being audio and/or video recorded as part of the project

Where human biological samples are taken e.g. blood samples or biopsy samples then the following wording should be included: I consent to the taking of biological samples from me, and understand that they will be the property of the University of Strathclyde.

Where it is proposed to carry out DNA analysis of material in any samples then the following statement should be included in the consent form: I consent to DNA in the samples being analysed.

For investigations where it has been decided that "no fault compensation" cover will be provided the following wording needs to be included: In agreeing to participate in this investigation I am aware that I may be entitled to compensation for accidental bodily injury, including death or disease, arising out of the investigation without the need to prove fault. However, such compensation is subject to acceptance of the Conditions of Compensation, a copy of which is available on request.

(PRINT NAME)	
Signature of Participant:	Date:

University of Strathclyde Glasgow

GENERAL RISK ASSESSMENT FORM (S20)

Persons who undertake risk assessments must have a level of competence commensurate with the significance of the risks they are assessing. It is the responsibility of each Head of Department or Director of Service to ensure that all staff are adequately trained in the techniques of risk assessment. The University document "Guidance on Carrying Out Risk Assessments" will be available, in due course, to remind assessors of the current practice used by the University. However, reading the aforementioned document will not be a substitute for suitable training.

Prior to the commencement of any work involving non-trivial hazards, a suitable and sufficient assessment of risks should be made and where necessary, effective measures taken to control those risks.

Individuals working under this risk assessment have a legal responsibility to ensure they follow the control measures stipulated to safeguard the health and safety of themselves and others.

SECTION 1

1.1 OPERATION / ACTIVITY	Complete the relevant details of the activity being assessed.		
Title:	Generic Risk Assessment for the activity of data collection for the research title Switching Behaviour of Producers and Consumers for Transition to Circular Economy with Particular Reference to the Automotive Sector in Thailand		
Department:	Civil and Environmental Engineering		
Location(s) of work:	Various automotive firms and shops in Thailand	**Ref No.**	
Brief description: The data collection activity is a part of the research title "Switching Behaviour of Producers and Consumers for Transition to Circular Economy with Particular Reference to the Automotive Sector in Thailand". The research aims to empirically study what it takes to switch behaviour of producers and consumers in the sector for transition to circular economy in Thailand.			

1.2 PERSON RESPONSIBLE FOR MANAGING THIS WORK			
Name:	Dr. Girma Zawdie	**Position:**	Senior Lecturer
Signature:	M Zawdie	**Date:**	20/09/2018
Department:	Civil and Environmental Engineering		

1.3 PERSON CONDUCTING THIS ASSESSMENT			
Name:	Dr. Girma Zawdie	**Signature:**	M Zawdie
Name:	Mr. Bancha Dokmai	**Signature:**	Bancha Dokmai
Name:	Dr. Christine Switzer	**Signature:**	
Date risk assessment undertaken:	October 2018 – December 2018		

1.4 ASSESSMENT REVIEW HISTORY

This assessment should be reviewed immediately if there is any reason to suppose that the original assessment is no longer valid. Otherwise, the assessment should be reviewed annually. The responsible person must ensure that this risk assessment remains valid.

	Review 1	Review 2	Review 3	Review 4
Due date:				
Date conducted:				
Conducted by:				

