The Impact of Serviceability on Service Operations Performance, Service Cost and Customer Satisfaction

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DISSERTATION

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Abstract

In this thesis, three empirical studies on serviceability were performed in Japan toward investigating the effect of serviceability in manufacturing industries, exploring the important of service cost (after-sales service cost and ownership cost), and identifying the serviceability impact on customer satisfaction during experiencing serviceability-oriented products in after-sales service. The first research empirically examines the importance of designing products for serviceability and derives a framework that links management practices, design for serviceability practices, and operational performance in after-sales service. The developed structural model was tested with structural equation modelling (SEM) and the results show strong empirical evidence for most hypothesized relationships. This first research demonstrates the strategic value of designing products for serviceability and guides top management in adopting the necessary management and design practices to support product service operational performance goals. The second research investigates the customer's perspective on product serviceability, including its impact on after-sales service cost and satisfaction/loyalty when experiencing service or repair on two products (automobiles and air-conditioners). Based on SEM results, this second research identified four serviceability-oriented dimensions: tangibles dimension of serviceability, assurance dimension of serviceability, responsiveness dimension of serviceability and after-sales service cost. Hypotheses were tested for both products and were found to be supported. As contributions to the product serviceability literature, after-sales service cost was found to act as a mediating variable by which customers viewed the product. Thus, these results provide insight to scholars and practitioners for strategizing after-sales service requirements during new product development and for offering customer-friendly practices in after-sales service. The third research investigates the influence of ownership cost on automobiles customers' perspective through maintenance, service and repair. SEM was also employed for examining the relationships between various constructs, including six different dimensions of product quality, ownership cost, customer satisfaction, and customer loyalty. Most of the hypotheses were supported, and the ownership cost factor was revealed as playing a significant role in enhancing customer loyalty. Thus, serviceability contributes in producing service-friendly products and also supports in achieving less after-sales service cost as well as low ownership cost for customers.

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CHAPTER 1

Introduction

1.1 Research introduction

Global competition has forced various industries to produce quality products that are not only functional but also customized, easy to use and service, economical and environmentally-friendly. Typically, all the embedded elements are important for customers and environment, which subsequently could increase customer satisfaction in after-sales service and protect the environment.

In this study, easily used products and services were mainly focused toward marketing economical products and extending products' lives in the after-sales service so that customers could gain better value (e.g., low service cost) for the purchased products. Therefore, manufacturers are encouraged to continuously consider customer requirements associated with after-sales service in product design phase. In order to ensure easy services and product are produced with low service cost, one of the design requirements known as serviceability is implemented by manufacturers. In today's agile product development environment, serviceability is fast becoming one of the most important criteria for marketing products. Generally, serviceability is defined as a component, device or system that is easily maintained, serviced and repaired promptly and accurately toward preventing future product malfunction or breakdown during operation. A faster maintenance, service and repair at manufacturers' networks (including service centers, repair outlets) can sustain the quality of product with low costs and thus, the importance and awareness of serviceability keeps increasing simultaneously toward meeting customer satisfaction in after-sales service. Customer satisfaction is an essential element in product and service strategies of organizations, which should be aligned with customers' ever-changing demands, with respect to countless products offered by various manufacturers (e.g., automobile, heavy equipment, and home appliances). This reality urges manufacturers to deliver high value products without compromising on quality (Hansen and Bush, 1999).

In terms of the effort performed by various industries, it was noticed that large-sized organizations (e.g., Xerox, Caterpillar, Chrysler, Ford, Hewlett-Packard, IBM and Toyota) considered service requirement in after-sales service for decades. However, for small and medium-sized organizations, the existing researches did not comprehensively investigated the quantitative research is associated with quality management practices (top management, teamwork, design information and analysis, customer focus and supplier involvement) on the significance of serviceability upon service operations performance. Moreover, there was also less attention pertaining to how customer perceived serviceability elements on the marketed products.

Since small and medium-sized organizations have dominated most of products due to higher percentage of population compared to large-sized organizations, further researches need to be conducted to investigate the level of serviceability implementation in various industries as well as examine customer point of view with regard to highly purchased products such as automobiles and home appliances. Hence, three focal serviceability-related researches were conducted, whereby Japan was selected as the best touchstone to examine the importance of designing products for serviceability in manufacturing organizations and to evaluate the perceptions of customers who experienced serviceability-oriented products in after-sales service. In addition, product quality dimensions (including serviceability) were also examined in order to investigate the level of effect on ownership cost (e.g., costs which need to be borne by customers after product purchase such as maintenance cost), customer satisfaction and customer loyalty.

1.1.1 Definition of serviceability

As pre-described in previous section, serviceability represents service or repair speed, the courtesy of service premises in entertaining customers, service personnel competence when solving service problems, and the level of easiness in repairing malfunctioned products (Garvin, 1987). Achieving superiority in serviceability therefore, requires firms to design products that are easy to service and maintain during its life-cycle (known as design for serviceability) and have efficient and effective after-sales service operations for its customers. The design for serviceability is the ability to, with relative ease, diagnose, remove, replace, replenish, and/or repair components to its original specifications. The design for serviceability measures several aspects, such as the ability of service personnel at service centers who are needed to perform services and repairs, the lead time to perform the service, and related incurred costs. Since customers are continuously concerned with the cost factor, the cost associated with poor design for serviceability will negatively influence total ownership cost. Hence, design for serviceability will help to determine and optimize future services by improving the total life-cycle span of the product, reducing ownership cost, and raising customer satisfaction levels.

1.1.2 Serviceability from internal company perspective

Although current technology is designated to produce innovative products with minimized errors and reduced human workload, it is still difficult to create a highly reliable product without maintenance within its life cycle. Therefore, from a company's perspective, the design for serviceability is very important in increasing the design quality and guaranteeing serviceability-oriented design. This, however, can be achieved by standardizing and simplifying designs for a swift disassembling method by using existing equipment and facilities, and incorporating customers and service technicians who are needed during the new product development (NPD). In order to deliver good serviceability products to the market, concurrent engineering is important for product development so that the design for serviceability could be integrated simultaneously within cross-functional design activities. One of the efficient methods to achieve this serviceability goal is by conducting virtual analysis using the Computer-Aided-Design (CAD). The usage of CAD improves product development time, quality and productivity, and ultimately pays off in terms of reduced ownership costs from after-sales services.

Thus, engineers with experience in customer and service support should also be involved in communicating with after-sales service personnel and customers, since this initiative can add substantial value by making the products more 'service-and-maintenance friendly'. Technical aspects involved during the development of a new product, specifically on serviceability and maintaining practices, should be applied by design engineers during the design stage. The reason for this is to have better insight into creating easy services, repairs, replacement, and maintenance of products for after-sales service benefits. With this advantage, top management can manage and continuously provide all the resources accordingly as they are in the right position to decide on the future direction (Harmancioglu, Grinstein, and Goldman 2010) during NPD process.

1.1.3 Serviceability from external consumer perspective

With regards to serviceability-oriented dimensions on customer products, customers are more likely to view serviceability as high valued-added product characteristics, which can easily be serviced, repaired, and maintained by customers and service personnel, depending on the level of design complexity. From a customer's point of view, manufacturing companies or service providers (e.g. service centers) are responsible for providing low service cost to customers in order to gain low ownership cost. Customers believe that manufacturing companies are capable of delivering quality products and subsequently, customers may feel comfortable with the after-sales support.

Therefore, customer-oriented elements, especially efficient service and continuous after-sales support may increase the value of products. This is because customers depend highly on service personnel since customer perception in the context of after-sales service is eventually the customers' point of view after utilizing the purchased product and experiencing certain service or repair. Due to this fact, it reflects that customers' perspective is definitely important for providing immediate and efficient service or repair during routine maintenance on purchased products and products that have malfunctioned. By performing an efficient after-sales service on serviceability-oriented products at the service center, customers anticipate to gain meaningful pleasure in terms of economical after-sales service cost, as well as directly and indirectly achieving constant satisfaction in product service or repairs. Subsequently, customers may think that they can prevent further repair and avoid any return to service centers for reinvestigation of unsolved service issues.

1.1.4 Serviceability in a broader customer perspective on product quality

Garvin (1987) introduced eight dimensions of quality as guidance to manufacturing industries to produce robust products, deliver efficient performance and offer user-friendly after-sales services. Since serviceability is part of product quality dimension, customers who experienced product with good serviceability aspects (e.g. easy service and safe maintenance), tend to be loyal to a particular product brand or service center. Products with hassle-free after-sales service signifies that the product has been embedded with serviceability requirement in the design stage. This indirectly gives impact in terms of less service and repair cost, spare part cost and other after-sales service costs during routine maintenance or unexpected malfunction. Although routine maintenance is compulsory, customers still prefer a longer interval for maintenance, which periodically incurs charge on the customers for example, vehicle owners, even though parts without malfunction obviously prevented its owners to bare unexpected repairs and spare part costs. Due to this fact, the potential costs may be considered as part of ownership costs and will apparently burden the customers if there is less consideration from manufacturers in terms of serviceability requirement towards producing quality product.

Thus, manufacturers are responsible for ensuring that every designed part or components can be well serviced and inspected during routine maintenance in order to retain customer's satisfaction. From a customer's perspective, serviceability is associated with ownership cost and hence, may encourage customers to aware the importance of serviceability dimension before purchasing a product.

1.2 Schematic diagram for three inter-related researches

In order to have a better understanding of each research, Figure 1.1 displays three inter-related researches in a single schematic diagram. The three inter-related researches consist of Research 1 (focused on company survey on design for serviceability in new product development stage), Research 2 (focused on customer survey on serviceability-oriented products) and Research 3 (focused on customer survey on product quality dimensions and ownership cost). The ultimate aims for each research are service operations performance (Research 1), customer satisfaction (Research 2) and customer loyalty (Research 3).

Prior to achieving all the aims, five key practices (top management commitment, teamwork, design information and analysis, customer focus and supplier involvement) in manufacturing company are required to be implemented during product design for serviceability.

As a result from the five practices in manufacturing companies, user-friendly product service support artifacts (e.g., service manual, tools and equipment) and serviceability-oriented products (e.g., easy service automobiles) could be produced concurrently and then, delivered to service personnel at service centers for maintenance, service and repair purposes, and marketed to actual customers.

For instance, the product service support artifacts are beneficial in enhancing the service personnel's technical knowledge when performing routine maintenance and resolving any service or repair issues right for the first time using an established service manual as well as appropriate tools and equipment. Through the efficient maintenance, service and repair, the service operations performance can be enhanced at service centers, as what has been discovered in research 1.

Besides producing user-friendly product service support artifacts to service personnel, the marketed serviceability-oriented products (e.g., easy service automobiles) can be easily serviced, repaired and maintained by well-educated service personnel. The service personnel were able to communicate effectively with customers and resolve any service matters raised by them in order to meet customer's expectations. Throughout the prompt service and repair, customers could gain economical service and repair costs (such as avoiding repeating inspection or repair), which could subsequently enhance customer satisfaction. This benefit was revealed in research 2.

At the same time, products (e.g., automobiles) embedded with serviceability characteristic also influenced ownership costs (e.g., fuel consumption is reasonable, spare part price is reasonable). Since cost is a sensitive factor for customers, ensuring a low ownership cost until the product's end-of-life may increase customer loyalty. This relationship was discovered in research 3, whereby ownership cost positively influenced customer loyalty. However, customers felt satisfied when there was no service or repair on the purchased products because research 3 also found that there was no significant relationship between serviceability and customer satisfaction.

For long-term benefit, customers may continuously share and recommend similar products and service centers to others who seek their opinion or advice. Once a customer is positively informed by positive word of mouth, the society becomes more knowledgeable and aware of the benefits of serviceability-oriented products.

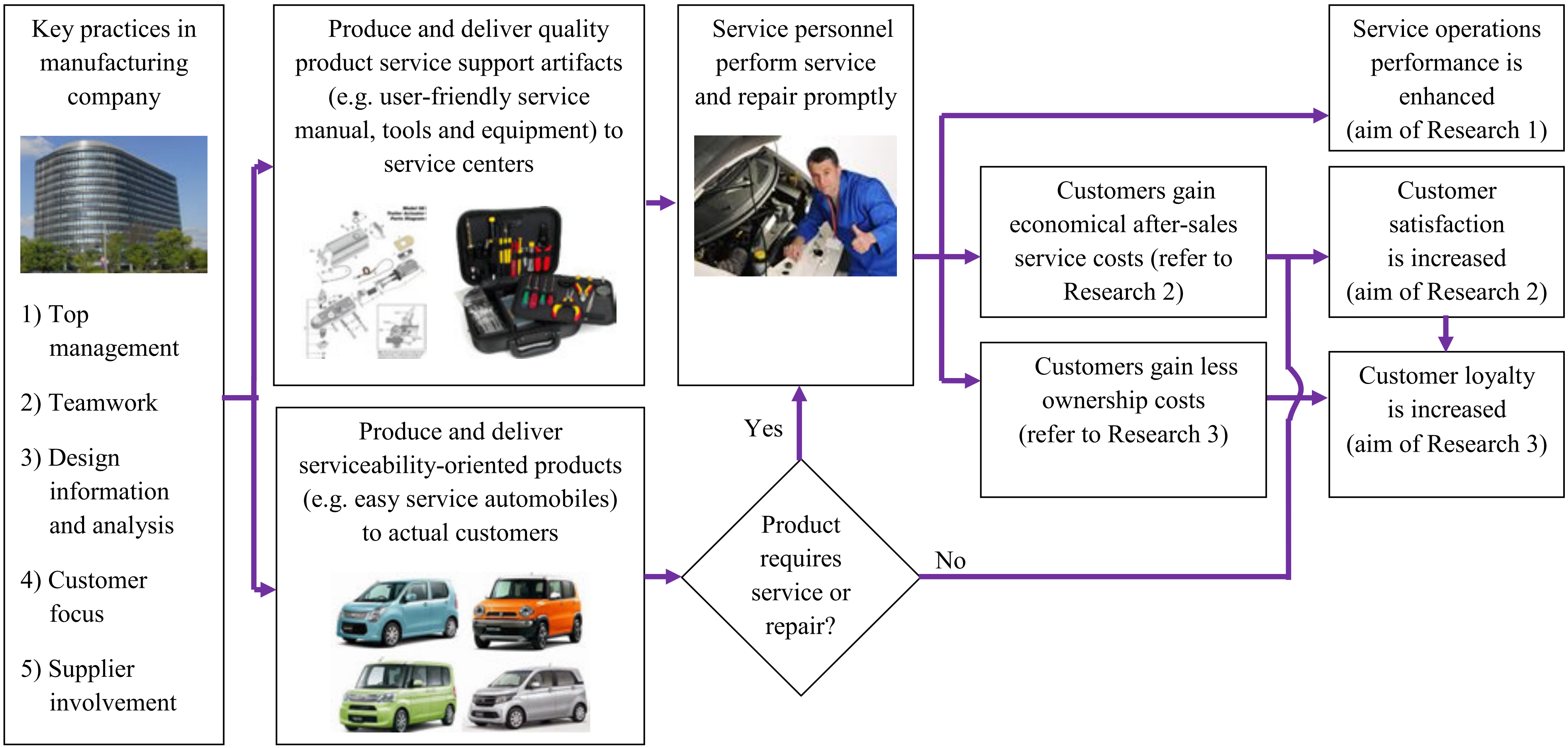

Figure 1.1: A schematic diagram of three inter-related researches

1.3 Research motivation

Prior to performing this research that is significant for current and future scholars, as well as practitioners, several research gaps associated with serviceability are identified from literatures. There are several motivations which influence the production of three inter-related researches. For the first research, while the broader fields of product quality, servitization and product-service systems have built up a sizeable body of literature, the subject of how to design products for serviceability and for integration with service operations has received scant attention.

For the second research, despite serviceability's prominence as an important dimension of product quality, there has been little empirical research on what constitutes serviceability from the customer's perspective. As potential constructs for product serviceability, this research draw upon Parasuraman et al's (1988) widely used SERVQUAL instrument, which examines service process elements of the service interaction, and then, enhance the instrument by embedding elements of product service support artifacts (e.g. service manual, user manual, tools and equipment), which should be provided by the manufacturer to service personnel. Furthermore, product service/repair-related costs borne by the user as a new, unexplored aspect of serviceability in the literature. Hence, there is a need for empirical research on how consumers perceive product serviceability and its impacts on after-sales service cost and customer satisfaction and loyalty for the product.

For the third research, further research on customer perspectives of quality of automobiles is important for continued development and success in the automobile industry. While serviceability was identified as one of eight fundamental dimensions of product quality by Garvin (1987), it has been discussed mostly at a conceptual level in the literature. Even though existing studies revealed that Garvin's quality dimension displays significant benefits to the manufactured products, no study has been conducted pertaining to the application of adopting Garvin's quality dimensions in the context of customer perspectives upon ownership cost. Hence, a detailed research in creating better comprehension of Garvin's quality dimensions and customers' perception about the benefits of ownership cost dimension is important toward facing the unstable world economy in this challenging decade.

1.4 Structure of the thesis

The remaining chapters of this thesis are organized as follows. Chapters 2, 3, and 4 describe each research, titled 'Designing products for serviceability: Antecedents and impact on service operations performance', 'The impact of serviceability-oriented dimensions on after-sales service cost and customer satisfaction' and 'Customer Perceptions of Mediating Role of Ownership Cost in Garvin's Dimensions of Quality', respectively. Chapter 2 explains the importance of designing products for serviceability from a company perspective, which then derives a framework that links management practices, design for serviceability practices, and operational performance in after-sales services. Chapter 3 elaborates the customer's perspective on product serviceability, including its impacts on after-sales service cost and satisfaction/loyalty when experiencing service or repairs. Chapter 4 describes automobile customer perspectives of product quality dimensions and ownership cost using a newly developed conceptual model. Chapters 2, 3, and 4 consists of general introduction, literature review for essential terminologies and constructs/dimensions, outlines of the hypotheses, proposed conceptual models, research methodology, analysis and findings, discussion, conclusions and future recommendations. Chapter 5 deliberates the overall conclusion for this thesis.

In terms of appropriate methodology for each individual research, the first study, which is designing products for serviceability is mainly to validate most of the existing dimensions. Confirmatory factor analysis (CFA) was only conducted in association with the survey on manufacturing companies in Japan. Meanwhile, the second and third studies require an exploration of the appropriate measurement items that belong to the extracted constructs. Hence, an exploratory factor analysis (EFA) is first initiated based on customer's perspectives followed by CFA by analyzing the findings from different sets of samples in each EFA and CFA.

CHAPTER 2

Designing Products for Serviceability: Antecedents and Impacts on Service Operations Performance

2.1 Introduction

Serviceability is a key dimension of product quality that influences customer experience and satisfaction (Garvin, 1987; Brucks et al., 2000) and is an increasingly important objective for product manufacturers as they pursue business strategies of servitization and environmental sustainability. As defined by Garvin (1987) in his eight dimensions of quality, serviceability is "the speed, courtesy, competence, and ease of repair" for a product. Achieving superiority in serviceability, therefore, requires that firms design products to be easy to service and maintain over their life cycle and that their after-sales service operations provide efficient and effective service to customers. Serviceability's importance to customers is underscored by, for example, a study of consumer evaluation of home air-conditioning systems, which found serviceability to be one of the three most important attributes to purchasers (Seitz et al., 2010). Serviceability's importance to the firm is evidenced by its role as a source of competitive advantage vis-à-vis other products in the marketplace, as a source of expanded revenue and higher profit margins, as a generator of customer satisfaction, and as a key factor in a new product success (Goffin and New, 2001).

Consideration of product serviceability also supports the strategic move of many firms toward servitization, wherein manufacturers "shift from selling products to selling integrated products and services that deliver value in use" (Baines et al. ,2009; see also Vandermerwe and

Rada, 1988; Lightfoot et al., 2013; Baines et al., 2017). In their categorization of product-services, Baines and Lightfoot (2014) describe three types: base services (provision of product and spare parts; knowing how to build it), intermediate services (maintenance of product condition; knowing how to repair it), and advanced services (performance of the product; knowing how to keep it operational). All three types of product-service offerings are supported more effectively by designing products for serviceability and integrating with after-sales service operations. The benefits of servitization strategies have been summarized as competitive (differentiation, defense against low cost competitors), financial (higher profit margin and stability of revenue stream), and marketing-related (expanded customer relationships and selling opportunities, product differentiation) (e.g. Baines et al., 2009; Wise and Baumgartner, 1999).

Environmental sustainability benefits also can be obtained through improved product serviceability and a form of servitization called product-service systems (PSS) (e.g. Goedkoop et al., 1999; Mont, 2002). Firms with a PSS business model (e.g. car sharing services) do not sell ownership of the physical product per se, but rather sell the service functions that the product provides while owning and maintaining the product themselves. The environmental benefit derives from dematerialization as increasing numbers of customers can receive the desired service function from a smaller total number of products in use, and hence a reduction in materials and energy intensity is achieved. Product-service systems are part of a broader trend from a throw-away society to a "repair society" (Blau et al., 1997, as cited in Mont, 2002) or a "circular economy" (e.g. WEF, 2014; Tukker, 2015). Designing products for serviceability supports the viability of such product-service systems through efficient, effective service and repair operations and the resultant extension of product lifetimes and their embedded energy and materials.

In several ways described above, designing products for serviceability and improved service operations yields important advantages in terms of strategic positioning, financial returns, marketing opportunities, and reduced environmental impacts. These advantages can accrue to the firm whether it be a conventional manufacturer that is simply selling quality products which customers prefer because they are easier to service and use over an extended lifetime, or a firm pursuing a strategy of servitization or product-service systems.

2.2 Research objectives

This study determined two main objectives as follows:

i) To examine the available literature and forms hypotheses on the organizational practices and design approaches that support the design of products for serviceability and the resulting impacts on service operations performance.

ii) To develop a conceptual framework associated with organizational practices, product service support artifacts and service operations performance.

2.3 Literature review

2.3.1 Design for serviceability

In the context of new product development (NPD), concurrent engineering is a systematic approach for manufacturers to design a robust product and establish manufacturing process simultaneously (Droge et al., 2004) in a cost-effective way (Yeh and Chu, 1991) and shorter development lead-time (Clark and Fujimoto, 1991).

The effective concurrent engineering is by embedding product characteristics, production requirements and voice of customers in design and process stage so that the development constraints could be anticipated and resolved economically. In terms of product characteristics, various elements of product lifecycle are discovered such as design for assembly (DfA), design for manufacturability (DfM), design for serviceability (DfS) and design for environment (DfE) (Gupta et al., 1997). Thus, the product lifecycle elements are categorized as design for X (DfX) and practiced by design engineers in decision-making and sometimes propose creative design solutions (Tan and Vonderembse, 2006) in resolving critical design issues. Huang, Lee, and Mak (1999) defined DfX as an emerging philosophy to support practitioners during decision making phase particularly related to product and process design. Initially, design for assembly (DfA) was studied by Boothroyd and Dewhurst (1983) to anticipate accurate installation sequence and production cycle time towards achieving low production cost. Hence, DfA and DfM deliver immediate engineering benefits to manufacturers especially in minimizing the difficulties in designing product and obtain cost saving in establishing production process (Kuo et al., 2001).

In order to strengthen the relationship between manufacturers and potential customers in the context of user-friendly service, Cavalieri et al. (2007) and Ionzon and Holmqvist (2005) identified design for serviceability as an important requirement that needs to be addressed the early design stage, concurrently with other DfXs. This requirement aims to help design engineers understand the requirements, further increasing awareness in the design department to detect potential serviceability issues from the early stage of new product design development in their company (Yu et al., 2011).

Meanwhile, it is not a significant difference between the definitions of design for serviceability and design for maintainability. The characteristics of both designs share the same purpose, which is to produce a product with easy repair (Tan et al., 2010; Yu et al., 2011) and an efficient repair process. Yu et al. (2011) also mentioned that a product with good maintainability could also enhance the levels of serviceability and reparability, which are able to avoid high maintenance cost, besides meeting customer satisfaction. Moreover, many industries such as airline industry are more concerned with maintainability (e.g. Knezevic, 1999) as it is part of product characteristics for proactive design engineers (Ghodrati et al., 2012) to build in the design stage (Narayan, 2012), in order to attract a lot of educated consumers (Madu, 2005) with more reliable products. Thus, this is the reason for the after-sales service processes to be specifically focused during the design and development stage in manufacturing companies in delivering user-friendly, service-friendly and environmental-friendly products into the market.

2.3.2 Top management commitment

Organizational culture was studied in order to introduce the top management and employees characteristics in a firm (Hofstede, 1998). Wu et al. (2011) added that organizational culture had an impact on organizational operation, decision-making and employees behaviors. Top management plays essential roles to create a conducive workplace in order to influence employees' positive attitudes. Frequent communication between managers and subordinates (for example, being fair to others and being a good listener) (Hofstede et al., 1990) and prompt action on highlighted issues were also reflected on employees insight (Hofstede, 1998). Hence, strong commitments from the top management impact the teamwork success in the organization. Previous studies (Fotopoulus and Psomas, 2010; Sila and Ebrahimpour, 2005; Mellat-Parast, 2015; Chin et al., 2010; Kim et al., 2012; Badri et al., 2005; Flynn et al., 1994) reported that top management's commitment influences teamwork, customer focus, design and analysis as well as supplier involvement. For example, Mellat-Parast (2015) found that top management's commitment has direct relationships with the Malcolm Baldrige National Quality Award (MBNQA) practices such as customer focus and information and analysis.

Besides, the top management's commitment plays a critical role and is a crucial driver in determining the success of quality improvement programs in the organization. They must continue to support any improvement efforts (Montes et al., 2005), pay attention to every comment (Tsang and Antony, 2001), and ensure all required resources are available for their sub-ordinates to carry out activities effectively. The top management will also act as a decision maker (Jun et al., 2006; Williams et al., 2010) and provide direction for any issues detected (Montes et al., 2005).

Thus, managers should be present when discussing issues in management meetings through open discussions (Wahid et al., 2011) and as a token of appreciation, they might provide rewards to employees who have contributed in enhancing company's performance (Tsang and Antony, 2001). As suggested by Wahid et al. (2011), a reward can be in many forms, such as incentive, bonus, and salary increment. Tsang and Antony (2001) added that the top management's commitment, recognition, and appreciation are required to increase employees' motivation in managing workloads and the level of employees' participation (Montes et al., 2005) in suggesting ideas for design improvement (Williams et al., 2010; Gebauer et al., 2009). By creating this working culture, the top management can continuously strengthen the professional relationship between them and employees (Wahid et al., 2011) and influence their employees to be more proactive (Williams et al., 2010) in performing other serviceability practices in the organization. Since the current top management is gradually capable to reorganize a manufacturing company from only selling a product to selling an integrated product-service to end user (Kastalli and Looy, 2013), managers need to ensure their knowledge about competitors and customers are also updated in order to compete in the competitive business market.

Since serviceability is one of the design requirements in NPD, full top management commitment supported by proactive teamwork with its employees are two important drivers towards the successful implementation of the design for serviceability in many industries. In the context of product support or service support, several case studies were conducted by previous scholars (e..g. Hull and Cox, 1994; Ionzon and Holmqvist, 2005; Szwejczewski et al., 2015). The case studies discovered that the top management acknowledged the importance of design for serviceability or after-sales requirement in NPD and encouraged full involvement of after-sales service personnel in product design decisions (Szwejczewski et al., 2015). Thus, highly-concerned top management of design for serviceability is anticipated to enforce direct participation of customers and suppliers in evaluating product design towards producing service-friendly products. It was contrasted from conventional NPD, which relied on respective department to manage design or process individually with less 'design-process integration' and no 'overlapping engineering activities' (Droge et al., 2004).

Alfalla-Luque et al. (2015) and Gebauer et al. (2009) also mentioned a study on the interaction between top management and customer. For instance, a good management's behavior such as spending time listening to employees (Harmancioglu et al., 2010), suppliers and customers becomes one of the important factors to motivate their full participation in the organization. The top management is also responsible in strengthening the relationship with suppliers and customers through close collaborations (Harmancioglu et al., 2010; Raddats et al., 2014) and considering supplier and customer future trends and knowledge in order to offer better products and services (Gebauer et al., 2011), which are in line with their new expectation.

According to Kastalli and Looy (2013) and Chin et al. (2010), all inputs from customers and suppliers could contribute to cost reduction during the design stage and subsequently create higher satisfaction to the top management. With this benefit, the top management shall manage all the resources properly since they are in the right position to decide for further direction (Harmancioglu et al., 2010) during NPD process.

As stated by Chin et al. (2010), manufacturing companies have to enhance their capability in designing products by clearly determining design specification, arranging design review sessions and preventing frequent design change. Hence, the core practice related to design for serviceability (DfS) is design information and analysis, which consists of virtual analysis and prototype analysis. One of the widely used tools in performing virtual analysis during product design is computer-aided design (CAD). Both analyses focus on disassembly and reassembly processes in order to ensure easy maintenance at the after-sales service. Design information and analysis is essential to remind design engineers considering DfX requirements, including DfS so that the top management is able to avoid unnecessary additional investment. The additional investment might consist of tooling modification, special high-end resources (Gebauer et al., 2009) or new facilities. Hence, top management should allocate appropriate resources such as latest CAD facilities or relevant service artifacts in developing highly-skilled employees to ensure effective collaboration with service personnel, suppliers and customers. Subsequently, highly-competent employees and service personnel may enhance service centers role as a knowledge sharing center for customers during the service and maintenance operations.

Based on this review of related issues, it is critical for top management to continuously monitor and support the project so that the design team can make design decisions based on the best available technical information from serviceability information and analysis, customers and suppliers.

2.3.3 Teamwork and communication

In terms of serviceability, the serviceability team needs to have good communication within the team members and other employees in the cross-functional team in order to gain various information and suggestions (Tan and Vonderembse, 2006) about the new product. Proactive involvement from various stakeholders especially managers and frontline employees, might influence productive technical discussion in the design and development phase. For example, Yip et al., (2014) identified that stakeholders' engagement in early development stage of product-service system was important to improve the quality service in healthcare industry. This practice is implemented to assess the involvement of serviceability team members in cross-functional team activities, such as participation in meetings for more effective discussion with other departments. The main purpose of cross-functional teams is to collaborate among each related department in the organization and increase cooperation during decision making process for achieving a win-win situation (Jiang, 2009). Throughout direct communication in cross-functional teams, each team could collaborate among many design engineers, simultaneously highlighting their specific requirements on the specific product and avoiding limited serviceability features in new product (Gebauer et al., 2008).

Henke et al. (1993) suggested that a good relationship between each team could generate better understanding among project team in various perspectives especially during designing a product with good serviceability. At the same time, every team member should also work as a team with trust (Tsang and Antony, 2001) to generate good ideas in any problem-solving initiatives towards reducing uncertainty during new product development (NPD) (Henke et al., 1993). A good teamwork and communication in an organization will have high possibility for lead-time reduction since they are able to develop more creative ideas in shorter time compared to individual effort. Knowledge sharing session could be conducted in order to strengthen the understanding and commitment (Tan and Vonderembse, 2006) within team members prior to generate better conclusion on specific issues. Employees of the organization, customers and suppliers are encouraged to collaborate in sharing opinions and knowledge (Swink et al., 2007) towards fulfilling end user requirements in the market. Konecny and Thun (2011) described that a good teamwork in the organization could encourage employees to collaborate simultaneously with customers and suppliers when analyzing a product using CAD and actual prototype part. The collaboration is part of the integration process with customers and suppliers in order to incorporate market needs as well as to create a good relationship with serviceability team members.

Besides communicating with the actual end user of the product, manufacturing companies' interaction with service centers could be closer because service personnel are also part of the cross functional teams (Knezenic, 1999). Furthermore, service centers might present the current and future customer demands (Harmancioglu et al., 2010) so that the serviceability team could integrate indirect requests into the early design development stage (Reim et al., 2015). As a result, this situation shows that there is an interrelated relationship between research team members, customers (consists of service personnel and end user) and suppliers in handling complicated demands from the market.

2.3.4 Design information and analysis

Design for X approaches were commonly practiced by various cross-functional teams to generate design solutions associated with assembly, testing, quality and service. Livingston (1988) identified that Design for Service (DfS) was practiced by Rank-Xerox during new product design stage especially on how service personnel perform easy maintenance within a specified time and fix any problem on a malfunction product. Roll Royce also performed DfS in manufacturing power systems and was concerned on costs corresponds with product lifecycle such as overhaul and disposal costs (Harrison, 2006). The approach was also known as digital manufacturing, which supported product design process using 3D CAD and a simulation tool for efficient development and production stage. The significant output of virtual analysis was accurate information in gaining minimum time and cost.

The purpose of CAD is to speed-up product data sharing within cross-functional teams, especially in facilitating and integrating various component designs of each product. Once a new product data is available in CAD format (Tan and Vonderembse 2006), design engineers could perform virtual analysis by using suitable software, such as Digital Mock-Up (DMU). DMU is a concept that allows the product description, usually in 3D Computer Added Model (CAM), for assembly assessment, layout verification, and interference checking (Sun, 2007) without any physical prototype parts. The DMU software is equipped with a human model, which enables engineers to measure service difficulty level in visibility, reachability, postures, stress, and fatigue aspects. By performing DMU, serviceability engineers are able of compiling all related CAD data simultaneously, while for design engineers, CAD can support them to expedite new product development (Jayaram et al., 1999). Without DMU, each part cannot be verified thoroughly, including the surrounding area, since each part is designed by different design engineers (Tan and Vonderembse, 2006; Hu et al., 2010).

Due to the fact that operations are usually performed in a restricted area and within a limited time span, such as service personnel’s movements being often constrained by the surrounding components, the virtual analysis can detect any clash or contact between components in order to minimize unforeseen circumstances as early as the design stage (Yu et al., 2011). Through virtual analysis, serviceability engineers are also able to produce initial service procedures with related service diagrams as well as propose the suitable tools or equipments. Any critical issue will be reported to the top management to seek management decision especially issue that require additional investment or total project schedule extension. Usually, the actual prototype part is frequently required when actual service analysis is conducted. With good serviceability, or repairability aspects, the actual prototype product could easily be accessed by using bare hands or common tools and equipment. Understandable procedures can be established and the design can be finalized prior to mass production. As categorized by Goffin and New (2001), an established service procedure was part of seven elements in after-sales services to support service-related tasks at service centers. Other elements consisted of part replacement, user training, maintenance and repair, online support, warranty and product upgrading.

Thus, 3D digital mock-up (DMU) and rapid prototyping were two recognized approaches by manufacturing companies to evaluate product design in minimal development lead time and project cost instead of producing full physical repeated multiple prototypes (Thomke and Fujimoto, 2000). This practice is part of the product design goal (Goffin and New, 2001) to prevent high cost-of-ownership to customers, such as high labor cost and expensive spare part. Hence, design information and analysis is a process, which is performed by the design department in order to incorporate a full understanding of product related service requirements (Swink et al., 2007).

2.3.5 Customer focus

For customer focus practice, the serviceability team members have to specify customer requirements based on customer voice in the market. This is in line with a study carried out by Yang and Fang (2004), which stated that listening to customer voices is also part of quality improvement efforts. The customers were categorized into two groups; internal customers, and external customers. In the context of designing product for serviceability, internal customers (e.g. service personnel at the service center) are considered as end users of service-related products (e.g. service manuals and tools) that are delivered by manufacturing companies to service centers for the internal customers to perform maintenance, service, or repair on the sold products. Meanwhile, external customers (the actual users of the product) are the buyers of sold products that are marketed by manufacturing companies through distributors, dealers, and sales department.

Although the serviceability personnel and design department portray good teamwork in conducting service-related analyses, internal customers are also required to be part of the team in order to exchange ideas during the decision-making meeting (Dotchin and Oakland, 1994). Loyal internal customers are able to understand the latest customer requirement (Yee et al., 2010), and then, share their experiences or offer valuable suggestions to the manufacturing companies.

Case study investigations by Johnstone et al., (2009) and Szwejczewski et al. (2015) underscore the importance of understanding the customer's requirements and perspective, and reflecting these into product design to enhance product serviceability and support. Specifically, in their study of three leading manufacturers (AeroCo, VendingCo and AutoCo), Szwejczewski et al. (2015) found that they explicitly considered external customers in serviceability analysis carried out the in the new product development stage, as part of efforts to create reliable product service support artifacts. Since direct communication exists between serviceability personnel and design department with service personnel at service centers, service personnel are also invited to anticipate potential issues in after-sales service and simultaneously establish better service or repair procedures based service center expectations.

Hence, customers' involvement in NPD is required in order to evaluate the importance of customer focus practice from top management and cross-functional teams' perspectives and subsequently examine the impact of this factor upon product service support artifacts and service operation performance.

2.3.6 Supplier involvement

Besides performing design information and analysis as well as inviting internal and external customer, the organizations should also create a good relationship with suppliers from the design stage until the after-sales service stage. According to Jayaram et al. (1999), supplier is the single most important factor in expediting the new product introduction stage. Hackman and Wageman (1995) reported that a strong partnership with suppliers drives manufacturers to continuously improve business process. For example, organizations shall provide technical assistance to suppliers, educate them for better performance, and discuss any arising problems. This practice allows the organization to obtain more inputs from suppliers, such as valuable technical product knowledge, past experiences, as well as the capability to produce a product with serviceability features by integrating the supplier's process into their production line (Perols et al., 2013).

Holschbach and Horfmann (2011) added that long-term relationship between manufacturers and suppliers influence the understanding of product requirements, including service-related design reviews. It is because the suppliers are highly capable in highlighting their supplied components based on their broader technical know-how in design, production and service perspective. Kaynak and Hartley (2008) concluded that a good collaboration with the supplier since the early design stage can generate more profit to the organization, reduce waste and able to provide customers with higher quality product and service. Thus, supplier's input influences quality product (Kaynak, 2003) which covered less engineering changes and high reliability. Once a reliable product is delivered to the market, customer may experience minimum parts problem and gain low ownership cost until product end of life. In the context of after-sales service, no severe issue is anticipated to exist and subsequently may produce efficient service operation at service centers. Hence, continuous relationship with suppliers (Anh and Matsui, 2011; Prakash, 2011) and customers will establish knowledge sharing culture in an organization to determine the up-to-date market requirements including product innovativeness in service (Anh and Matsui, 2011).

2.3.7 Product service support artifacts

At the new product development stage, the main outcome of design for serviceability is the creation of effective product service support artifacts (e.g. service manual, spare parts, tools, equipment and diagnostic tool) for directly meeting the needs of service personnel as internal customers, and indirectly for end-users as external customers. Product support in after-sales service is continuously being considered by manufacturers to facilitate maintenance process and support customers in operating product function efficiently (Markeset and Kumar, 2003). For example, product documentation (e.g. service manual, product technical manuals and training manuals) and user-friendly spare parts are two example of service instruments (Tan et al., 2010) or product service support artifacts or tangible product of product service support (Wang et al., 2011) which enable service center to drive service operation smoothly.

Frequent disassembly and reassembly during virtual analysis and actual prototype analysis may create the safest and most accurate service procedures. In order to transfer the technical knowledge to internal customers (e.g. service personnel) and external customers (end user or buyer), the service procedures then are documented systematically in product documentation (Shankar et al., 2013) for reference by service personnel and end user respectively. In line with high efficiency of information and technology (IT), nowadays service manuals are produced electronically and become an essential digital artifact to overcome service issues within a specified period. In the service manuals, service instructions are updated immediately via internet connection and thus guide service personnel in performing better repair and maintenance, as well as aid them in part disassembly process especially on complicated and high-level product subsystems.

Regarding the spare parts, service centers could rapidly replace the malfunction parts and generate additional profit through spare part sales since design for free- maintenance is impossible for manufacturers (Markeset and Kumar, 2003). Throughout designing product for serviceability, user-friendly spare parts can be produced by establishing many serviceable parts and modular parts for service personnel and customers benefits, which may reduce total service or labor time in service operations directly and avoid additional total service cost for customers.

Furthermore, service personnel are also satisfied with the effectiveness of tools used. For instance, they could utilize the existing tools for any replacements, service, or repair on the malfunction part. Service personnel will be equipped with a set of tools for them to use for multiple tasks. Hence, service center can also avoid purchasing unnecessary new tools, such as a new special tool for a certain service or repair, as a new special tool might be required if the serviceability aspects of a product did not undergo the design information and analysis practice in NPD. The ability to utilize appropriate tools and equipment are also considered important artifacts for service personnel to perform service operation (such as part replacement, repair and diagnostic tasks) efficient and effectively (Porcelli et al., 2013). For product diagnostic, diagnostic tools with embedded updated software are also part of artifacts for service personnel to perform accurate product troubleshooting (Case et al., 2010) associated with electronic-circuit or electronic control unit and fix the product back to original specification.

Talib et al. (2013) in their study mentioned that the quality management practices such as customer focus, information and analysis as well as supplier involvement contribute in innovating the development of new service procedures in order to ensure quality product is designed for respective customers and then contribute to higher market share (Su et al., 2008). Thus, product service support artifact is a key predictor to gain an optimum maintenance quality. Once the components of particular product are service-friendly designed, routine maintenance is much easier and contribute to less labor cost. Subsequently, the service centers will operate efficiently when compared to the conventional business process.

2.3.8 Service operations performance

Service centers have the capacity to achieve high performance during service operation. With easy access to a part at specific locations, less time is consumed for untightening and retightening fasteners, as well as replacing any malfunction part from the system. By referring to the established service manuals, they could also perform correct replacement, service, or repair without error or secondary defect at surrounding products. Thus, service, repair, or replacement tasks will be able to be completed timely, as promised to the customer, due to simple disassembly process and no 'try and error' job needed. On top of that, the availability of individual spare parts is essential for service personnel to replace the only malfunction part promptly without the need to change the modular assembly part. Without modular assembly part, service personnel could avoid unnecessary additional labor cost, which needs to be remunerated by the customer. Hence, high level of serviceability is important to help customers pay the minimum cost in between when the product is purchased until the end of the product's life cycle. The implementation of the preceding serviceability practices is anticipated to directly support in producing effective product service support artifacts and enable subsequent improvement of operational performance at product service centers.

2.4 Research hypotheses and framework

The aim of this study is to establish the relationship between serviceability practices, product service support artifacts and service operations performance. Hence, this research explored the benefits of serviceability to manufacturing companies and service centers. Based on relevant literature review, thirteen hypotheses were proposed in the previous section dealing with manufacturing company, service center, actual customer and supplier. The relationships represent how significant the top management influences their cross-functional teams to consider serviceability requirements as well as encourage customers' and suppliers' participation in producing valuable product service support artifacts for efficient service operation at service centers. Hence, the following hypotheses are presented:

Hypothesis 1a. Top management commitment positively influences teamwork and communication.

Hypothesis 1b. Top management commitment positively influences customer focus

Hypothesis 1c. Top management commitment positively influences design information and analysis

Hypothesis 1d. Top management commitment positively influences supplier involvement

Hypothesis 2a. Teamwork and communication positively influences customer focus

Hypothesis 2b. Teamwork and communication positively influences design information and analysis

Hypothesis 2c. Teamwork and communication positively influences supplier involvement

Hypothesis 3. Design information and analysis positively influences product service support artifacts

Hypothesis 4a. Customer focus positively influences product service support artifacts

Hypothesis 4b. Customer focus positively influences service operations performance

Hypothesis 5a. Supplier involvement positively influences product service support artifacts

Hypothesis 5b. Supplier involvement positively influences service operations performance

Hypothesis 6. Product service support artifacts positively influence service operations performance

Pertaining to all the constructs presented, Figure 2.1 shows the hypothesized conceptual model which representing the relationships between serviceability practices, product service support artifacts and operation performance.