SECTION 2

Work Task Identification and Evaluation of Associated Risks									**Page 2 of 6** **Ref No.**
Component Task / Situation	**Hazards Identified**	**Hazard Ref No.**	**Who Might be Harmed and How?**	**Existing Risk Control Measures (RCM)**	**Likelihood**	**Severity**	**Risk Rating**	**Risk L, M, H, VH**	**RCM' s Acceptable Y/N**
1) Overseas Travel between the U.K. and Thailand	1.1) Lack of international travelling documents	01	Who: Investigator How: Risks of lost passport & tickets, be stranded, and no help available causing stress	- Checking legal passport and other documents as valid - Preparing a copy of passport/documents and details of tickets in an alternative location in a suitcase, and/or saved on-line - Reviewing possible contacts with Foreign & Commonwealth Office (FCO), Thai embassy or travel agents for advice on travel	2	1	2	L	Y
	1.2) Manual carrying and lifting heavy suitcases	02	Who: Investigator How: Carrying and lifting luggage and equipment causing potential injury	Using trolleys, escalators, elevators and other facilitating transports where possible instead of carrying suitcases in long ways	3	2	6	M	Y
	1.3) Air travel crossing time zones	03	Who: Investigator How: Air transport accidents, jet lag, de-hydration, and deep vein thrombosis	- Selecting an airline whose safety standards and availability are acceptable - Strictly complying with on-flight safety briefing - Doing on-flight exercise - Drinking a lot of water to keep hydrated	1	5	5	M	Y
2) Domestic travel in Thailand	2.1) Travel and Transportation - Traveling in unfamiliar areas - Poor conditions of vehicles including maintenance, size, and weight - Inexperience or tiredness of driver	04	Who: Investigator How: Risk of accidents leading to physical injury	- Learning the basic geography of destinations - Reviewing directions prior travel - Using experienced routes which possible - Selecting the most safety transportation and reputable transport providers	1	5	5	M	Y
	2.2) Weather conditions during travel - Extreme conditions of weather - Natural disaster including flood	05	Who: Investigator How: Extreme heat, and rain leading to illness, wet and slippery conditions	- Checking weather conditions before and during travel - Selecting suitable clothing and footwear - Carrying a bottle of water to keep hydrated - Avoiding activities during the hottest period of the day	4	1	4	M	Y

SECTION 2 – continuation sheet

Work Task Identification and Evaluation of Associated Risks				**Page 3 of 6**	**Ref No.**				
Component Task / Situation	**Hazards Identified**	**Hazard Ref No.**	**Who Might be Harmed and How?**	**Existing Risk Control Measures (RCM)**	**Likelihood**	**Severity**	**Risk Rating**	**Risk L, M, H, VH**	**RCM' s Acceptable Y/N**
	2.3) Manual carrying and lifting heavy documents	06	Who: Investigator How: Carrying and lifting heavy documents causing physical injury	- Not handling too heavy loads - Separating heavy loads into smaller or lighter loads. - Using trolleys, moving workways, and other facilitating transports/tools where possible - Parking in the most safety and nearest areas of the destinations - Using electronic documents where possible	3	2	6	M	Y
3) Data collecting	3.1) Unwillingness to cooperate of targeted participants	07	Who: Investigator How: Unsuccessful in targeted number of respondents causing stress	- Ensuring that all questionnaires have been satisfied the ethics committee, hence resentment is unlikely made - Reviewing any cultural & conditional differences of the targeted firms (MNCs in particular) prior site visiting - Being polite behaviours - Being aware of individual space and opinion - Appropriately clothing, and modestly wearing for avoiding attention	4	1	4	M	Y
	3.2) Specific hazards in site visits	08	Who: Investigator How: Safety issues in site visits, including in auto-factories, and aggressive behaviours of respondents leading to physical injury	- Strictly complying with any safety instructions in working fields - Immediately removing from the fields in cases of aggressive behaviours from respondents	1	4	4	M	Y

SECTION 3

Identified Actions to Improve Control of Unacceptable Risks (as evaluated in Section 2) **Page 4 of 6** **Ref No.**

Hazard Ref No.	Risk	Recommended Additional Risk Control Measures	Implemented Y/N	Action By	Target Date	Completion Date	Revised Risk				Revision of Risk Signed Off
							Likelihood	Severity	Risk Rating	Risk L, M, H	

SECTION 4

RECORD OF SIGNIFICANT FINDINGS **Page 5 of 6**

Ref No.