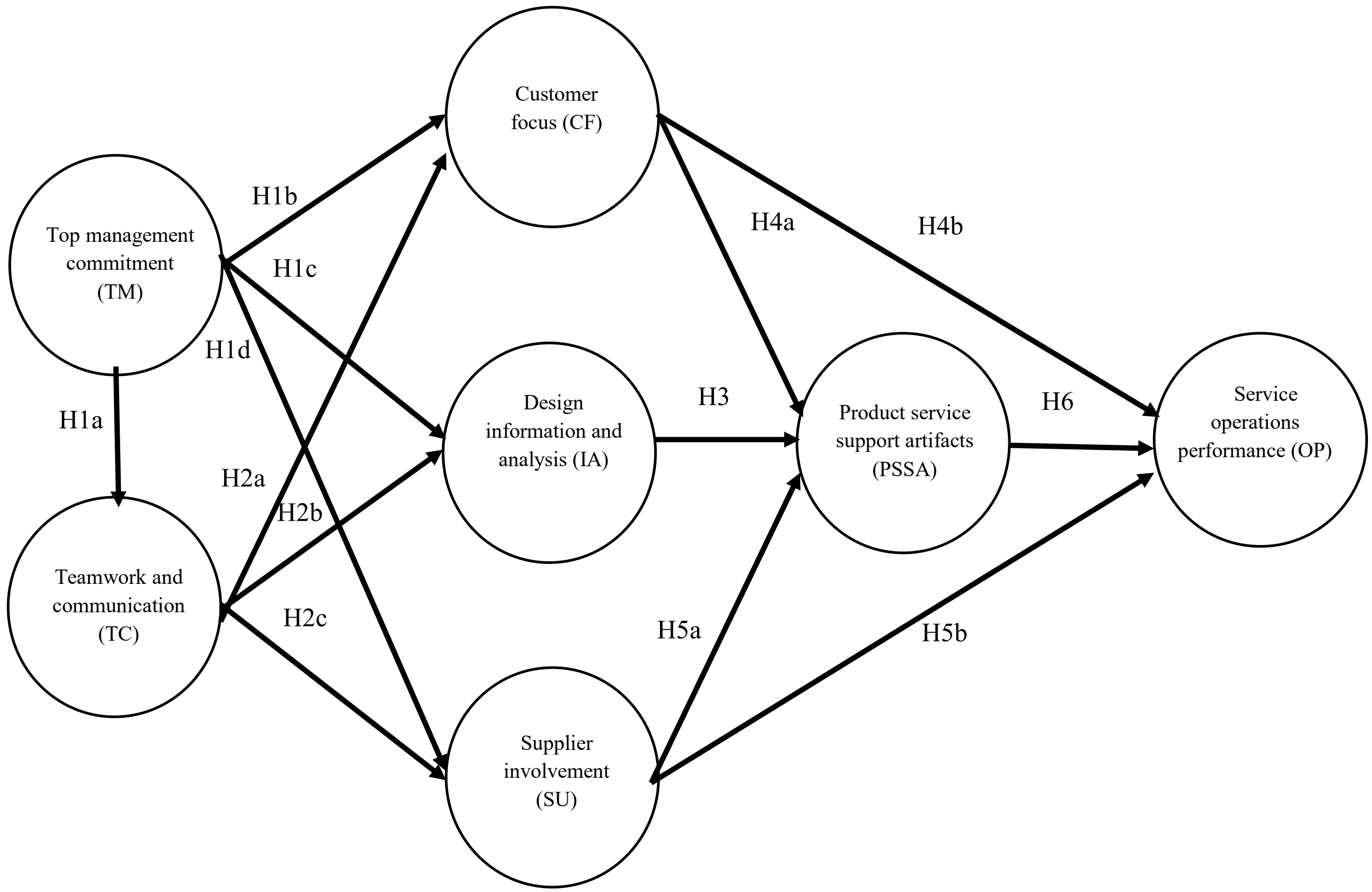

Figure 2.1: The hypothesized conceptual model for serviceability practices, product service support artifacts and service operations performance

2.5 Research methodology

2.5.1 Measurement items development

The survey contained measurement scale items for the seven constructs in the conceptual model. The scale items were finalized through a comprehensive review of existing validated scales items in related literatures (e.g. Saraph et al., 1989; Flynn et al., 1994; Prajogo and Sohal, 2006). Since the context and specific practices of serviceability have not been empirically examined previously, it was necessary to adapt the existing scale items to enhance the validity of survey instrument and in some cases, to add new items to better measure the underlying constructs. In total, 44 items were included, as shown in Appendix I.

Hence, all the 44 adapted and new measurement scale items that were anticipated can measure each respective construct were identified: Top Management Commitment (5 items), Teamwork and Communication (4 items), Customer Focus (8 items), Supplier Involvement (4 items), Design Information and Analysis (10 items), Product Service Support Artifacts (6 items), and Service Operations Performance (7 items). In term of general description and original sources of each construct, the items in the measurement scale for Top Management Commitment (TM) refer to the involvement and ongoing support by top management for the firm's serviceability efforts, and are adapted from Saraph et al., (1989), Flynn et al., (1994), Chow and Lui (2001), Talib et al. (2013) and Lee et al. (2011). Secondly, Teamwork and Communication (TC) items reflect a teamwork approach and cross-functional sharing of information with regard to serviceability, and are drawn from Badri et al. (1995), Arauz and Suzuki (2004), Prajogo and Sohal (2006), Talib et al. (2013), Samson and Terziovski (1999) and Wahid et al. (2011). Thirdly, Customer Focus (CF) refers to involving and understanding the needs of service/repair personnel as internal customers, as well as understanding the serviceability-related needs of end-users as external customers. Items for the CF scale are adapted from Flynn et al. (1994), Wahid et al. (2011), Wickramasinghe and Gamage (2011), Talib et al. (2013), Lee et al. (2011), Prajogo and Sohal (2006) and Samson and Terziovski (1999). Fourthly, Supplier Involvement (SU) concerns the involvement and support of external suppliers for product serviceability, and includes items drawn from Saraph et al. (1989), Flynn et al. (1994), Badri et al. (1995), Chow and Lui (2001), Prajogo and Sohal (2006), Wahid et al. (2011), Talib et al. (2013) and Prakash (2011).

Fifthly, items for Design Information and Analysis (IA) relate to the use of information from product benchmarking, 3-D visualization (digital mockup) analysis, and actual prototype product analysis. As many of these particular serviceability practices have not been empirically examined in the literature, new scale items for IA were developed to operationalize their meanings based on related literature and industry practice. Sixthly, Product Service Support Artifacts (PSSA) deals with the artifacts that support product serviceability such as manuals, procedures and tools. New items were developed, in similar manner, for the PSSA scale. Finally, Service Operations Performance (OP) refers to speed, quality (accuracy), and cost-related issues for product servicing by service personnel. Perceptual measurement items for OP include new additions specific to product servicing, as well as adapted items from Oh and Rhee (2008), Doll, Hong, and Nahm (2010), Laroche et al. (2010), Parasuraman et al. (1985), Abu-El Samen et al. (2013), Synnes and Welo (2015), Salaheldin (2005) and Ganguli and Roy (2010).

2.5.2 Survey instrument development and content validity

Survey questions were translated into Japanese by multiple native and bilingual speakers and back-translated for verification of meaning. This process was continued until consistency was achieved between the English and translated Japanese versions. To ensure similarity in translation, the questionnaire items were then translated back into English for comparison (Mullen, 1995). Several methods were used to ensure face validity and content validity of the survey instrument. Face validity is the prima facie notion of whether the scales represent what they purport to represent. Content validity, as described by Kaynak and Hartley (2008), is evaluated according to logical and theoretical thinking about how well a scale measures the intended concept. Both face validity and content validity were ensured through comprehensively reviewing the literature and adapting existing scales as the foundation. In addition, the major annual trade fair for manufacturers was used to conduct informal interviews with company managers and engineers regarding serviceability issues, and their feedback was solicited. Finally, the survey instrument was pilot tested with expert academics from two universities and practitioners from three different manufacturing companies to assess the validity and usability of the survey instrument. From their feedback, further refinements were made to improve its content and readability. Items were estimated through respondents' perceptual evaluations on a seven-point Likert scale, with anchors of 1 ("totally disagree") and 7 ("totally agree").

2.5.3 Data collection

To test the theoretical model and hypotheses presented in the previous section, empirical data was collected through a mail survey of manufacturing companies in Japan. In addition to having the third largest economy in the world, Japan is recognized for quality and product engineering (Clark and Fujimoto, 1991; Liker et al., 1995), making Japanese manufacturers an appropriate and useful sampling frame. A leading business research database firm was engaged to generate a representative sample of manufacturers in industry sectors whose products are relevant to serviceability, with multiple sectors targeted to increase the study's generalizability (see Table I). Using the key informant approach, a cover letter instructed companies to have the survey completed by a relevant senior manager with responsibilities and experience in product design and service.

2.5.4 Total sample and response rate

In total, 1689 survey questionnaires were distributed to manufacturing companies located throughout Japan. At the same time, an official cover letter was attached with the questionnaire towards compiling actual responses from dedicated person especially management level (e.g. Chairman and Director) or managers from the After-Sales Service Department, Design Department and Quality Department. The management level was anticipated could answer all the questions based on their wider knowledge across all the respective departments as well as their ability to receive more reliable sources immediately (e.g. Sanders, 2008) .

Several methods were employed to increase the response rate: the survey's sponsorship by a leading Japanese university was communicated to recipients, a postage-paid return envelope was provided, respondents were promised anonymity and confidentiality and were offered the study results upon request, and two follow-up mailings were made with reminder post cards and surveys. From these efforts, a total of 238 responses were received, which included some partially completed or otherwise unusable surveys. After omitting such responses, 202 usable responses were obtained, yielding an effective response rate of 12.0%.

2.5.5 Respondent profile

As shown in Table 2.1, virtually all respondents held senior-level positions, with 46.7% having job titles of Chairman, Director, Chief Executive Officer or Managing Director, followed by Managers (41.9%), Technical Leaders (7.2%) and other personnel (4.2%). The firms represented multiple industry sectors for which product serviceability is most relevant, including general machinery manufacturing (45.0%), electrical machinery and equipment manufacturing (20.8%), transportation equipment manufacturing (19.3%), and precision instrument and medical instrument manufacturing (14.9%). The great majority (68.8%) were certified to one or more ISO management system standards (e.g. ISO 9001, ISO 14001, ISO/TS 16949), and six companies were recipients of Japan's prestigious Deming Prize. Furthermore, the sample represents a broad cross-section of small, medium, and large-sized firms.

Table 2.1: Demographic data of survey respondents

Title of respondent	Percent
Chairman/Director/CEO/Managing Director	46.7
Manager	41.9
Technical Leader	7.2
Other	4.2
Total	100.0

Company classification	Percent
General machinery manufacturing	45.0
Electrical machinery and equipment manufacturing	20.8
Transportation equipment manufacturing	19.3
Precision instrument and medical instrument manufacturing	14.9
Total	100.0

Company size	ISO certified company		Non-ISO certified company		Total	
	n	Percent	n	Percent	n	Percent
1 - 50 employees	29	14.3	44	21.8	73	36.1
51 - 250 employees	62	30.7	15	7.4	77	38.1
More than 250 employees	48	23.8	4	2.0	52	25.8
Total	139	68.8	63	31.2	202	100.0

2.5.6 Tests for non-response bias

While the response rate of 12.0% is comparable to that of other recent survey-based research (*e.g.* Salvadora et al. 2014: 10.6%; Koufteros et al. 2001: 10%; Doll et al. 2010: 9.1%; Braunscheidel and Suresh 2009: 7.4%; Tan and Vonderembse 2006: 6.7%), there is the possibility of non-response bias. Following Armstrong and Overton's (1977) method, we compared several item responses between early responders (first 10%) and late responders (last 10%) and found no significant differences with independent t-test. Additionally, we investigated reasons for non-response through communications to/from some of the non-responders and found the prevalent reasons to be lack of time, company policies prohibiting response to surveys, or the company's lack of involvement in product design and service (for which non-response is appropriate). Based on these results, we can assume that non-response bias is not a concern.

2.5.7 Confirmatory factor analysis

The CFA was carried out to establish multidimensionality of constructs. CFA is a multivariate statistical technique used to evaluate how well each of the measurement scales item represents each factor. Confirmatory factor analysis (CFA) is used to develop an acceptable measurement model. At the same time, it is useful to assess the reliability and validity for each latent variable. According to Gerbing and Anderson (1988), CFA was conducted to validate each studied factor and two-stages of CFA, which are the measurement model and structural model, are required in order to test the conceptual model. Measurement model is applied by scholars to identify the relationship between factors and corresponding measurement scale items (observed variables) and subsequently performing structural model for testing the hypothesized relationship.

The results from the CFA models for all the constructs were assessed using multiple fit indices, including Chi-square, Comparative Fit Index (CFI), Incremental Fit Index (IFI), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA). For this study, the sample size was appropriate to run structural equation modelling (SEM). SEM is a mathematical method for behavior and social modelling. SEM enables us to test several multiple regression equations and it is very beneficial to test for model fit with a lower degree of measurement error. In this research, the measurement model includes the relationship between the dimensions and the questionnaire items (indicators). Therefore, the proposed hypotheses were examined via SEM method, whereby the data were analyzed using Statistical Package of

Social Sciences (SPSS) version 23 and AMOS version 23. Since the raw data were used as input for SEM, several statistics representing mean, standard deviation, skewness, and kurtosis were measured. According to the guidelines for severe non-normality (i.e. skewness > 2; kurtosis > 7) (Vaidyanathan & Devaraj, 2008), the normality assumption of all measurement items was satisfied. The following sub-sections discuss common procedures, corresponding to CFA data validation.

In this analysis, we focused on several standard fit indices to test the measurement model. The relationships between the dimensions (the five serviceability practices, product service support artifacts, and service operations performance) and the questionnaire items (indicators) were examined. The goodness-of-fit statistics were examined through the measurement model. Each fit index has a cut-off point with the ratio of chi-square to the degree of freedom (x^2/df) that should be less than 5.0 (Marsh and Hocevar, 1985; Bentler, 1990); Comparative Fit Index (CFI) and Incremental Fit Index (IFI) should be more or equal to 0.9 and close to 1.0 (Hair et al., 2006; Bentler, 1990; Hatcher, 1994); and the Root Mean Square Error of Approximation (RMSEA) values should be less or equal to 0.080 (Hair et al., 2006). For the measurement model, which comprises of seven latent variables, the fit indices were as follows: x^2 (df=262) = 1,313.62 with p-value = 0.000; x^2/df = 1.93; CFI = 0.91; IFI = 0.91; TLI = 0.90; and RMSEA = 0.07. Applying these criteria to our measurement model, an adequate level of fit has been obtained overall. Figure 2.2 shows the measurement model.

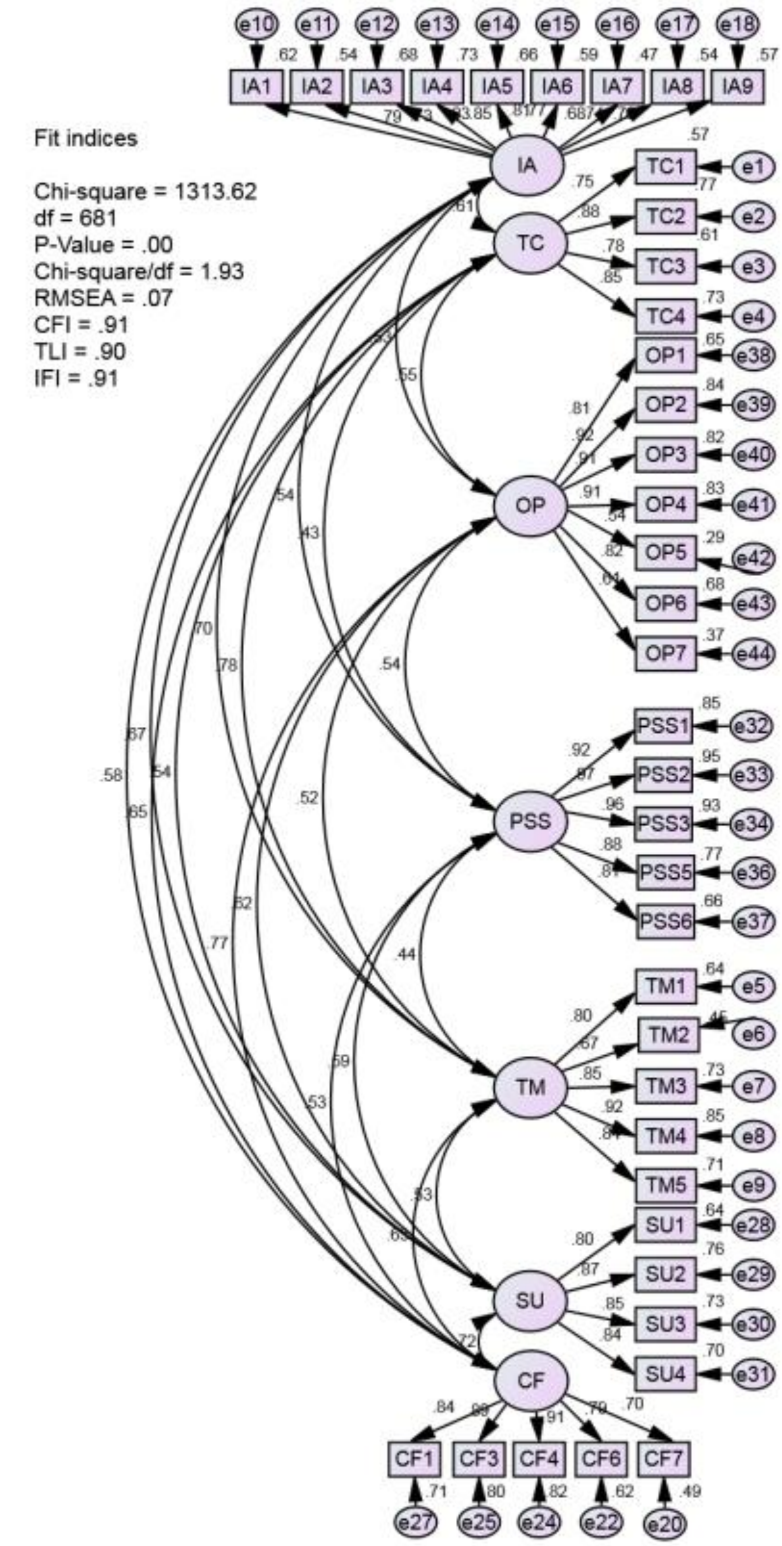

Figure 2.2: Measurement model of design for serviceability practices

2.5.8 Test for construct validity

Construct validity is the degree to which the measurement scale items measure the construct (Churchill, 1979). Construct validity is comprised of convergent validity and discriminant validity. Construct validity is defined as "the correspondence between a construct and the operational procedure to measure or manipulate that construct" (Schwab, 1980). In this analysis, convergent validity and discriminant validity were employed to assess construct validity.

2.5.8.1 Test for convergent validity

Convergent validity is the degree to which the observed variables measure the inherent factor, which can be assessed through Average Variance Extracted (AVE) and composite reliability. According to Hair et al. (2006), the indicators' AVE should be greater than 0.50 and the composite reliability of each construct should exceed 0.70. The results in Table 2.2 show that the average variance extracted ranges from 0.600 to 0.833 and the composite reliability of the constructs ranges from 0.890 to 0.961, thus establishing convergent validity.

Table 1.2: Average variance extracted (AVE) and composite reliability

Factor	AVE	Composite reliability
Top management commitment (TM)	0.677	0.912
Teamwork and communication (TC)	0.671	0.890
Design information and analysis (IA)	0.600	0.931
Customer focus (CF)	0.688	0.916
Supplier involvement (SU)	0.708	0.906
Product service support artifacts (PSSA)	0.833	0.961
Service operations performance (OP)	0.641	0.924

2.5.8.2 Test for discriminant validity

Discriminant validity is the degree to which measures of different latent constructs are unique enough to be distinguished from one another, which is demonstrated if the square root of average variance extracted for each construct is greater than the correlations between constructs (Li et al., 2008). The diagonal values are the square roots of the AVE's for each factor. As shown in Table 2.3, the square root of AVE (on the diagonal) exceeds the squared correlations (on the off-diagonal) for the study instrument, thus establishing the discriminant validity of the serviceability practice constructs.

Table 2.2: Average variance extracted (on the diagonal) and squared correlation coefficients (on the off-diagonal) for study instrument

	Variables	TM	TC	IA	CF	SU	PSSA	OP
1	Top management commitment (TM)	**0.823**						
2	Teamwork and communication (TC)	0.781	**0.819**					
3	Design information and analysis (IA)	0.700	0.613	**0.775**				
4	Customer focus (CF)	0.627	0.652	0.585	**0.829**			
5	Supplier involvement (SU)	0.535	0.539	0.669	0.720	**0.841**		
6	Product service support artifacts (PSSA)	0.443	0.433	0.543	0.526	0.594	**0.912**	
7	Service operations performance (OP)	0.523	0.548	0.526	0.775	0.617	0.543	**0.801**

2.5.9 Tests for common method variance

Common method variance is a possible problem in every conducted survey (e.g. Flynn et al, 1990). Since the same survey instrument was used to collect independent and dependent variable measures from single respondents in each firm, there is the possibility of common method variance (CMV) biasing the results. To reduce or avoid CMV, several procedural remedies were employed, including use of middle and senior level managers with relevant knowledge as respondents, proximal separation of predictor and criterion variables in the survey instrument, protection of respondent anonymity, and improvement of scales items through inclusion of definitions and examples to reduce ambiguity (Podsakoff et al., 2003). We tested for CMV using Harman's single-factor test, which is one of the most widely used methods (Podsakoff and Organ, 1986). From this result, common method bias is unlikely an issue in this research.

2.6 Analysis and findings

While there are differing recommendations for the minimum sample sizes needed to carry out structural equation modelling, our dataset with 202 usable responses meets the more stringent criterion of n>200 (Hair et al., 2006; Hussey and Eagan, 2007). The structural model, shown in Figure 2.3, was produced using AMOS software version 23.

In this structural model, the relationship between the respective latent variables was tested. The indices were within the acceptable range of values, with x^2/df = 2.03, comparative fit index (CFI) = 0.90, incremental fit index (IFI) = 0.90, and root mean square error of approximation (RMSEA) = 0.07. Thus, the overall structural model fit was judged to be satisfactory. Hypothesis 1a regarding the positive effect of top management commitment on teamwork and communication was highly supported (standardized coefficient = 0.78, $p<0.01$). Thus, our study contributes to the literature by extending the general findings of other researchers on the importance of top management support (e.g. Kim et al., 2012; Fotopoulus and Psomas, 2010) to the specific context of serviceability design and service operations. The structural model also supported hypotheses 1b, 1c, 1d, 2a, 2b, and 2c, indicating that top management commitment as well as teamwork and communication had a significant effect on design information and analysis, customer focus and supplier involvement (Fotopoulus and Psomas, 2010; Sila and Ebrahimpour, 2005; Mellat-Parast, 2015; Chin et al., 2010; Kim et al., 2012; Badri et al., 2005; Flynn et al., 1994). The standardized coefficients for H1b, H1c, H1d, H2a, H2b and H2c were standardized coefficient = 0.55 ($p<0.01$), standardized coefficient = 0.30 ($p<0.05$), standardized coefficient = 0.30 ($p<0.05$), standardized coefficient = 0.21 ($p<0.05$), standardized coefficient = 0.44 ($p<0.01$) and standardized coefficient = 0.35 ($p<0.05$) respectively.

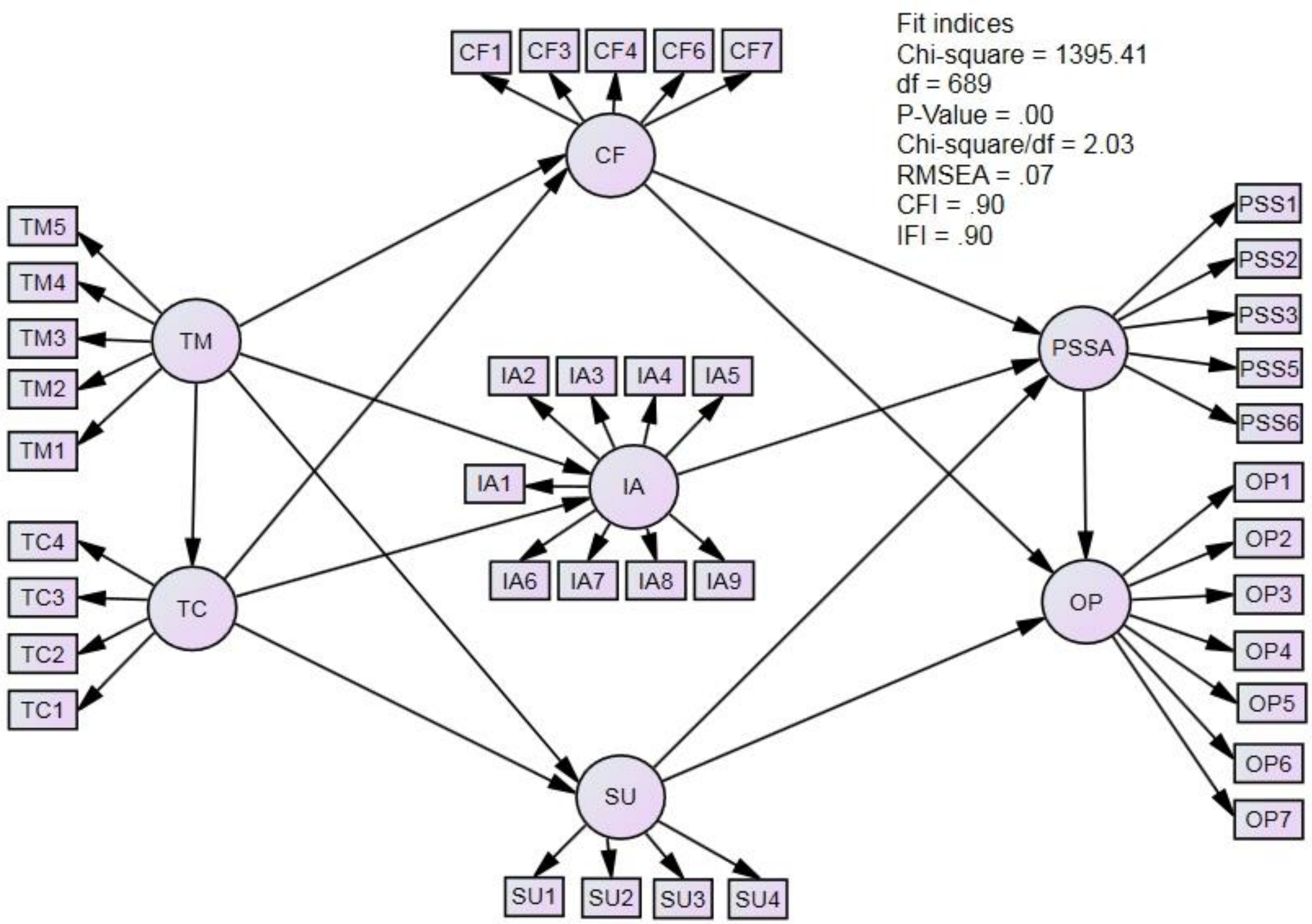

Figure 2.3: Structural model of design for serviceability practices

H3, regarding the positive effect of design information and analysis on the creation of product service support artifacts, also was highly supported (standardized coefficient = 0.24, $p < 0.01$). Thus, our study provides empirical support for the serviceability context concerning Su et al. (2008)'s assertion that the ideas and technical knowledge generated from quality practices such as information and analysis contribute to the success of good product and service design. The serviceability practices benefits ensured high efficiency in terms of product service support artifacts and operation performance in after-sales service operation. The benefits supported Hypothesis 4a (standardized coefficient = 0.17, $p<0.05$) and marginally supported Hypothesis 4b (standardized coefficient = 0.64, $p < 0.01$) whereby customer focus was positively related to the product service support artifacts and service operations performance. A previous study (Feng et al., 2012) demonstrated that customer focus and customer involvement during NPD could speed up the delivery of new products to the market. In this case, the materials and information from product service support artifacts were essential to be distributed in order to support after-sales service operation at the service centers. This result is consistent with Konecny and Thun (2011) and Devaraj et al. (2007) who found that customers had a positive significant effect on cost, flexibility and delivery performance. In addition, the relationship between supplier involvement and product service support artifacts (H5a) was highly supported (standardized coefficient = 0.35, $p < 0.01$), which is consistent with Su et al. (2008).

Hypothesis 5b regarding the direct effect of supplier involvement on service operations performance was not supported (standardized coefficient = 0.09, $p > 0.05$). On the surface, this result appears contrary to previous studies by Wienggarten et al. (2014), Chin et al. (2010), Devaraj et al. (2007), Singh et al. (2011), and Konecny and Thun (2011). Their results proposed that qualified supplier participation seemed to be a realistic approach towards enhancing operating performance, such as minimizing operating time and executing efficient delivery to the customer. Hypothesis H6 was also supported (standardized coefficient = 0.17, $p<0.05$). This hypothesis was in-line with a recent research (Raddats et al., 2014) indicating that manufacturing companies that offer suitable methods and service tools to technical support teams were able to deliver more cost effective service to customers. All the preceding hypotheses and results are summarized in Table 2.4.

Table 2.3: Summary of hypothesis test results for structural model.

Hypotheses	Path	Standardized Coefficient	Hypotheses supported?
H1a	Top management (TM) → Teamwork and communication (TC)	0.78***	Yes
H1b	Top management (TM) → Design information and analysis (IA)	0.55***	Yes
H1c	Top management (TM) → Customer focus (CF)	0.30**	Yes
H1d	Top management (TM) → Supplier involvement (SU)	0.30**	Yes
H2a	Teamwork and communication (TC) →Design information and analysis (IA)	0.21**	Yes
H2b	Teamwork and communication (TC) → Customer focus (CF)	0.44***	Yes
H2c	Teamwork and communication (TC) → Supplier involvement (SU)	0.35**	Yes
H3	Design information and analysis (IA) → Product service support artifacts (PSSA)	0.24***	Yes
H4a	Customer focus (CF) → Product service support artifacts (PSSA)	0.17**	Yes
H4b	Customer focus (CF) → Service operations performance (OP)	0.64***	Yes
H5a	Supplier involvement (SU) → Product service support artifacts (PSSA)	0.35***	Yes
H5b	Supplier involvement (SU) → Service operations performance (OP)	0.09	No
H6	Product service support artifacts (PSSA) → Service operations performance (OP)	0.17**	Yes

Path significant at: $^{**}p < 0.05$; $^{***}p < 0.01$.

2.7 Discussion

The structural equation modelling (SEM) explored significant relationships between serviceability practices, product service support artifacts, and service operations performance across multiple manufacturing sectors in Japan. Based on confirmatory factor analysis, five main constructs of serviceability practices (top management commitment, teamwork and communication, design information and analysis, customer focus, and supplier involvement) were associated directly and indirectly with product service support artifacts and with service operations performance.

As a main foundation of serviceability practices, top management commitment positively influenced all the other four serviceability practices (teamwork and communication, design information and analysis, customer focus and supplier involvement). Subsequently, teamwork and communication also displayed a significant relationship with three of the serviceability practices (design information and analysis, customer focus and supplier involvement). The results are in line with previous studies, which were also associated with information analysis, customer focus and supplier involvement (Fotopoulus and Psomas, 2010; Sila and Ebrahimpour, 2005; Mellat-Parast, 2015; Chin et al., 2010; Kim et al., 2012; Badri et al., 2005; Flynn et al., 1994). Hence, top management commitment, as well as teamwork and communication are very important in establishing a good foundation for design information and analysis (consists of virtual analysis and actual prototype analysis), customers focus (consists of internal and external customers) and suppliers involvement. Throughout continuous commitment from management and high co-operation within employees, manufacturing companies were able to perform progressive design information and analysis as well as encourage full commitment from customers and suppliers. Those efforts influenced the production of customer-oriented products, particularly in producing understandable, reliable and user-friendly service procedures, tool and equipment as well as generating low service cost and less service time (Markeset and Kumar, 2003) at service centers.

Among all of the five serviceability practices, the most essential practice which significantly generated the benefits of product service support artifacts and operation performance was design information and analysis. This practice clearly differentiated the tasks from other engineering scopes of work in the organization. Design information and analysis had very positively influenced the product service support artifacts since the p-value was less than .01, indicating that design information and analysis practices were regularly being performed by manufacturing companies towards enhancing the serviceability level of products. Thus, our study provides empirical support for the serviceability context concerning Su et al. (2008)'s assertion that the ideas and technical knowledge generated from quality practices such as information and analysis contribute to the success of good product and service design. The serviceability practices benefits ensured high efficiency in terms of product service support artifacts and operation performance in after-sales service operation.

By performing virtual analysis on the new 3D data, serviceability engineers could perform verification about the design characteristics related to easy replacement and maintenance. As explained in the previous section, each part of the design will be assembled with other surrounding parts in order to become a modular or assembly part. By analyzing those parts, initial service procedures on how to access each part could be developed, and any difficulties while removing parts such as fasteners removal process or part maneuver direction can easily be detected accordingly.

During actual prototype analysis, serviceability engineer is responsible to conduct an actual maintenance study on the product such as performing actual removal and reinstallation process for the final design validation. This practice could directly detect any serviceability-related problem on each individual component of the part such as fastener accessibility, part removal direction, serviceable component, part labeling, tightening procedures as well as tool and equipment used. Since virtual analysis is able to explore the best assembly and disassembly sequence of components and overcome any unexpected interference, manufacturers were capable of delivering interactive workshop manuals for aircrafts or submarines (Gupta et al., 1997), easy service and repair products and positioned their products more customer-oriented in the market. Those benefits were also recognized by internal customers (i.e. skilled technician and specialist) from BMW who highlighted that analysis associated with assembly and disassembly was important in marketing quality vehicles and beneficial for future automotive industry (Gupta et al., 1997). The benefits influence more scholars to explore more serviceability outcomes in various products such as Alstrom train system (Davies, 2004), Ericsson (Davies, 2004), Nokia (Wise and Baumgartner, 1999), Rolls-Royce (Howells, 2000) and Xerox (Mont, 2001).

In terms of external and internal customer involvement during NPD, technical knowledge sharing and serviceability discussion were more comprehensive than conventional discussion. One of the advantages was it could speed up the discussion in terms of design improvement suggestion, lesson learnt issues (Knezenic, 1999) and new service procedures recommendations. The ideas and technical advice from service personnel were more reliable and realistic because they were experiencing various types of service issues. Some of the issues had been resolved based on their personal knowledge and collective discussion within their team members at service centers. With the service personnel information (Knezenic, 1999), the serviceability department was able to enhance their capability in solving service issues in many ways in order to produce more reliable service procedures and propose better tools and equipment for service centers. Previous scholars (Feng et al., 2012; Zu, 2009) demonstrated that customer focus and customer involvement during NPD could speed up the delivery of new products to the market. In this case, the materials and information from product service support artifacts were essential to be distributed in order to support after-sales service operation at the service centers. This description is also consistent with Konecny and Thun (2011) and Devaraj et al. (2007) who found that customers had a positive significant effect on cost, flexibility and delivery performance. Hence, customer was considered as an actor or co-designer in engineering design to disseminate after-sales service concern (Cavalieri and Pezzota, 2012) and recognized as a strong predictor in enhancing operation performance such as high productivity, quality output and efficient delivery (Samson and Terziovski ,1999 cited by Calvo-Mora et al., 2013).

The other serviceability practice, which was supplier involvement, can also deliver additional benefits for achieving higher operation performance (Su et al., 2008; Zu, 2009). Suppliers had more understanding on their produced part compared to manufacturers by providing accurate technical advice on the product features, such as how to disassemble the part, tightening torque and the part's safety procedure. By compiling all the technical information from the supplier, the produced service manual could be further updated and validated according. However, for service centers, supplier's participation during after-sales service was not very beneficial for operation performance. On the surface, this result appears contrary to previous studies by Wienggarten et al. (2014), Chin et al. (2010), Devaraj et al. (2007), Singh et al. (2011), and Konecny and Thun (2011). Their results proposed that qualified supplier participation seemed to be a realistic approach towards enhancing operating performance, such as minimizing operating time and executing efficient delivery to the customer. Even though a service center had requested the supplier technical department to jointly discuss on how to repair or diagnose the supplier's complicated design, it was not frequently practiced by the service center. This was due to the supplier products being thoroughly verified and validated with the supplier since the design stage.

Besides the five serviceability practices, product service support artifacts also positively influenced service operations performance. This connection was in-line with a recent research (Raddats et al., 2014) indicating that manufacturing companies that offer suitable methods and service tools to technical support teams were able to deliver more cost effective service to customers. That is why most of the customers, especially who are the owner of higher quality vehicles are keen to utilize authorized service center for routine maintenance and repair purposes (Devaraj et al., 2001). This practice displayed that manufacturing companies were always concerned in practicing serviceability during new product development (NPD) in order to perform efficient service and repair without failure as well as gain economical after-sales service cost. In addition, the technical knowledge gained by service personnel on the particular product, as well as the latest information described in service manual, helped service centers to fix any problem by themselves. The comprehensive service procedures and availability of existing service tool and equipment at all service centers had created a high possibility in enhancing the operation performance. Any malfunctioned product could be replaced in a minimum timeframe, subsequently reducing the total labor time and labor cost since unnecessary service charges can be avoided to be paid by the customers. Although the development of service methods and tools consumed financial support, both service materials became a essential contribution from manufacturers to ensure efficient after-sales service operation.

Theoretically, the empirical study findings enhanced the existing NPD-based and service operation-based literatures, whereby design information and analysis were crucial factors that can contribute to deliver product service support artifacts to service personnel directly and enhance service operation performance indirectly. In term of structural model outcome, the design information and analysis, customer focus and supplier involvement contributed 37% of variance ($R^2 = 0.37$) on product service support artifacts in order to ensure that the artifacts are embedded with service-friendly requirements for service centers purposes. Meanwhile, product service support artifacts, customer focus and supplier involvement were found meaningful for contributing 61% of variance (R^2= 0.61) on service operation performance. Since supplier involvement was not significantly part of support service operation performance, hence, product service support artifacts and customer focus were two key indicators used to potentially improve the efficiency of service centers in daily maintenance and service tasks.

That is why manufacturers are encouraged to practice servitization so that they can consider design for serviceability as part of product features towards upgrading after-sales service business, which directly result to higher profit margin compared to conventional business process. The servitized manufacturers are expected to transform the existing manufacturing-based business into manufacturing-after-sales service business with greater degree of support to the service personnel and subsequently deliver better offer to customers. The manufacturing-after-sales services business also plays an important role in expanding more service networks since the designed products are not only adjusted according to the customers demand but also to ensure the products are continuously functioning as expected with minimum ownership cost.

Our results also revealed that there is high possibility for the top management to reinforce product service systems in early product development, which displays significant transition from product-oriented firm to product-services-oriented firm. In terms of product-service-oriented firm perspectives, employees would normally perform continuous improvement related to product serviceability when strong rapport is established with the customers and suppliers. However, top management has to realize that adopting 'product-based', 'process-based' and 'design for service-based' in their business process are more challenging compared to organization that merely selling products or offering services to customers. Even though this type of business process requires comprehensive fine-tuning and close monitoring, product service systems lead to better profit margins for the organization through the offered after-sales service.

Since serviceability is also part of the design for life cycle (Umeda et al., 2012), the implementation of eco-design feature in product design seems possible as a value-added element in green maintenance initiative. It was noticed that manufacturers were indirectly concerned about environmental issues by designing easy dismantling products for easy disposal or recycle process towards preventing and resolving ecological impacts that mainly affect the ozone, climate and pollution. When the eco-design products require service, repair and maintenance, managers of the service field are responsible to continue monitoring the product flow especially the management of unused parts and waste materials. Thus, manufacturers created a timely and accurate maintenance process as well as a low ownership cost, which contributed strategically to high customer satisfaction, servitization, product service systems and environmental sustainability.

In terms of management commitment, the top management is required to increase the level of serviceability awareness in the organization. The high sensitivity of serviceability could strengthen the relationship between manufacturing companies and potential customers as an effort to establish continuous user-friendly service. Cavalieri et al. (2007) also discovered that the design for serviceability is an important requirement that needs to be emphasized by top management in the early design stage. More importantly, the top management needs to ensure that the employees involved in the design for serviceability are also highly motivated by considering all their concerns since every serviceability-related issue requires full support from the top management.

2.8 Conclusions

While there are a few articles that examine design-for-serviceability as a technical variant of design for X (DfX), this is the first study to empirically investigate the broader organizational approaches and design techniques that support product serviceability, and in turn, lead to improved service operations performance.

This research contributed in proving the importance of designing products for serviceability since available literatures did not empirically explore the significance of design for serviceability during NPD upon impacting service operations performance. Thus, this research outcome established the significant contribution of implementing design information and analysis with full management support and teamwork commitment, as well as direct involvement of suppliers, internal customers, and external customers during cross-functional activities.

Besides, this study is also the first empirical research that discovered the significance of five practices of designing product for serviceability upon product service support artifacts and service operation performance. Even though Goffin (1998) was also associated with after-sales support activities or design for supportability, which is design for supportability at medical and electronic industries, the research was not fully examined design for serviceability aspects in NPD. Besides Goffin (1998), other researches (e.g. Livingston, 1988; Hull and Cox, 1994; Knezevic, 1999; Goffin and New, 2001; Markeset and Kumar, 2003; Ionzon and Holmqvist, 2005) were qualitative research-based in various industries such as electronic, computer, defense, aerospace and telecommunication industries.

Based on survey results from senior-level managers in Japanese manufacturing firms, we extend the research literature by empirically examining thirteen hypotheses that link an organization's serviceability practices with product service support artifacts and service operations performance. Twelve of these hypotheses were supported.

From our analysis, we validated a serviceability framework that integrates design for serviceability practices with the creation of product service support artifacts and with high-performing service operations. This serviceability framework highlights the soft-hard nature of effective practices that support design for serviceability. "Hard" techniques of design information and analysis, such as digital mock-ups and actual prototype analysis, were found significant, but importantly, they were effective when used in the context of "soft" organizational approaches such as top management commitment, teamwork and communication, customer focus and supplier involvement. Thus, the derived serviceability framework provides a holistic view of the organizational and technical practices that support the successful design of product for serviceability during NPD at manufacturing companies.

As managerial implications, our research has confirmed the importance of top management commitment to a firm's design for serviceability initiatives. While many product design practices (e.g. design analyses with digital mock-ups) and product service support artifacts (e.g. service manuals, tools and equipment), may appear to be only technical in nature, our results underscore the importance of top management in creating the organizational infrastructure of teamwork and communication, supplier involvement, and customer focus that supports serviceability design. The research outcomes are also foreseen to be able to guide top management in implementing the various practices necessary to support a successful strategy of servitization or product-service systems. Through the improved service operations performance made possible through these practices, manufacturers are able to achieve economic efficiencies and improved customer satisfaction, as well as lessen environmental impacts over the product's lifecycle. Hence, manufacturers pursuing strategies based on after-sales service, servitization or product-service systems are well-advised to adopt the framework of serviceability practices developed in this study, as product serviceability is a foundational condition for success with such strategies. Since this research contributed in proving the importance of designing products for serviceability, Appendix II and Appendix III display the summary between this research as well as the existing research literature, and the comparison table respectively.

As limitations and implications for future research, the survey data reliability is limited by the use of a single informant per firm. The survey data was obtained from senior managers from a broad cross-section of manufacturing industries, though the respondents were limited to a single country, Japan. Thus, to further ascertain the generalizability of these findings, future research is advised to examine additional country contexts. In addition, this study undertook the firm's managerial perspective on serviceability-related practices and service operations performance. Of equal interest is the external customer's perspective of product serviceability and serviceability's impact on customer satisfaction and loyalty, which is the subject of further research.

CHAPTER 3

The Impact of Serviceability-Oriented Dimensions on After-Sales Service Cost and Customer Satisfaction

3.1 Introduction

The lines between manufacturing and service have blurred as manufacturers expand beyond their traditional role as producers of high-quality products to pursue servitization strategies, wherein they provide products bundled with related services (Baines, Lightfoot, Benedettini & Kay, 2009). Similarly, consumers expect more from manufacturers than the initial product alone, as they seek higher levels of after-sales service as well as lower cost of ownership. Accordingly, it is critical for managers and scholars alike to understand product serviceability, which is an increasingly important issue at the nexus of product quality and service quality.

Excelling in product serviceability is vital in the new product market, where it has been identified as one of the three most important attributes to purchasers (Seitz, Razzouk & Wells, 2010). Product serviceability also is critical for profitable success in the after-sales market, which has been estimated, in some cases, to be five times larger than the new product market, and to generate over three times the revenue of the original purchase (de Souza, Tan, Othman & Garg, 2011; Ahmad & Butt, 2012; Yang, Luo, Li, Yang & Lee, 2013).