Where this Section is to be given to staff etc., without Sections 2 & 3, please attach to the front of this page, a copy of the relevant Section 1 details.

The significant findings of the risk assessment should include details of the following:

- The identified hazards
- Groups of persons who may be affected
- An evaluation of the risks
- The precautions that are in place (or should be taken) with comments on their effectiveness
- Identified actions to improve control of risks, where necessary

Alternatively, where the work activity/procedure is complex or hazardous, then a written Safe System of Work (SSOW) or Standard Operating Procedure (SOP) is advised that should incorporate the significant findings. Such documents should again, have the relevant Section 1 attached. Please state below whether either a SSOW or SOP is available in this case.

Relevant SSOW available	Yes ☐	No ☒	Relevant SOP available	Yes ☐	No ☒

Significant Findings: (Please use additional pages if further space is required)

The key findings of the risk assessment of the overseas travel activity are that all above identified hazards can affect the investigator. Also, they are assessed in low and medium levels, although their servilities range from to be stressful to fatal.

In detail, there are eight risks which are identified in this assessment.

First of all, a lack of international travelling documents (Hazard Reference No. 01) can affect the investigator to be stressful. The first risk is unlikely arising and can lead to insignificant harm. As a result, the hazard is assessed to be a low risk. However, preparing and checking before travel are effective measures to control this risk.

Furthermore, injury from manual carrying, lifting or handling heavy loads (Hazard Reference No. 02 and 06) is a possible risk with the investigator, but its harm is only minor injuries including physical strain and sprain. Therefore, the risk is assessed to be a medium risk. Utilisation of any facilitating equipment is a best measure to efficiently limit the risk.

Next, the harm of accidents from air travel crossing time zones (Hazard Reference No. 03) is a hazard causing the investigator to be fatal. However, the risk is very unlikely. Finally, strictly complying with on-flight safety briefing can productively mitigate the harm.

Moreover, road accidents from travel and transportation in Thailand (Hazard Reference No. 04) is a risk as a result of various reasons of poor conditions of transportation. The researcher can be affected up to fatality by the risk, although the likelihood of it is unlikely. Accordingly, the hazard is assessed in the medium level. To review directions & modes of transportation, then to select the most safety choice is a useful method to handle the risk.

Also, poor and extreme weather conditions in Thailand (Hazard Reference No. 05) is a risk of the activity. This includes heat, rain and flood. The risk is likely arising with the investigator, but its danger is insignificant. Consequently, it is a medium risk. To avoid activities during the extreme period of the day is a best risk-control-measure.

The seventh identified hazard is unwillingness to cooperate of targeted participants (Hazard Reference No. 07). The risk can cause the researcher to be stressful. However, this is a medium risk. On the ground that its likelihood is likely, but its severity of illness is insignificant. Ensuring of ethical approval with all questionnaires and always being polite behaviours can mitigate the hazard.

Finally, Specific dangers in site visits (Hazard Reference No. 08), hazards in factories included, is assessed to be a medium risk as well. Although the hazard can lead the researcher to be fatal, the likelihood of the poor situation is very unlikely. However, strictly following any safety instructions in working fields can effectively limit the risk.

SECTION 5

RECEIPT OF SIGNIFICANT FINDINGS OF RISK ASSESSMENT **Page 5 of 6**

Please copy this page if further space is required. **Ref No.**

All individuals working to the risk assessment with the Ref. No. as shown, must sign and date this Section to acknowledge that they have read the relevant risk assessment and are aware of its contents, plus the measures taken (or to be taken by them) to safeguard their health and safety and that of others.

If following review of the assessment revisions are minor, signatories may initial these where they occur in the documentation, to indicate they are aware of the changes made. If revisions are major, it is advisable to produce a new risk assessment and signature page.

NAME (Print)	SIGNATURE	DATE
Dr. Girma Zawdie	[illegible]	20/09/2018
Mr. Bancha Dokmai	Bancha Dokmai	20/09/2018