3.2 Research objectives

This study underlined two main objectives as follows:

i) Development of a conceptual framework of customer perspectives on serviceability-oriented dimensions, based on empirical studies of two different products in the Japanese consumer market.

ii) Investigation of the impact of serviceability-oriented dimensions on after-sales service cost and on customer satisfaction/loyalty for the product and its after-sales service.

3.3 Literature review

In the research literature, product quality has come to be viewed as a multi-dimensional construct that encompasses tangible as well as intangible characteristics. In Garvin's (1987) seminal article, he identifies eight dimensions of product quality, one of which is serviceability, which he defined conceptually as the 'speed, courtesy, competence, and ease of repair'. Similarly, Brucks, Zeithaml and Naylor (2000) identified serviceability, along with ease of use, versatility, durability, performance and prestige, as the six dimensions by which consumers evaluate products.

Related to the notion of product serviceability is service quality, in the sense that product servicing involves interaction with service personnel who carry out the service or repair. As dimensions of quality for services, Parasuraman, Zeithaml and Berry (1988) identified tangibles, reliability, responsiveness, assurance and empathy. Their SERVQUAL instrument assesses service quality based on these five dimensions and has become widely used in service industries. However, product serviceability includes both service interaction between customers and service personnel, as well as product-related support materials and artifacts that facilitate product service and repair. Thus, this research adapts SERVQUAL instrument, which is the most recognized research related to service quality—as the main reference and extended it with product content elements of materials or artefacts supporting serviceability that may be provided by the manufacturer in product serviceability context (i.e. serviceability-oriented scale items such as service personnel smoothly perform routine maintenance procedures on the product, routine maintenance book is easy-to-understand, etc.). Historically, Sasser et al. (1978) started exploring dimensions associated with service quality in service operations field. Then, various scholars have discovered other service quality dimensions until Parasuraman et al. (1988) introduced the

SERVQUAL, which was also being extended by other scholars (i.e. Cronin and Taylor, 1992; Frost and Kumar, 2000) in service quality literature. Therefore, this research is required to propose set of serviceability dimensions in responding to Parasuraman et al.'s (1994) call by producing measurement items and investigating new dimensions for different industrial contexts. Appendix IV and Appendix V display the summary and timelines of service quality-related researches, respectively.

In another research on the dimensions of service quality, Schvaneveldt, Enkawa and Miyakawa (1991) identified performance, assurance, completeness, ease of use, and emotion/environment as five dimensions by which consumers evaluate services. Comparing these two sets of dimensions, it can be said that Parasuraman et al's (1988) dimensions do not involve the content of *what* service is provided, but rather examine the interaction process of *how* the service is provided. On the other hand, Schvaneveldt et al's (1991) dimensions encompass certain aspects of *what* is included in the service (e.g. completeness of features and amenities, ease of use), as well as aspects of the service interaction (*how*) (e.g. assurance, emotion-related items).

Despite serviceability's prominence as an important dimension of product quality, there has been little empirical research on what constitutes serviceability from the customer's perspective. Accordingly, this research aims to build upon Garvin's conceptual proposition about product quality and to connect it with the service quality literature. As potential constructs for measuring product serviceability, we draw upon Parasuraman et al's (1988) widely used SERVQUAL instrument, which examines service process elements of the service interaction, and augment it with product content elements of materials or artefacts supporting serviceability that may be provided by the manufacturer. In addition, we examine product service/repair-related costs borne by the user as a new, unexplored aspect of serviceability in the literature.

Through better understanding of product serviceability, we anticipate that manufacturing companies can offer higher quality and value to customers by providing superior after-sales service (Cavalieri, Gaiardelli, & Ierace, 2007), which can increase customer satisfaction (Gupta, McDaniel & Herath, 2005) and market share. With increasing attention to servitization, manufacturers are looking to service centers as new sources of revenue and competitive advantage. For these reasons, service centers are not merely places for product repair, but are increasingly called upon to provide training, inspection, spare parts, troubleshooting and hotlines for their products (Gebauer, Krempl, Fleisch & Friedli, 2008; Goffin & New, 2001). Moreover, by offering the best after-sales service support, purchased products can be used by their customers for a longer period, which creates a high-value image compared to their competitors (de Souza et al., 2011).

3.3.1 Roles of tangibles in serviceability

In this research, tangibles represent facilities, equipment, tools, user manuals, routine maintenance books, and other such artefacts. These tangible items are essential during service center operations and are beneficial in avoiding any service failures. Lehtonen, Ala-Risku, and Holmström (2012) identified three main reasons for service failure, namely, lack of spare parts, lack of documents or information, and lack of tools. If any of these issues occurs, service personnel may be put into a situation of overwhelming pressure, affecting the service or maintenance outcome (Winter, Sarbu, Suri, & Murphy, 2011), especially when customers require immediate action. Tangibles support service centers in identifying the part or the product that needs to be serviced, repaired or maintained, so that service personnel can organize the required spare parts, documents and tools accordingly (Lehtonen et al., 2012). Special-purpose tools and other service artefacts then facilitate service personnel in efficiently executing service tasks based on the recommended service procedures. Such measures reduce total labour time and cost, which was found by Williams, Khan, Ashill & Naumann's (2011) to be a relatively high concern for service industry customers. In these ways, tangibles facilitate effective service that satisfies the customer and that benefits the service firm and customer alike through efficient, reduced cost of service or repair.

Furthermore, serviceability-oriented products should incorporate other tangibles such as multiple labels that educate customers in all user functions during actual product usage, including an easy-to-understand 'quick guide' and precautions/warnings. Other important tangible items include a routine maintenance book to guide customers on the services that should be performed for each service interval, and an up-to-date user manual that can serve as a helpful reference for Do-It-Yourself (DIY) maintenance tasks. As noted by Sundin, Lindahl, & Ijomah, (2009), DIY support can lead to "win-win" situations for manufacturers and customers alike.

These and other customer support artefacts contribute to a satisfying user experience and can reduce user costs through proper care and usage of the product.

3.3.2 Role of assurance in serviceability

Assurance refers to efforts to ensure that product and service performance consistently achieves firm objectives and satisfies customer requirements. Hence, it is the responsibility of the firm to prevent any fault or defect with the manufactured product and related services so that customers are able to experience quality after-sales service and safe usage of the product. This scenario is aligned with the two main principles of assurance, which are fulfilling the purpose of the product or service and accurately performing related jobs right the first time.

Assurance aspects of serviceability are dependent on the skills and competence of service personnel, who are frequently involved in face-to-face interaction with customers in order to gather needed information, suggestions and feedback, and accurately assess the product's service needs. From this direct communication, service processes can be performed more thoroughly and carefully, and the customer can be assured of the condition and safety of the product after it is serviced. For repair processes that require specific service procedures and equipment, specialized service personnel may be required to fully investigate the problem so that the product may be repaired and function as per required specifications. Furthermore, service personal create assurance through credible and competent delivery of product-related information and sharing of technical knowledge with customers (Parasuraman, Berry & Zeithaml, 1991).

Hence, assurance is an essential aspect of serviceability for enhancing customer trust regarding service center competency, as well as fulfilling customer expectations for after-sales service. Assurance also contributes to high customer satisfaction by reducing the total cost of product ownership through efficient service and repair that is performed correctly the first time and through reduced time spent on follow-up service. Furthermore, according to Murali, Pugazhendhi, and Muralidharan (2016), smooth interactions with competent service personnel, vis-à-vis competing firms, also is advantageous in achieving high customer satisfaction. Thus, assurance aspects of serviceability will help to ensure that minimum service and repair costs are achieved along with high customer satisfaction for the product and after-sales service from service centers.

3.3.3 Role of responsiveness in serviceability

Responsiveness refers to quick action, without delay, on the customer's need or request. Service personnel at service centers have high responsibility in providing immediate action on the requested service or repair, and should be highly capable in resolving any problem promptly (Parasuraman et al., 1988, 1991; Zeithaml, Berry & Parasuraman, 1996). Even before a customer decides on a product purchase, service personnel should be available to explain the type of service that must be performed. After product purchase, the firm must continue to offer prompt support to the customer. To be responsive in the eyes of the customer, service personnel must quickly act on customer requests even in the midst of other essential daily tasks at their workplace. Hence, responsiveness is viewed in this research to be an integral aspect of product serviceability that is essential for achieving high customer satisfaction.

3.3.4 Role of after-sales service cost in serviceability

As discussed by Chen and Keys (2009), costs for maintenance and serviceable parts replacement are considered as non-manufacturing costs and need to be borne by the customer. Also, customers also may need to bear unexpected overhaul costs or damage repair costs due to accidents. These and certain other non-manufacturing costs can be categorized as after-sales service costs, which are borne by the customer until the product's end-of-life disposition. Logically, low after-sales service cost is desired by customers in order to affordably obtain after-sales service benefits and maximize product lifetime and value.

All products that physically operate will require maintenance at regular time intervals (Ghodrati, Benjevic & Jardine, 2012) in order to obtain a longer life cycle, higher reliability (Markeset & Kumar, 2003) and optimum performance. For example, it is recommended by manufacturers that car and air conditioner owners perform regular maintenance (e.g. air-filter replacement) (Go, Wahab, Rahman, Ramli, & Hussain, 2012). Such routine maintenance tasks can avoid damage on internal parts of the product and extend the product's operating life. At the same time, serviceability-oriented products can avoid high service and warranty costs by incorporating many serviceable items that have been purposely designed for easy replacement, or preferably, to not require replacement. Moreover, the required time intervals for routine maintenance and parts replacement should be extended as long as possible, which will contribute to the avoidance of high labor costs from frequent maintenance periods. For parts replacement, individual spare parts should be readily available for purchase by customers for replacement of a malfunctioning serviceable part (e.g. El-Haram & Horner, 2002). Importantly, it should not be necessary to replace a single malfunctioning part with a modular product by making single spare parts available in the market for purchase. These considerations also contribute to low after-sales service cost during service or repair at a service center.

In addition, effective management of individual spare parts inventory at service centers is essential in order to prevent downtime due to parts unavailability during maintenance. If downtime occurs, it can be considered as an indirect cost that extends the lead time for service or repair maintenance (Ellram & Siferd, 1993) and consequently, decreases customer satisfaction. Therefore, service centers need to ensure that their inventory systems (Kennedy, Patterson, & Fredendall, 2002) maintain availability of many types of spare parts at the optimum level (Asjad, Kulkarni, & Gandhi, 2016) for prompt parts replacement process. An efficient parts storage system at the service center can also facilitate an increase in the number of services or repairs possible, whereby more customers can be accommodated in a shorter period of time. Hence, low after-sales service cost that is made possible by serviceability-oriented products should lead to superior customer satisfaction with the product and its after-sales maintenance, service and repair.

3.3.5 Customer satisfaction

According to a widely held view, customer satisfaction is an overall, post-purchase evaluation of a product (Fornell, 1992). In making this evaluation, the customer considers prior expectations for the product as well as perceptions of the product’s performance over time. In terms of product serviceability, the customer may evaluate a variety of product and service-related characteristics, such as the knowledge and skills of service personnel, the facilities of the service center, the provision of product guides and manuals, the availability of spare parts, reasonable cost maintenance services and so forth. Logically, firms that excel in these aspects will be evaluated highly and better satisfy the customer. Furthermore, satisfied customers are more likely to have positive attitudes about the product and to repurchase it (e.g. Chang, Wang & Yang, 2009; Setó-Pamies, 2012). This chain from product/service performance to customer satisfaction and customer loyalty has been substantiated in the research literature (e.g., Fornell, 1992; Johnson, Herrmann, Huber & Gustafsson, 1997; Eskildsen, Kristensen, Juhl & Østergaard, 2004; Frank, Torrico, Enkawa & Schvaneveldt, 2014).

While early studies viewed loyalty narrowly as repurchase-related behaviors (e.g. Jacoby & Chestnut, 1978), more recent research has broadened the loyalty construct to include both relative attitude and repurchase behavior (e.g. Dick & Basu, 1994). Relative attitude may be represented by positive word-of-mouth, willingness to recommend a service to others, repurchase intent and other forms of loyalty intention (Dick & Basu, 1994; Zeithaml et al., 1996). Gaining customer loyalty is critical because of its connection to business success in terms of market share and profitability (e.g., Reichheld, 1993).

3.4 Research hypotheses and framework

In the context of product serviceability, manufacturers must design and build products that satisfy the customer over the product's lifetime, not only during usage, but also during service, maintenance and repair of the product. Through addressing the tangibles, assurance, responsiveness and after-sales service cost dimensions of serviceability, manufacturing companies and service centers have the capability and capacity to offer safe and reliable products that can indeed meet customer needs. As a consequence, it is anticipated that the customer will be satisfied with the product and related service providers and will develop loyalty intentions such as willingness to recommend and to repurchase (Zeithaml et al., 1996).

Based on the preceding review of the research literature and related discussions of serviceability, we propose the following six hypotheses. The conceptual model depicting their interrelationships is shown in Figure 3.1.

Hypothesis 1: Tangibles dimension of serviceability positively influences (i.e., reduces) after-sales service cost.

Hypothesis 2: Tangibles dimension of serviceability positively influences customer satisfaction/loyalty.

Hypothesis 3: Assurance dimension of serviceability positively influences (i.e., reduces) after-sales service cost.

Hypothesis 4: Assurance dimension of serviceability positively influences customer satisfaction/loyalty.

Hypothesis 5: Responsiveness dimension of serviceability positively influences customer satisfaction/loyalty.

Hypothesis 6: Reduced after-sales service cost positively influences customer satisfaction/loyalty.

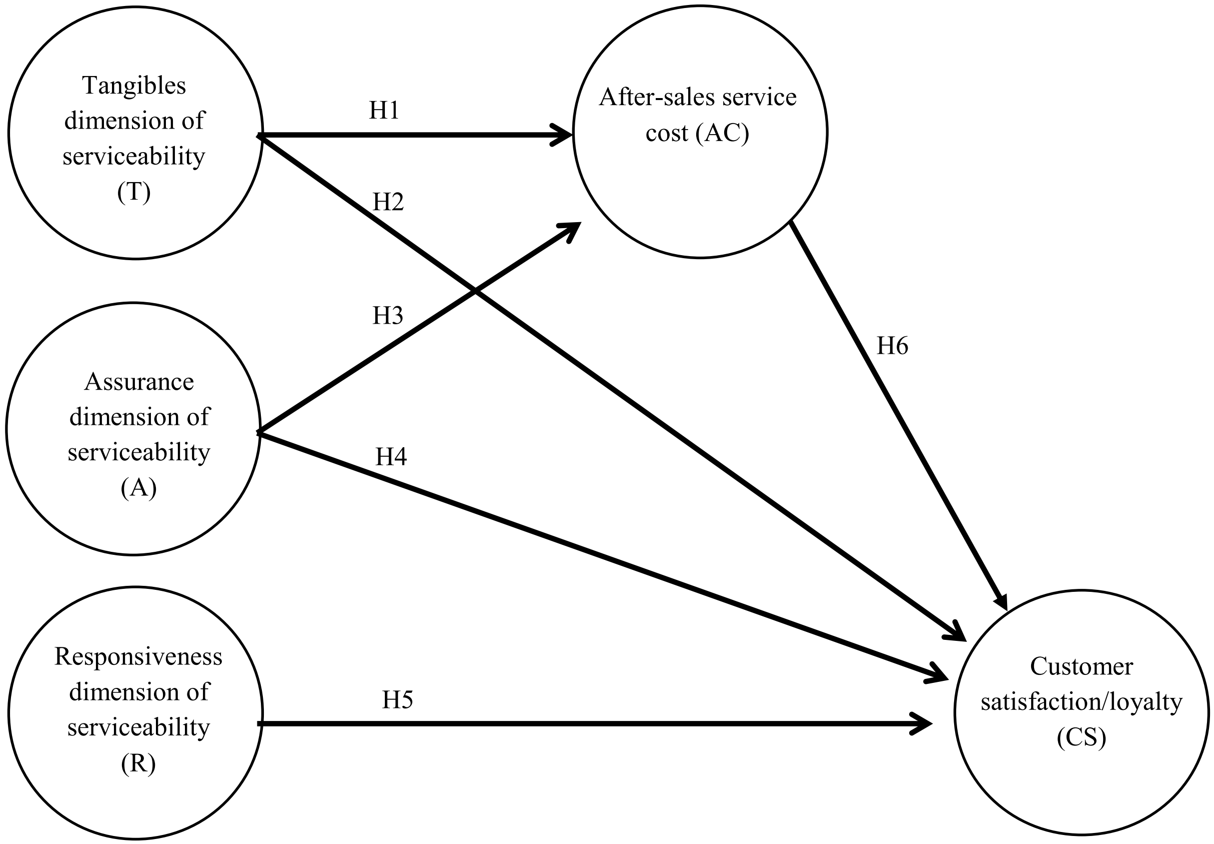

Figure 3.1: The hypothesized conceptual model for serviceability-oriented practices, after-sales service cost and customer satisfaction/loyalty

3.5 Research methodology

In order to investigate these aspects or dimensions of serviceability, two product types, namely automobiles and air conditioners, were selected for this research based on their close connection with after-sales service and high market penetration. There were two stages in producing validated dimensions for serviceability-oriented products. The first stage was to perform an exploratory factor analysis (EFA). In EFA, all new measurement items were verified and validated through a pre-test and an actual survey. In the second stage, a confirmatory factor analysis (CFA) was generated by conducting another survey to validate the conceptual model. In performing comprehensive methodology for EFA and CFA, the following sub-sections describe the development of measurement items, survey instrument, content validity, data collection and demographic, EFA, common method variance and CFA.

3.5.1 Measurement items development

A detailed literature review was performed, with a particular focus on the literature related to service quality and after-sales service. Throughout this extensive review, relevant measurement items were developed by considering previous empirical studies and theories. Since measurement items for service quality have been widely used with some modification and adaptation by numerous researches, this study also practiced a similar technique of modifying and adapting existing scale items, as well as developing new items, in order to meet the survey objectives. This is consistent with Parasuraman, Zeithaml, and Berry, (1994) who suggested for future researchers to produce measurement items for proving existing service quality theory and investigating new industry-specific dimensions (e.g. Lee, Lee & Yoo, 2000; Akroush, 2008).

3.5.2 Survey instrument development and content validity

In terms of survey instrument development, the instrument was produced in English based on the relevant research literature and then translated into Japanese. To ensure similarity in translation, the questionnaire items were then translated back into English for comparison (Mullen, 1995).

The survey instrument developed for this research was a structured questionnaire containing two sections. Section 1 consists of demographic information from the consumer respondents, including gender, age, occupation, location in Japan, and the manufacturer of the product for which the customer had received service or maintenance. Section 2 comprises measurement items related to this research. All scale items are presented in Appendix VI.

Many considerations were made to ensure high face validity and content validity for the survey instrument. Numerous high-impact published articles were reviewed comprehensively to identify the most cited measurement items. All measurement items were validated by experts, including academicians, industry practitioners and consumers who owned an automobile or air conditioner and had it serviced or repaired. Each measurement item was examined to ensure that the content was logical and theoretically sound for measuring each observed variable. The fact that measurement items in the survey instrument have been used in many previous studies also showed that their contents have been extensively validated.

Next, a pre-test was conducted with academicians, technical experts and actual consumers for compiling more suggestions and feedback on the produced measurement items. The main purpose was to ensure no difficulties or no confusion from one question to another since every person has different interpretations. Considering all the compiled feedback, the survey instrument had been further enhanced and argued that all measurement scale items fit the survey's purposes and were collectively validated. Once the pre-test was completed, revisions were made to the measurement items to improve content validity, readability and ambiguity (Dillman, 2000).

To qualify the respondents, screening questions asked whether the consumer was an automobile owner/driver or air conditioner owner and had experienced repair or maintenance service for their automobile within the past 5 years or for their air conditioner within the past 10 years. Persons not meeting these criteria did not proceed with the survey and are not included among the respondents. Each measurement item was phrased as a closed-response question with a 10-point Likert scale whose values ranged from 1 ("totally disagree") to 10 ("totally agree"), aligned with previous studies' approach (e.g. Srinivasan et al., 2012).

3.5.3 Data collection

In this survey, the target respondents were Japanese consumers who owned an automobile or air conditioner. An on-line survey company was appointed to execute a web-based survey to a national panel of consumers in Japan. This approach is part of probability-based sampling technique in order to reach targeted respondents and receive higher response rate in shorter time. This approach also gave respondents the flexibility to answer each question at their preferred place and time. Appropriate demographic questions were used to ensure the participation of the right respondents at the right time.

3.5.4 Total sample and response rate

However, the response rate could not be measured in this study as the respondents who participated in the survey were invited by the appointed national panel online survey company to participate in the surveys until the targeted sample size was achieved. The total useable sample size was 1464 respondents. Hence, the total population was not fixed and is unlikely to be used for measuring the response rate.

3.5.5 Respondent profile

From this sampling approach, 310 respondents who met the criteria were obtained. Based on detailed screening in the demographic section, a number of relevant customers for the surveyed products provided precise data, which could be generalized for a total population. For both product surveys used in EFA and CFA, the majority who participated were male. It was also found that approximately 50% of the surveys were answered by respondents who were older than 50 years, followed by middle-age persons (41–50 years old). This survey was distributed to all regions in Japan, with the most populated regions of Kantō, Kansai and Chūbu having the highest participation compared to the other five regions. For the automobile survey, the majority of the respondents had driven and received service for vehicles manufactured by Toyota Motor Corporation (35.8% – EFA; 34.7% – CFA) and Honda Motor Co., Ltd. (18.7% –EFA; 19.4% – CFA). In the air conditioner survey, most of respondents owned and received service for an air conditioner manufactured by Daikin (23.2% – EFA; 19.0% –CFA). Hence, Table 3.1 and Table 3.2 display the demographic data.

Table 3.1: Profile of respondents (automobile)

			Valid percentage (%)	
Demographic variables	Descriptions	Total (n = 754)	The first-split sample for EFA (n = 310)	The second-split sample for CFA (n = 444)
Gender	Male	498	66.5	65.8
	Female	256	33.5	34.2
Age	20 – 30 years old	51	5.5	7.7
	31 – 40 years old	144	17.9	20.1
	41 – 50 years old	181	23.0	25.0
	> 51 years old	378	53.6	47.2
Area	Hokkaidō region	32	4.2	4.3
	Tōhoku region	47	6.7	5.8
	Kantō region	283	36.2	38.5
	Chūbu region	130	18.3	16.4
	Kansai region	136	16.8	18.9
	Chūgoku	41	4.9	5.8
	Shikoku	22	3.2	2.7
	Kyūshū	63	9.7	7.4
Manufacturer	Toyota Motor Corporation	265	35.8	34.7
	Nissan Motor Co., Ltd.	112	17.7	12.8
	Honda Motor Co., Ltd.	144	18.7	19.4
	Mazda Motor Corporation	52	7.1	6.8
	Fuji Heavy Industries Ltd.	30	3.2	4.5
	Mitsubishi Motors Corporation	21	2.6	2.9
	Suzuki	75	9.4	10.4
	Daihatsu Motor Co., Ltd.	51	5.2	7.9
	Isuzu Motors Limited	1	0	0.2
	Others	3	0.3	0.5

Table 3.2: Profile of respondents (air-conditioner)

			Valid percentage (%)	
Demographic variables	Descriptions	Total (n = 710)	The first-split sample for EFA (n = 310)	The second-split sample for CFA (n = 400)
Gender	Male	440	55.5	67.0
	Female	270	44.5	33.0
Age	20 – 30 years old	69	7.1	11.8
	31 – 40 years old	159	20.6	23.8
	41 – 50 years old	179	26.8	24.0
	> 51 years old	303	45.5	40.5
Area	Hokkaidō region	6	1.0	0.7
	Tōhoku region	26	4.2	3.2
	Kantō region	311	41.0	46.0
	Chūbu region	111	18.4	13.5
	Kansai region	163	22.6	23.3
	Chūgoku	25	3.5	3.5
	Shikoku	16	1.6	2.8
	Kyūshū	52	7.7	7.0
Manufacturer	Daikin	148	23.2	19.0
	Panasonic	122	17.1	17.3
	Mitsubishi Electric Corporation	104	16.1	13.5
	Hitachi	118	14.2	18.5
	Toshiba	74	9.7	11.0
	Sharp	46	6.5	6.5
	Fujitsu General Limited	59	6.1	10.0
	Mitsubishi Heavy Industries Ltd.	26	4.5	3.0
	Corona	7	1.3	0.8
	Others	6	1.3	0.4

3.5.6 Tests for non-response bias

Non-response bias was tested in two ways. First, the sample and the population means of demographic variables, namely gender and total years of driving experience were compared to check for any significant difference. The results indicated no significant difference. Second, the responses of early and late responses were compared to provide additional support of non-response bias (Armstrong & Overton, 1977). The results of the statistical tests and qualitative data indicated that non-response bias was not a significant problem in this research.

3.5.7 Exploratory Factor Analysis (EFA)

EFA was used in this research for the purpose of identifying serviceability dimensions for automobiles and air conditioners. EFA is a multivariate statistical method that is frequently used in the initial research stage when compiling relevant literatures and developing theory about the relationship among dimensions or variables of interest. EFA is appropriate when there is no hypothesis regarding the developed measurement scales. Through EFA, a minimum number of latent dimensions or variables can be identified from within the measurement scales by grouping individual items into a limited set of clusters based on shared variance. In order to determine the latent factors associated with the 41 items and 40 items for the automobile and air conditioner surveys respectively, EFA was applied to the sample data (n=310 for automobile and n=310 for air conditioner). Principal components was used as the extraction method (Tabachnick & Fidell, 2007) and Varimax as the rotation method. The sample size (n=310) met the minimum requirement of 300 for EFA (Comrey & Lee, 1992).

3.5.8 Kaiser-Mayer-Olkin (KMO) Measure and Bartlett's Test of Sphericity

The Kaiser–Mayer–Olkin (KMO) Measure and Bartlett's Test of Sphericity were used to test the validity of constructs. KMO can identify the suitability of each item and express the adequacy of sample size for factor analysis. The value of KMO ranges from 0 to 1, whereby values closer to 1 indicate more adequate sample size for running the factor analysis. A KMO value of 0.60 or above is required for a good factor analysis (Tabachnick & Fidell, 2001). As shown in Table 3.3, the KMO value for the automobile and air conditioner studies were 0.968 and 0.969, respectively, which demonstrates that the data had very good inter-correlations among the indicators.

Bartlett's Test of Sphericity can identify sufficient level of correlation between indicators prior to running factor analysis. It is also used to test the null hypothesis that the correlation matrix is an identity matrix. The chi-square values of Bartlett's test were 15,993.755 (automobile) and 17,406.806 (air conditioner), which are statistically significant ($p < .05$) and indicate that the correlations between each item are appropriate for running factor analysis. Accordingly, it can be concluded that the factor model was applicable for this research, since both the KMO and Bartlett tests of sphericity, demonstrated that there was no multi-collinearity problem and that all items were suitable for factor analysis.

Table 3.3: KMO and Bartlett's Test

		Automobile	Air-conditioner
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.968	.969
Bartlett's Test of Sphericity	Approx. Chi-Square	15993.755	17406.806
	Degree of freedom	741	741
	Significance level	.000	.000

3.5.9 Reliability analysis (alpha)

Reliability means the overall consistency of a measurement test, in producing certain results. Reliability is important for survey investigations in order to determine whether the results are constant or unstable. Cronbach's alpha is the best measure to determine the level of reliability and ranges between 0 and 1. Values closer to 1 are considered more reliable (Hair, Black, Babin, Anderson & Tatham, 2006), with 0.7 as the minimum value for observed variables to be considered a reliable construct (Nunnally, 1978). Prior to performing EFA, the coefficient values obtained for general reliability of the survey instrument's measurement items were determined to be 0.983 and 0.985 for the automobile and air conditioner surveys, respectively, which demonstrates that the survey instruments were very reliable, constant and had no instability issues.

3.5.10 Measurement items reduction and communalities

After completing the reliability analysis, we determined the important dimensions of product serviceability. This is a scale refinement method for reducing a large number of observed variables and was carried out through exploratory factor analysis with SPSS version 23. In EFA, measurement items were analyzed based on data gathered from 310 respondents for the automobile survey, as well as 310 respondents for the air conditioner survey. Since each construct consisted of many measurement items, EFA was used to check the construct structure and identify any items that can be deleted due to low factor loading or major cross-loading. The coefficient alpha and item-to-total correlations subsequently were recalculated until there were no low factor loadings and/or major high cross-loadings. According to Hatcher (1994) and Tabachnick and Fidell (2001), there are several recommended cut-off points for deletion, as follows: factor loadings <0.5, cross-loadings >0.4, or reliability coefficients <0.7. The factor loading indicates how strongly the items contribute to the identified factor, with higher factor loadings representing higher contribution by the items to the factor (Harman, 1976).

Communality is the variance in observed variables that is accounted for by common factors. Communality is more relevant for EFA than principal components analysis (Hatcher, 1994). The communalities value for each factor shows the proportion of variance common in every factor, where 0 indicates that the factor does not contribute to overall variance change, and 1.0 shows that the factor contributes entirely to overall variance change. If the communality of a variable is less than 0.4, the variable is considered to be useless and normally should be removed from the model. For this study, through EFA it was found that the communalities for all variables were higher than 0.4, hence all variables were deemed useful.

3.5.11 Total variance explained

For the automobile survey, the initial 40 items were minimized to 39 items, accounting for 79.56 percent of the total variance, while the total variance extracted for air-conditioner was 82.59 percent from the finalized 39 items. Rotated factors were easier to interpret in comparison to before rotation. Rotation can produce clearer structure, whereby each factor will consist of minimum variables or items with high factor loadings (Rummel, 1970). Table 3.4 and 3.5 present the factor loadings for measurement scale items in each of the five factors. For example, 0.811 is the highest factor loading for the responsiveness factor from the automobile survey and represents the most important item in the responsiveness dimension of serviceability. From Table 3.4 and 3.5, it also can be seen that the reliability coefficients (Cronbach's alpha, α) for all factors were much higher than the cut-off point of 0.7 (e.g., 0.972 for the responsiveness factor from automobile survey data), which means that the proposed measurement scale items had very high reliability.

Table 3.4: Results of exploratory factor analysis (automobile)

Items	Factor loadings 1	2	3	4	5
Factor 1. Responsiveness dimension of serviceability					
Service personnel explain what services should be performed on the product.	0.811				
Service personnel are polite in explaining the product after purchase.	0.793				
Service personnel are fast in servicing the product.	0.789				
Service personnel are polite in explaining the product before purchase.	0.781				
Service personnel give quick response.	0.779				
Service personnel are fast in repairing the product.	0.772				
Service personnel are willing to consider your needs	0.752				
Service personnel are never too busy to respond to your request.	0.737				
Service personnel inform you of time to service your product.	0.579				
Service personnel inform you of time to repair your product.	0.568				
Factor 2. Tangibles dimension of serviceability					
User manual is up-to-date.		0.806			
Understandable 'quick guide' label is available on the product.		0.770			
Understandable warning label is available on the product.		0.760			
Routine maintenance book is easy-to-understand.		0.740			
The product warranty covers many items.		0.706			
The product has extended warranty options available.		0.688			
Service center has modern facilities.		0.587			
The product has a user manual for customer reference.		0.585			
Schedule for routine maintenance is available.		0.570			
Factor 3. Assurance dimension of serviceability					
The product is made safe after maintenance procedures.			0.675		
Service personnel have technical skills to solve problems with the product.			0.673		
Service personnel have knowledge to answer your questions.			0.658		
Service personnel smoothly perform routine maintenance procedures on the product.			0.650		
Service personnel accept your suggestions for further consideration.			0.599		

Warranty claims can be handled smoothly by service personnel.			0.587		
Service personnel solve problems right the first time.			0.572		
Service personnel give you individual attention.			0.538		
Factor 4. After-sales service cost					
Individual spare parts can be purchased to replace a malfunctioning component.				0.745	
Less replacement of parts is required during routine maintenance.				0.699	
Routine maintenance cost is reasonable.				0.671	
Malfunctioning product components can be replaced immediately with available spare parts.				0.567	
Factor 5. Customer satisfaction/loyalty					
I will recommend this product to persons that seek my advice.					0.862
I will say positive things about the service personnel of the service center to other people.					0.823
I will say positive things about the service center to other people.					0.822
I will say positive things about the product to other people.					0.815
I plan to buy the same product in the future.					0.765
I am satisfied with the product.					0.577
I am satisfied with the service center.					0.548
I am satisfied with service personnel of the service center.					0.544
Reliability coefficient (α)	0.972	0.933	0.968	0.922	0.961

Table 3.5: Results of exploratory factor analysis (air-conditioner)

Items	Factor loadings 1	2	3	4	5
Factor 1. Responsiveness dimension of serviceability					
Service personnel are polite in explaining the product after purchase.	0.829				
Service personnel explain what services should be performed on the product.	0.800				
Service personnel are polite in explaining the product before purchase.	0.794				
Service personnel are never too busy to respond to your request.	0.648				
Service personnel are willing to consider your needs	0.611				
Factor 2. Tangibles dimension of serviceability					
The product warranty covers many items.		0.807			
User manual is up-to-date.		0.796			
Understandable warning label is available on the product.		0.795			
The product has extended warranty options available.		0.793			
Understandable 'quick guide' label is available on the product.		0.778			
Routine maintenance book is easy-to-understand.		0.774			
Schedule for routine maintenance is available.		0.768			
Service center has modern facilities.		0.668			
The product has a user manual for customer reference.		0.668			
Factor 3. Assurance dimension of serviceability					
Service personnel have technical skills to solve problems with the product.			0.792		
Service personnel smoothly perform routine maintenance procedures on the product.			0.789		
Service personnel have knowledge to answer your questions.			0.767		
Warranty claims can be handled smoothly by service personnel.			0.765		
Service personnel are fast in repairing the product.			0.739		
The product is made safe after maintenance procedures.			0.721		
Service personnel give quick response.			0.679		
Service personnel are fast in servicing the product.			0.664		

Service personnel solve problems right the first time.			0.654		
Service personnel accept your suggestions for further consideration.			0.552		
Malfunctioning product components can be replaced immediately with available spare parts.			0.550		
Routine maintenance cost is reasonable.			0.547		
Service personnel give you individual attention.			0.546		
Service personnel inform you of time to service your product.			0.510		
Service personnel inform you of time to repair your product.			0.502		
Factor 4. After-sales service cost					
Individual spare parts can be purchased to replace a malfunctioning component.				0.589	
Less replacement of parts is required during routine maintenance.				0.560	
Factor 5. Customer satisfaction/loyalty					
I will recommend this product to persons that seek my advice.					0.773
I will say positive things about the product to other people.					0.763
I will say positive things about the service personnel of the service center to other people.					0.748
I plan to buy the same product in the future.					0.745
I will say positive things about the service center to other people.					0.726
I am satisfied with the service center.					0.645
I am satisfied with service personnel of the service center.					0.626
I am satisfied with the product.					0.615
Reliability coefficient (α)	0.949	0.963	0.974	0.908	0.976

3.5.12 Confirmatory factor analysis

After classifying the five clear factors through EFA, a second-split sample of consumer data (n=444 for automobiles and n=400 for air conditioners) was collected and used in the structural equation modelling (SEM) for CFA. Even though the EFA had verified the groups and factor loadings in the rotated component matrix table, CFA is still required for further screening of the measurement scales in each identified factor in order to establish multidimensionality of constructs.

For this study, x^2 (df=262) is 1,650.33 (automobile) and 1,591.89 (air-conditioner) with both p-value is 0.000; x^2/df is 3.659 (automobile) and 3.545 (air-conditioner); CFI is 0.936 (automobile) and 0.931 (air-conditioner); IFI is 0.936 (automobile) and 0.931 (air-conditioner) as well as RMSEA is 0.077 (automobile) and 0.080 (air-conditioner). Consequently, the same five factors were confirmed, with another seven scale items dropped from each survey. As a result, 32 items with five factors were modelled in the research framework. Table 3.6 displays each index for both surveys, with all index values falling within the recommended requirements. Hence, the measurement models for both surveys are considered to have acceptable fit. Figure 3.2 and Figure 3.3 show the measurement model for both surveys.

Table 3.6: Fit indices of measurement model on both surveys

Factor	Requirement	Automobile	Air-conditioner
Degrees of freedom (x^2/df)	< 5.0	3.659	3.545
Comparative Fit Index (CFI)	≥ 0.9	0.936	0.931
Incremental Fit Index (IFI)	≥ 0.9	0.936	0.931
Normed Fit Index (NFI)	≥ 0.9	0.914	0.906
Tucker-Lewis Index (TLI)	≥ 0.9	0.930	0.923
Root mean square error of approximation (RMSEA)	≤ 0.08	0.077	0.080

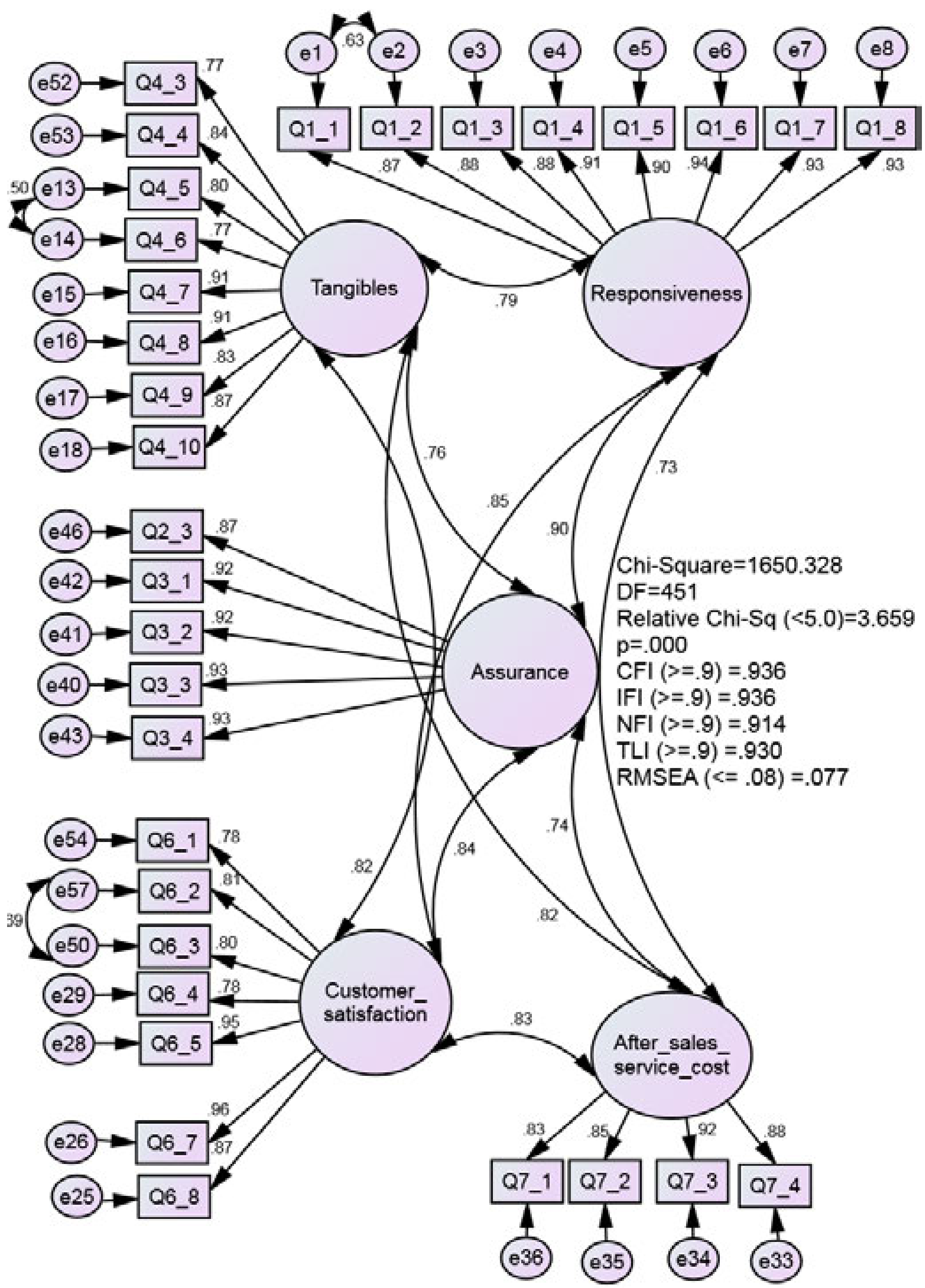

Figure 3.2: Measurement model of serviceability-oriented dimensions (automobile)

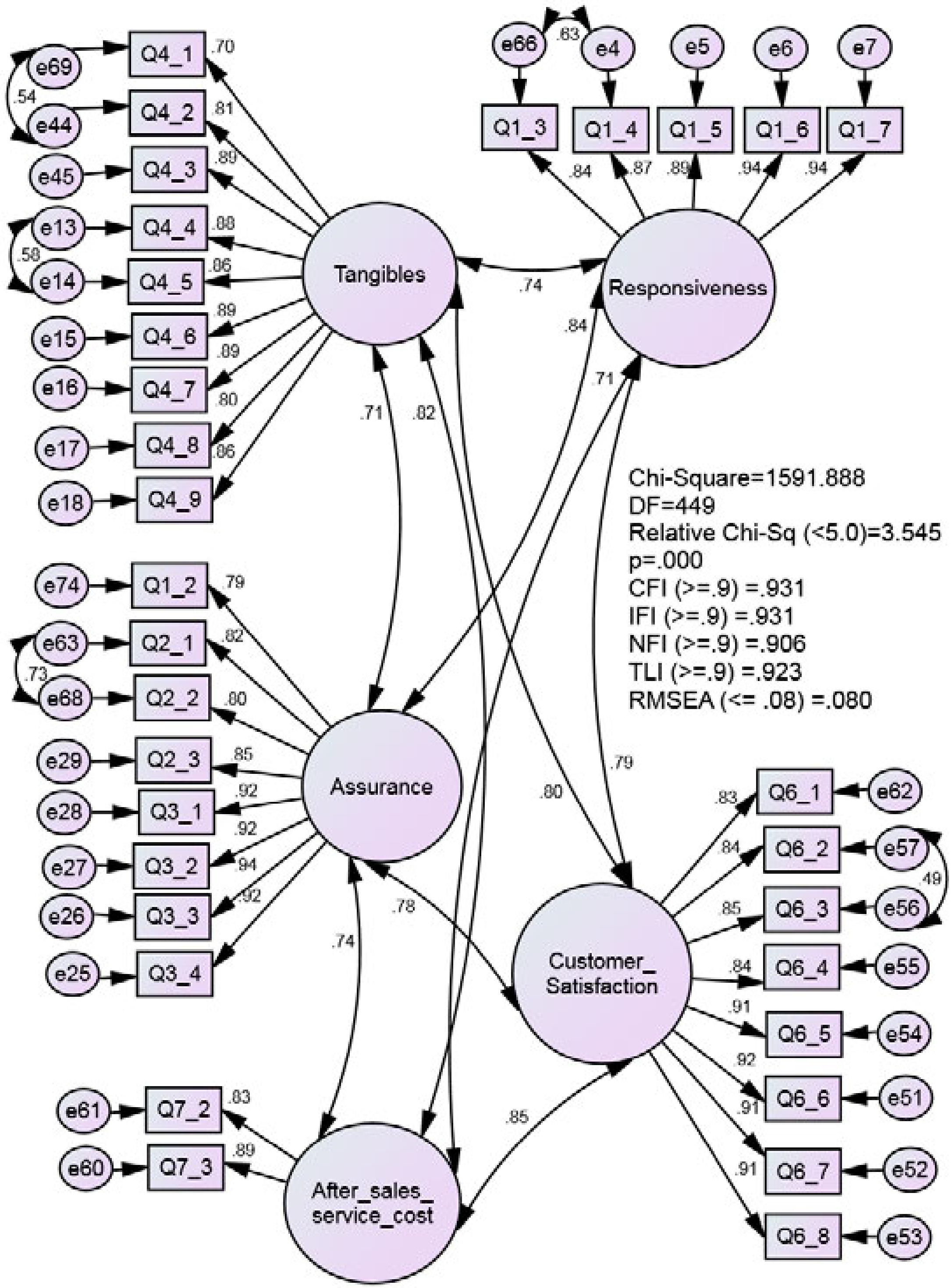

Figure 3.3: Measurement model of serviceability-oriented dimensions (air-conditioner)

3.5.13 Test for construct validity

Construct validity measures the correspondence between a concept and the set of items used to measure that construct (Kaynak & Hartley, 2008). In this analysis, convergent validity and discriminant validity were employed to assess construct validity.

3.5.13.1 Test for convergent validity

As shown in Table 3.7, the automobile study results indicate that the AVE ranged from 0.704 to 0.839, while CR ranged from 0.927 to 0.973, whereas for the air conditioner study, AVE and CR were between 0.709 and 0.805, and between 0.854 and 0.964 respectively. Thus, both surveys displayed convergent validity.

Table 3.7: Convergent validity of measurement model

Factor	Automobile		Air-conditioner	
	AVE	Composite reliability	AVE	Composite reliability
Tangibles dimension of serviceability	0.704	0.950	0.709	0.956
Assurance dimension of serviceability	0.839	0.963	0.762	0.962
Responsiveness dimension of serviceability	0.819	0.973	0.805	0.954
After-sales service cost	0.760	0.927	0.745	0.854
Customer satisfaction/loyalty	0.728	0.949	0.770	0.964

3.5.13.2 Test for discriminant validity

Overall, the results indicated that the measurement model had adequate measurement properties and was appropriate to be used with the full structural model. Table 3.8 and Table 3.9 show the discriminant validity for the measurement model of automobiles and air-conditioner, correspondingly.

Table 3.8: Discriminant validity (square root of AVE and inter-constructs correlation) for measurement model of automobile survey

Factors	T	A	R	AC	CS
Tangibles dimension of serviceability	**0.839**				
Assurance dimension of serviceability	0.761	**0.916**			
Responsiveness dimension of serviceability	0.792	0.904	**0.905**		
After-sales service cost	0.823	0.743	0.730	**0.872**	
Customer satisfaction/loyalty	0.819	0.842	0.850	0.834	**0.853**

Table 3.9: Discriminant validity (square root of AVE and inter-constructs correlation) for measurement model of air-conditioner survey

Factors	T	A	R	AC	CS
Tangibles dimension of serviceability	**0.842**				
Assurance dimension of serviceability	0.714	**0.873**			
Responsiveness dimension of serviceability	0.745	0.844	**0.897**		
After-sales service cost	0.819	0.743	0.708	**0.863**	
Customer satisfaction/loyalty	0.799	0.785	0.787	0.847	**0.877**

3.5.14 Tests for common method variance

In this research, the survey data were obtained from individual informants, who responded on all measurement items based on their experience with the product and after-sales service. Due to this, there is the possibility that common method variance might exist, where variance arises from the measurement method itself (Podsakoff, & Organ, 1986; Sanders, 2008). As a test for common method variance, Harman's one-factor test was used to see if a single factor accounts for a majority of variance, though previous scholars have described that common method variance did not necessarily pose a threat even if the first factor extracted in factor analysis accounted for more than 50% of the total variance explained (Rönkkö & Ylitalo, 2011; Sirén, Kohtamäki & Kuckertz, 2012, cited by Kohtamäki, Partanen, & Möller, 2013). Hence, common method variance is unlikely a major concern in this research.

3.6 Analysis and findings

The structural model represents the relationships of each factor, and a structural model test was employed to test all hypothesized paths of the proposed conceptual model. In keeping with

Hussey & Eagan (2007), a sample size greater than 200 is required. The structural models shown in Figure 3.4 and Figure 3.5 were produced, and the relationship between respective factors was tested. The fit indices considered were those most commonly recommended for this type of analysis. According to the automobile survey result, chi-square relative to the change in degrees of freedom (x^2/df) = 3.652, CFI = 0.936, IFI = 0.936, NFI = 0.914, TLI = 0.930 and RMSEA = 0.077. In the air conditioner survey, all indices were also within the specified range: x^2/df = 3.538, CFI = 0.931, IFI = 0.931, NFI = 0.906, TLI = 0.924 and RMSEA = 0.080. Thus, from these statistics we conclude that the overall structural model has satisfactory fit.

Table 3.10 presents a summary of all hypotheses, paths, coefficients, and test of significance results. For *H1* on the relationship between the tangibles dimension of serviceability and (reduced) after-sales service cost, a very significant relationship was observed with standardized regression coefficients (β) of 0.61 ($p < .01$) for automobiles and 0.59 ($p < .01$) for air conditioners, where *p* is the *p*-value for the corresponding coefficient. *H2* regarding tangibles and customer satisfaction/loyalty also is supported, with β = 0.14 ($p < .01$) for automobiles, and β = 0.16 ($p < .05$) for air conditioners. These results are similar to that obtained in previous studies by Bitner (1990, 1992), Zhang, Xie, Huang and He (2013) and Chang, Chen, Pang, Chen and Yen (2013), who found in multiple service industries that the tangibles aspect influenced customer satisfaction. In addition, a mediation test was performed which showed (see Table 3.11) that the relationship between the tangibles dimension and customer satisfaction/loyalty is partially mediated by after-sales service cost for both product types (automobiles: β = 0.21, $p < .01$; air conditioners: β = 0.26, $p < .01$).

As shown in Table 3.10, *H3* regarding the effect of the assurance dimension on (reduced) after-sales service cost also is strongly supported (automobiles: β = 0.28, $p < .01$; air conditioners: β = 0.32, $p < .01$), as is *H4* on the relationship between assurance and customer satisfaction/loyalty (automobiles: β = 0.21, $p < .01$; air conditioners: β = 0.15, $p < .05$). These results for the relationship between assurance and customer satisfaction are in line with several recent empirical studies (Murali et al., 2016; Narteh, 2015; Chang et al., 2013; Zhao, & Benedetto, 2013; Chou, Liu, Huang, Yih, & Han, 2011; Kumar, Mani, Mahalingam, & Vanjikovan, 2010), which investigated numerous sectors, including banking, airlines, and home appliances. Also as shown by the mediation test results in Table 3.11, after-sales service cost was found to partially mediate the relationship between the assurance dimension and customer satisfaction/loyalty (automobiles: β = 0.10, $p < .01$; air conditioners: β = 0.14, $p < .01$).

H5, with β = 0.30 ($p < .01$) for automobiles and β =0.23 ($p < .01$) for air conditioners, was also positively significant for the relationship between responsiveness and customer satisfaction/loyalty. These results are consistent with the findings obtained by other researchers pertaining to service quality and after-sales service (e.g. Parasuraman, Zeithaml, & Malholtra, 2005; Rigopoulou, Chaniotakis, Lymperopoulos & Siomkos, 2008; Komunda & Osarenkhoe, 2012; Zhang et al., 2013; Zhao & Benedetto, 2013).

Finally, the hypothesized relationship between after-sales service cost and customer satisfaction/loyalty (H6) was supported (automobiles: β = 0.35, $p < .01$; air conditioners: β = 0.45, $p < .01$). Thus, reduced after-sales service cost was very positively related with customer satisfaction/loyalty. In summary, the hypotheses, the path, the coefficient, and the hypotheses (direct effect and mediation) results are listed in Table 3.10 and Table 3.11.

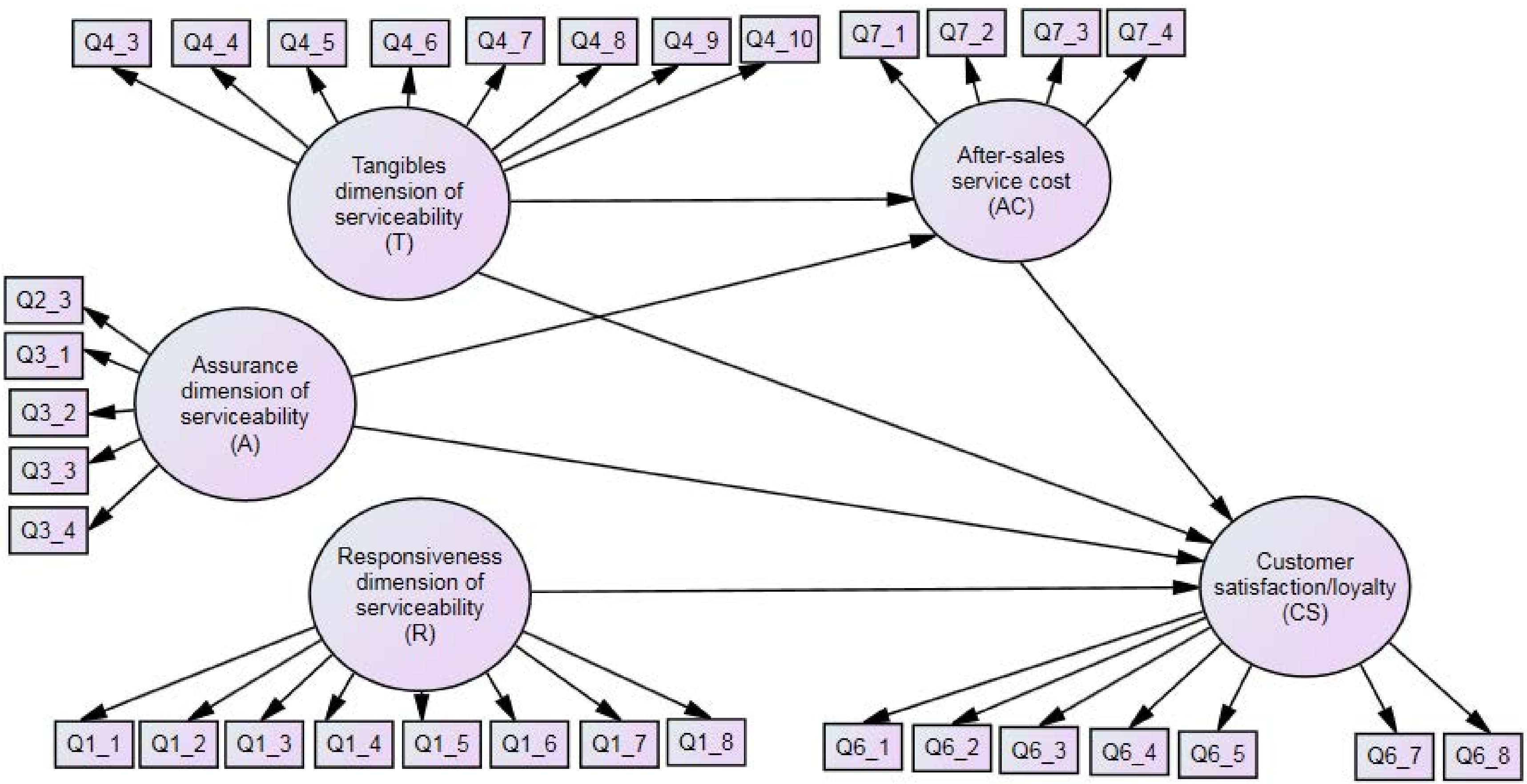

Figure 3.4: Structural model of serviceability-oriented dimensions (automobile)

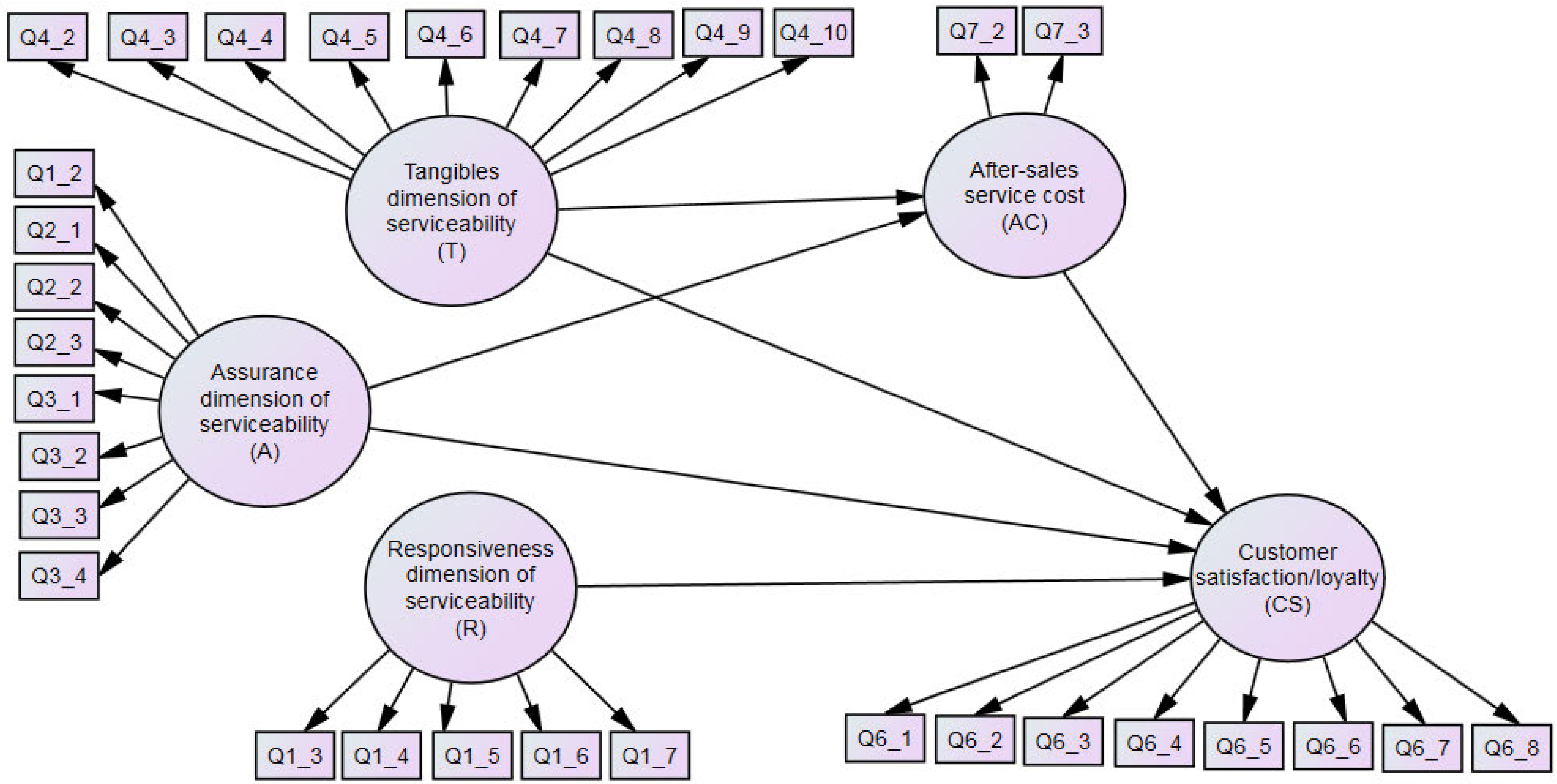

Figure 3.5: Structural model of serviceability-oriented dimensions (air-conditioner)

Table 3.10: Summary of hypotheses test results for structural model

Hypotheses and paths		Coefficient		Hypotheses supported?
		Automobile	Air-conditioner	
H1	Tangibles (T) → After-sales service cost (AC)	0.61***	0.59***	Yes
H2	Tangibles (T) → Customer satisfaction/loyalty (CS)	0.14***	0.16**	Yes
H3	Assurance (A)→After-sales service cost (AC)	0.28***	0.32***	Yes
H4	Assurance (A)→ Customer satisfaction/loyalty (CS)	0.21***	0.15**	Yes
H5	Responsiveness (R) → Customer satisfaction/loyalty (CS)	0.30***	0.23***	Yes
H6	After-sales service cost (AC) → Customer satisfaction/ loyalty (CS)	0.35***	0.45***	Yes

Path significant at: $**p < 0.05$; $***p < 0.01$,

Table 43.11: Summary of mediation test results for structural model.

Paths	Description	Coefficient		Significant
		Automobile	Air-conditioner	
T->AC->CS	AC mediates the relationship between T and CS	0.21***	0.26***	Yes
A->AC->CS	AC mediates the relationship between A and CS	0.10***	0.14***	Yes

Path significant at: $**p < 0.05$; $***p < 0.01$,

3.7 Discussion

This research has developed a new conceptual framework for understanding customers' perspectives on product serviceability and after-sales service. Through this, the impacts and potential benefits of serviceability-oriented products are also examined. Based on EFA and CFA of survey data on two different consumer durable goods, five factors with high reliability were extracted: tangibles dimension of serviceability, assurance dimension of serviceability, responsiveness dimension of serviceability, after-sales service cost, and customer satisfaction/loyalty. As is shown in the previous structural models (Figures 8 and 9), the tangibles dimension of serviceability, assurance dimension of serviceability and responsiveness dimension of serviceability are categorized as endogenous variables, after-sales service cost as a mediator, and customer satisfaction/loyalty as an exogenous variable.

As the tangibles dimension of serviceability, it was found that items such as a 'quick guide' label, warning label, product warranty, routine maintenance book and service facilities are viewed together by customers as a dimension of product serviceability. These items are extensions of the tangible product itself and/or are tangible artefacts that support product usage, service and repair. For example, routine maintenance typically is a preventive action on operating products carried out by service personnel or by customers. An understandable user manual also can guide customers to perform simple maintenance and parts replacement (e.g. air-filter replacement), while also saving time and money for manufacturers since service personnel are not required to assist customers. This kind of support to customers for performing DIY tasks can create cost savings for the customer (Sundin et al, 2009). It also can create cost savings for the firm by making customers feel confident to initiate easy part replacement or inspection at their own premise without requesting service personnel to perform such tasks. At the same time, it is understandable that respondents also viewed modern facilities and equipment as important tangibles for routine maintenance, troubleshooting and repair carried out at service centers. As shown by the analysis results for H1 and H2, the tangibles dimension of serviceability was perceived by customers to significantly reduce after-sales service costs and to increase their satisfaction and loyalty intentions.

Items in the assurance dimension of serviceability deal with competency in solving any service, repair and maintenance problem, as well as helping the customer to feel confident and assured that their needs are being addressed properly by the service center. Hence, the assurance dimension includes service/repair competency issues, as well as issues such as the service center's consideration of customer suggestions and smooth handling of warranty claims. Of note, this dimension includes three adapted items from SERVQUAL's (Parasuraman et al., 1988) Reliability dimension: Q1: Service staff informs the customer of time to service the product; Q2: Service staff informs the customer of time to repair the product; and Q3: Service personnel solve problems right the first time. All three of these reliability items are related to the competency of service personnel in fixing a variety of service or repair issues quickly and right the first time (Parasuraman et al., 1988). Consequently, customers are able to avoid further repair and returns to the service center for reinvestigation of unresolved service issues. For a firm to address the assurance dimension, its service personnel must be highly capable in investigating and resolving any service issues safely without wasting unnecessary time and money. Furthermore, they must have full commitment to provide individual attention to customers, especially in overcoming any malfunctioning mechanism in the product. If the product has been well-serviced, the product is able to function according to the original specification and prevent any safety issues. Thus, low-cost routine maintenance or repair and high customer satisfaction can be achieved via not requiring any repeat service.

For the responsiveness dimension of serviceability, customers viewed items such as prompt repair and service of the product, together with politeness by service personnel in explanations and interactions, as forms of responsiveness to the customer. This includes, for example, service center personnel answering customer queries politely regarding services that should be performed for their product, as well as responding to customer requests or needs quickly, even when busy with other tasks. Even though there may not be immediate revenue generated through responsiveness to customers, all these responsiveness practices are very meaningful for long-term customer relations and therefore increased customer lifetime value. As shown by the analysis results for H5, firms that can successfully address the responsiveness dimension will be in a better position to win the customer's satisfaction and loyalty.

With regard to the after-sales service cost, it has been discussed above how product accessibility, correct repair and service procedures, purpose-designed tools, and timely replacement procedures can increase the operational efficiency and performance of service centers. As an after-sales service cost dimension of serviceability, customers viewed together such items as the availability of individual spare parts, less replacement of parts during routine maintenance, and reasonable routine maintenance cost. These serviceability considerations provide significant cost benefits for the customer by reducing the need to dismantle and replace parts or to replace a malfunctioning single part with a new modular system. As evidenced by the analysis results for H6, customers viewed product serviceability considerations such as these, as significantly influencing their satisfaction and loyalty for the product and its after-sales service.

3.8 Conclusions and implications

As discussed above, serviceability encompasses a broad range of issues that affect the customer's purchase decision, usage experience, and satisfaction and loyalty intentions for the product. This research sheds new light on our understanding of serviceability by analyzing empirically the perspectives by which customers view product serviceability, as well as its influence upon customer satisfaction/loyalty. Based on factor analysis and structural equation modelling using consumer survey data on two different product types (automobiles, air conditioners), a conceptual framework of serviceability was derived, consisting of three endogenous variables (tangibles dimension of serviceability, assurance dimension of serviceability and responsiveness dimension of serviceability), one mediator (after-sales service cost) and one exogenous variable (customer satisfaction/loyalty).

The proposed set of serviceability dimensions responds to Parasuraman et al's (1994) call for service quality researchers to produce measurement items and investigate new dimensions for different industry contexts. In addition to adapting and augmenting existing measurement scales to the context of serviceability, we examined after-sales service cost as a new, unexplored dimension. The measurement scales for each dimension are logically coherent with high Cronbach's alpha values ($\alpha > 0.9$), and are a new contribution to the research literature.

Through structural equation modelling, six hypotheses were investigated regarding the relationships between the dimensions in the conceptual framework. All hypotheses were supported for both product types. Specifically, the tangibles (T) and assurance (A) dimensions of serviceability were found to significantly influence both after-sales service cost (AC) and customer satisfaction/loyalty (CS), and the responsiveness dimension (R) was found to significantly influence customer satisfaction/loyalty (CS). As another research finding, after-sales service cost (AC) was identified as a new dimension of product serviceability that helps clarify the mechanism by which serviceability influences customer satisfaction/loyalty. In addition to its direct relationships, after-sales service cost (AC) was found also to partially mediate the effect of tangibles (T) and assurance (A) on customer satisfaction/loyalty (CS). Therefore, in the context of serviceability, tangibles (e.g. manuals, product warranty, service facilities) and assurance (e.g. service personnel knowledge, skills) support lower after-sales service cost in service operations, which provides an added, indirect effect in fulfilling customer expectations. These outcomes support and also extend the results from recent studies (e.g. Murali et al., 2016; Zhang et al., 2013 and Rigopoulou et al., 2008), which examined after-sales service's contribution in sustaining quality of product and service and enhancing customer satisfaction and loyalty.

In short, all serviceability dimensions in the research's conceptual framework had significant, positive effects (direct and/or indirect) on the customer's satisfaction with the product itself and with the after-sales service experience, as well as on the customer's loyalty intentions for repurchase and positive word-of-mouth. Consequently, these dimensions of serviceability are key factors for understanding and practicing user-friendly service and repair in after-sales service contexts. As a useful implication for scholars and practitioners, the scale items describe the major requirements for manufacturers in providing serviceability through tangibles associated with the product, through responsiveness and assurance, and through reduced cost of servicing.

In terms of additional managerial implications, this study provides insights to manufacturers regarding new product development (NPD), service operations, marketing, and competitive strategy. As for NPD, customer-friendly service and repair are highly dependent on the serviceability features embedded in the product's design. The serviceability-oriented dimensions derived in this study may act as a framework for manufacturers to understand the customer perspective of serviceability so that customer requirements (e.g. availability of spare parts and low ownership cost) may be properly reflected in NPD. By designing products for serviceability, manufacturers are able to support efficient service operations and economical costs associated with product service, repair and maintenance for the customer and firm alike. Moreover, consideration of serviceability during NPD enables the creation of tangible service artefacts (e.g. service manuals and customer guides) that support service personnel in performing efficient service, repair and maintenance, as well as educate customers for DIY servicing. By its very nature, successful design efforts for serviceability will require close coordination of functional departments within the manufacturing firm, as well as active input and involvement from after-sales service providers outside the firm.

The study results for the tangibles and assurance dimensions of serviceability also show the high impact of service centers on after-sales service cost and customer satisfaction/loyalty, which provides further justification to managers for service center upgrades and ongoing development of highly skilled personnel on the frontlines dealing with diverse customer behaviors and backgrounds. Since the responsiveness dimension of serviceability was shown to strongly influence customer satisfaction/loyalty, top management should provide adequate staffing and equipment, as well as ongoing employee training, to support the firm's service goals. Similarly, top management should continuously strive to increase service personnel satisfaction because motivated employees will sustain the quality of service, repair and maintenance that is experienced by the customer. Furthermore, managers should be mindful of customer expectations and perceptions of what constitutes caring, prompt service, which may differ over time.

As implications for marketing managers, this study revealed the significant influence of after-sales service cost on customer satisfaction, which suggests the need for firms to make the customer aware of the cost-saving benefits of its serviceability-oriented products. Customers may not realize, for example, to what extent individual spare parts are available and how that contributes to low ownership costs. Communicating such aspects of the product and service operations, in turn, may positively influence customer demand for the product and related routine maintenance services, which directly increases market share and typically garners high profit margins. Furthermore, firms should consider ways to offer service packages and to communicate their value vis-à-vis stand-alone service, repair and maintenance, as part of their initiatives to reduce expensive after-sales service costs for customers and thereby increase customer satisfaction.

As implications for competitive strategy, the serviceability-oriented dimensions derived in this study serve as a useful reference for evaluating and benchmarking competitors' serviceability practices. In addition, through implementation of the serviceability practices identified in this study, firms lay the foundation for successfully pursuing servitization as a strategy for differentiation and increased profitability.

Finally, the study results provide a key insight to managers regarding how customers view a manufacturer's products. From the factor analysis results, a customer's satisfaction/loyalty for the product itself was shown to be part of the same, single factor with the customer's satisfaction/loyalty for after-sales service experiences at service centers. In other words, the customer does not view the product and its after-sales service from separate perspectives. In the mind of the customer, the product and its after-sales service are part of an integral whole, and should be dealt with in integrated fashion by manufacturers and service centers. Since this research discovered the importance of the dimension of serviceability-oriented products and the influence upon customer satisfaction/loyalty, Appendix VII and Appendix VIII display the summary between this research as well as the existing research literature, and the comparison table respectively.

For future research, studies with broader samples and examining other serviceable products (for example, other home appliances or heavy industrial products) should be conducted in order to improve the generalization of the research findings.

CHAPTER 4

Customer Perceptions of Mediating Role of Ownership Cost in Garvin's Dimensions of Quality

4.1 Introduction

Customers are increasingly demanding in their evaluation of products, especially for similar products offered by multiple manufacturers. This reality forces manufacturers to deliver high value-added products without compromises in quality (Hansen and Bush, 1999). For example, automobile manufacturers are required to deliver high quality products with reasonable price, which may lead to low ownership cost, high customer satisfaction, and loyalty as well as indirectly improving the market share position. Automobiles are a product that is particularly important to consumers throughout the global economy. Automobiles have been prominent in the history and development of quality management, product design, and lean manufacturing, with Japan as the source of many progressive innovations (Womack et al., 1991; Clark and Fujimoto, 1991; Fujimoto, 1999). Several Japanese automobiles are undoubtedly a role model for other manufacturers to strengthen business processes from new product development until after-sales service. Various countries have recognized Japan's achievements and initiatively started collaboration mainly on manufacturing-based industries.

In terms of ownership cost, several main elements are reflected in automobiles such as service cost, repair cost, maintenance cost, price of product, loans from financial institutions, annual insurance premium cost, driving license renewal, registration cost, road tax, protection cost (anti-theft), toll charge and parking charge. Even though all of these elements are mostly acknowledged by the customers, they are still given significant attention to avoid or minimize additional costs that could incur during the automobile product life cycle. Customers may have no choice in avoiding such compulsory elements (e.g. price of product, loans from financial institutions, annual insurance premium cost, driving license renewal, registration cost and road tax) due to basic requirements but they still believe that service, repair, and maintenance costs are adjustable and subjective, depending on the product condition. Hence, ownership cost is anticipated to become the critical success factor for manufacturers to attract customers with economical vehicles as a value-added characteristic compared to other competitors. The economical vehicles can help customers in terms of cost saving during product lifecycle as an alternative way to cover hidden ownership costs such as depreciation of 25% in the first year and then every 10% in the following years (Faria et al., 2012).

Toward pursuing better quality of products, Japanese quality management has been recognized globally, particularly for its successes in improving efficiency, and reducing cost (Ishikawa, 1985; Akiba et al., 1992). For this purpose, it is helpful to consider all of the various dimensions of quality, such as originally proposed by Garvin (1987) with his eight dimensions of product quality, including performance, features, conformance, aesthetics, perceived quality, reliability, durability, and serviceability.

Garvin (1987) was the most recognized scholar in product quality-related research and published papers as well as text books are the most influential sources (i.e., very high citations), which are obviously focusing on manufactured products. As a well-known scholar, Garvin's publications were also the usual reference point for comparison, analysis, and discussion for other scholars prior to conduct product quality-related research in different contexts. Since this research is related to product quality dimension and manufactured products, a good connection has been established with the Garvin literature. Besides Garvin (1987), there were contributions from other scholars in introducing other quality dimensions including manufactured product-based field. Appendix IX and Appendix X display the summary and timelines of quality dimension-related researches, respectively. As per Appendix X, this research was a continuation from Garvin's (1987) research and aligned with the six subsequent researches (Sinclair, Hansen and Fern, 1993; Curkovic, Vickery, and Droge, 2000; Devaraj, Matta and Conlon, 2001; Sebastianelli and Tamimi, 2002; Schvaneveldt, 2011; Kianpour, Jusoh and Asghari, 2014) which examined Garvin's quality dimensions from customer's perspectives.

Given this background, further research on customer perspectives of quality of automobiles is important for continued development and success in the automobile industry. Even though existing studies revealed that Garvin's quality dimension displays significant benefits to the manufactured products, no study has been conducted pertaining to the application of adopting Garvin's quality dimensions in the context of customer perspectives upon ownership cost. Hence, a detailed research in creating better comprehension of Garvin's quality dimensions and customers' perception about the benefits of ownership cost dimension is important toward facing this challenging decade.

4.2 Research objectives

This study is aimed at two main objectives as follows:

i) To determine relevant variables of quality dimensions, ownership cost, customer satisfaction and customer loyalty have to be determined through the factor analysis.
ii) To conduct an empirical study and then test the hypotheses for entire relationships
iii) To develop a framework representing the relationships among quality dimensions, ownership cost, customer satisfaction, and customer loyalty.

4.3 Literature review

Although scholars have defined product quality differently, most of them introduced product quality based on the meanings of quality given by Juran (1974), who stated that quality is fitness for use, and Deming (1982), who believed that only customers could define quality based on the judgment on the product or service. Through eight dimensions of quality, Garvin (1987) sought to bring together these and other definitions of quality, as a form of guidance to manufacturers in providing-high quality products.

4.3.1 Performance

As Garvin's first dimension of product quality, performance is a "primary operating characteristic" of a product (Garvin, 1987). Performance is also defined as the ability of a customer to operate and utilize the product smoothly based on the provided instructions (Brucks et al., 2000). For an automobile, performance is usually measured according to the power of engine during traveling on the road. The car speed is calculated based on the maximum power produced by the engine. A quality engine can generate high power when overtaking other cars, as well as support the driver for smooth handling and braking to prevent accidents. Other than that, customers are able to evaluate the car when climbing uphill, since car acceleration reduces due to the high load. Usually, vehicle with high engine efficiency consumes less fuel during operation. However, some customers may think that a quality engine requires high fuel consumption. Therefore, production of many types of electric vehicles (Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV) and Plug-in Hybrid Electric Vehicle (PHEV)) instead of gasoline engine vehicles is one of the constructive initiatives that offer better performance of the fuel economy to the customers. Definitely, performance between electric vehicles and gasoline engine vehicles may differ since they are in different vehicle segments. Hence, if the car is designed with good performance, it is anticipated could enhances customer satisfaction and exceeds their initial expectation.

4.3.2 Features

Features are categorized as the secondary aspect of performance (Garvin, 1987). However, Brucks et al. (2000) identified that features are the most important dimension for certain products due to the variability of functions that could enhance product quality. Thus, manufacturers are forming new attractions by producing more high-end products in order to customize the products with the customers' changing demands. From the customer's point of view of automobiles, security, air-conditioner, and seat systems are also essential value-added elements, which may increase customer satisfaction during traveling.

4.3.3 Conformance

Conformance is the degree in which a product meets the design specification (Larson, 1993). Products or processes that are able to meet the established design standard are considered as fulfilling the required specification. Once the specification of the product meets the customers' desire, it represents that the product has met the specified standard and fulfilled the definition of conformance. For automobiles, if the designed products are manufactured according to certified international standards such as ISO 9001 or TS 16949, the organization assures high quality products to the customers, which subsequently impacts customer satisfaction.

4.3.4 Aesthetics

Aesthetic is a customer's judgment about product appearance and how the customer feels, tastes, hears or smells the product during utilization (Garvin, 1987). Thus, aesthetic is an intangible characteristic and customers evaluate the product subjectively according to their preference. For automobiles, aesthetics can be evaluated by customers while operating some functions such as interior buttons. Customers are expected to feel delighted if the button is easily touched without pain and the automobiles are equipped with many attractive exterior and interior designs. Several choices of colors and unique features could also attract customers to spot the products during product sales. Hence, a high aesthetics value can potentially build an initial stage of customer satisfaction on the product before they examine other mandatory product characteristics.

4.3.5 Perceived quality

Perceived quality represents how influenced the customer is to the product images, advertisement or brand name (Garvin, 1987). Moreover, perceived quality is a subjective dimension (Sebastianelli and Tamimi, 2002) and is associated with product reputation or previous experience, which may encourage or discourage the customer to purchase the product. These elements contribute to customer's first impression and may influence their behavior to purchase a product (Sinclair et al., 1993). Various messages should be provided to potential customers so that they may switch their intention to consider purchasing the advertised product in the future. For example, the reputation of an automobile manufacturer is anticipated to increase during its employees' direct involvement in social activities such as "green" programs.

Hence, customers' perceived quality is reliant on how successful the product brand is in the customers' perspective toward meeting customer satisfaction.

4.3.6 Reliability

Reliability is the probability of product failure within a specified time (Larson, 1993). Reliability can be evaluated as the mean time to the first failure, mean time between failures, and failure rate per unit time (Hansen and Bush, 1999; Garvin, 1987; Sinclair et al.,1993). Since reliability is reflected in product failure, breakable parts of an automobile such as the bumper, dashboard, and signal handle have to be designed using robust materials. While there are fewer failures on parts or components, high frequency of usage on particular vehicles can be realized. Hence, customers who have experienced high reliability of product are expected to bear lower ownership cost due to less repair or service. In this situation, a reliable product is anticipated to influence customer satisfaction and low ownership cost throughout product lifecycle.

4.3.7 Durability

Durability is the lifespan of product usage before the product becomes unstable and unrepairable (Garvin, 1987). Furthermore, durability represents the ability of the product to be utilized during its lifespan until it physically deteriorates or requires replacement (Hansen and Bush, 1999; Garvin, 1987; Larson, 1993). Brucks et al. (2000) explained that product durability level can be determined based on the number of failure cases. According to Sinclair et al. (1993), durability is also affiliated to the cost of repair, downtime, and spare parts because the malfunctioned products require a repairing process in after-sales service. Hence, the automobile is considered to surpass customer satisfaction with a reasonable ownership cost when the entire systems are consistently functioning as expected.

4.3.8 Serviceability

Serviceability refers to "speed, courtesy and competence of repair" (Garvin, 1987). Serviceability is mostly examined by customers after product's purchase until its end of life. According to the recommended procedures, a product with good serviceability is easily serviced or repaired (Larson, 1993) in after-sales service. Brucks et al. (2000) described that the service personnel of a service center are able to perform parts replacement on malfunctioned products. However, some minor services or repairs could be also fixed by customers, which are classified as Do It Yourself (DIY) services or repairs. Apart from that, good serviceability also covers the ease of obtaining spare parts in after-sales service. Moreover, services, repairs or diagnostic tasks can be performed by any service center smoothly within a specified time and at a competitive service or repair cost. Since efficient after-sales service is essential from customer's perspective, serviceability is expected to impact customer satisfaction, ownership cost, and customer loyalty.

4.3.9 Ownership cost

Ownership cost is the total cost of purchasing and maintaining a product over its lifetime. Ownership cost is a philosophy that describes the entire subsequent customer costs along the product life, which are beyond the initial product purchase (Ellram, 1994). In this study, the examples of cost consist of cost of maintenance, service, repair, spare part, and fuel. Since the costs are related to after-sales service, the most studied ownership cost in literatures was associated with the automobile industry and a source of concern by potential customers prior to vehicle purchase.

According to Faria et al. (2012), the new purchase of a vehicle is directly corresponded to the ownership cost of vehicle and customers need to consider this cost due to depreciation in cost. Other than depreciation, fuel consumption for product operation significantly affects the customer's financial aspect. However, due to customers' difficulty to evaluate the depreciation cost personally, this research excluded depreciation as one of the ownership cost elements in accessing the benefits of ownership cost upon customer satisfaction and customer loyalty. Even though the total cost of fuel consumption is also subjected to fuel price and type, a vehicle that is designed with an economical fuel consumption generates high fuel efficiency and subsequently influences the customer's daily cost saving. However, the vehicle fuel efficiency is still reduced if there is less awareness for routine maintenance (e.g. engine oil changes) and replacement processes on short lifespan parts (e.g. spark plug).

In the context of after-sales services, especially in service centers, elements of ownership cost differ from the product quality dimensions. Even though the ownership cost can also vary between customers, they still require good serviceability aspects (easy maintenance, service and repair) as well as high reliable and durable products since the three factors (serviceability, reliability and durability) may reduce ownership cost, prolong vehicle lifetime and more critically prevent potential safety issues during vehicle operation.

In this study, ownership cost represents how customers judge the total expenses spent related to two most important aspects, which are service-related costs (e.g. maintenance, service, repair and spare parts) and operating cost (e.g. fuel consumption) of their purchased automobiles during the product life cycle.

4.3.10 Customer satisfaction

Customer satisfaction is a customer's evaluation based on cumulative experiences with the product or service. The utilized product or service may influences customer satisfaction. According to Crosby, Evans and Cowles (1990), customer satisfaction is the result from the evaluation of quality of the previous transaction between the customer and organization (Boulding et al., 1993) and it subsequently can create a future expectation on the quality of the product or service. Rust and Oliver (1994) described customer satisfaction as customer's response associated with the buying feeling or purchasing experience of a product or service. Once high customer satisfaction is achieved, customer complaints to the organizations decrease and this subsequently increases customer loyalty on the products (Fornell and Wernerfelt, 1987).

4.3.11 Customer loyalty

Customer loyalty corresponds to customer intention to repurchase the similar product or service in future (Zeithaml et al., 1996). Various studies proved that positive relationship existed between customer satisfaction and customer loyalty (e.g. Flint et al., 2011). Customers reacted voluntarily to promote the experienced product or service to third parties (e.g. family, friends, and other people) who seek their advice. Positive word of mouth is a strong expression by customers and is anticipated can enhance the image of the manufacturers.

4.4 Research hypotheses and framework

In relation to Garvin's dimensions of quality, this research investigates the influence of ownership cost on automobiles customers' perspective through maintenance, service and repair. The related hypotheses are proposed as follows:

Hypothesis 1a: Serviceability has a positive effect upon ownership cost
Hypothesis 1b: Serviceability has a positive effect upon customer satisfaction
Hypothesis 1c: Serviceability has a positive effect upon customer loyalty
Hypothesis 2a: Reliability has a positive effect upon ownership cost
Hypothesis 2b: Reliability has a positive effect upon customer satisfaction
Hypothesis 3: Performance has a positive effect upon customer satisfaction
Hypothesis 4: Features have a positive effect upon customer satisfaction
Hypothesis 5: Aesthetics have a positive effect upon customer satisfaction
Hypothesis 6: Perceived quality has a positive effect upon customer satisfaction
Hypothesis 7a: Ownership cost has a positive effect upon customer satisfaction
Hypothesis 7b: Ownership cost has a positive effect upon customer loyalty
Hypothesis 8: Customer satisfaction has a positive effect upon customer loyalty

Figure 4.1 represents the conceptual model associated with Garvin's eight quality dimensions, ownership cost, customer satisfaction, and customer loyalty.

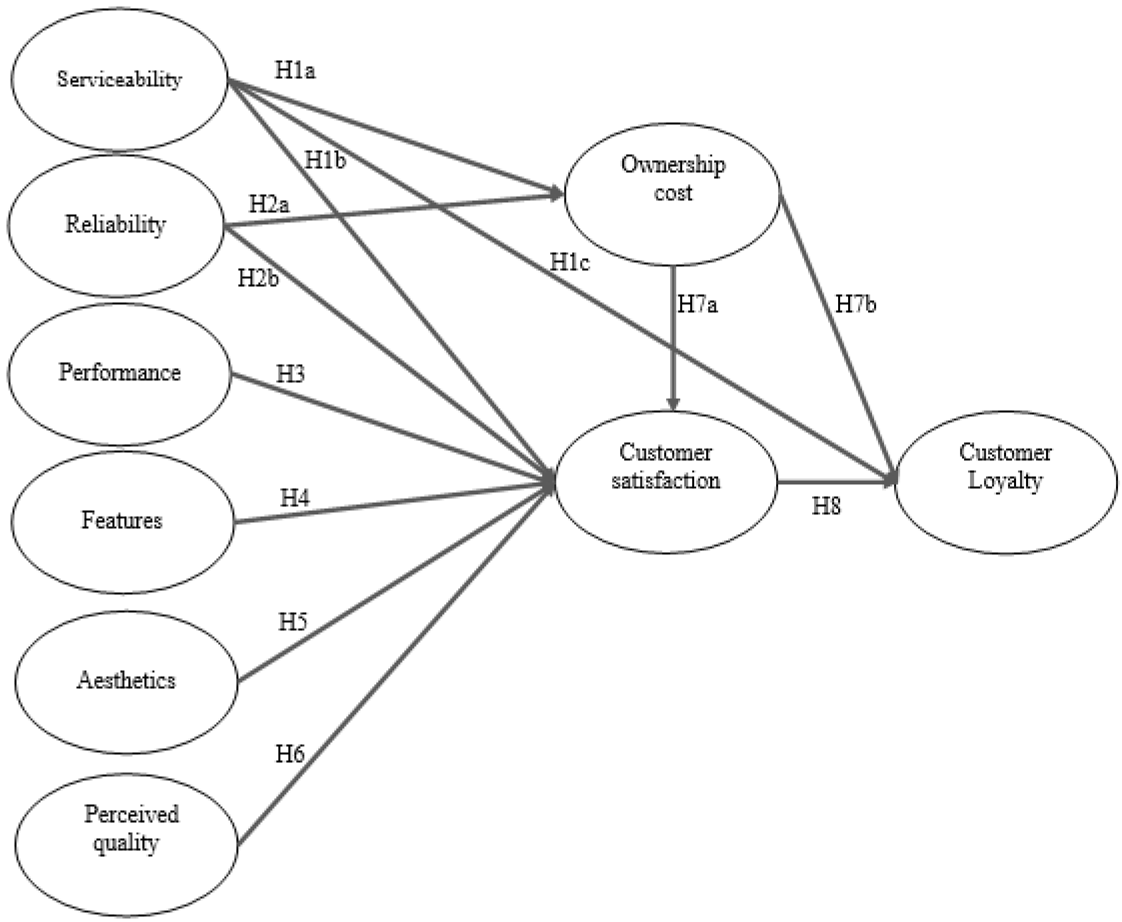

Figure 4.1: The hypothesized conceptual model for Garvin quality dimensions, ownership cost, customer satisfaction and customer loyalty

4.5 Research methodology

In order to analyze customer's perspective about the quality of automobiles and ownership cost, a quantitative research was conducted among automobile users in Japan. One of the quantitative research methods, survey, was performed similarly with previous studies (e.g. Hazen et al., 2016) to achieve the research objectives.

4.5.1 Measurement items development

Measurement items were developed by adopting most of the established measurement scale items and then slightly modifying them to suit within this research field. Most of the measurement scale items were aligned with the original description by Garvin (1987), adapted from literatures (e.g. Kianpour et al., 2014), and then further enhanced with the associated field of study. The remaining scale items, especially for ownership cost, were designed according to the automobiles and after-sales services context.

Elements of performance were described by Bruck et al. (2000), Chen (2007) and Shaharudin et al. (2011). For example, performance of automobiles could be measured through overtaking other cars, climbing a hill, acceleration, braking system, handling and fuel consumption. For features, literatures from Hazen et al. (2016), Kianpour et al. (2014), Shaharudin et al. (2011) and Hazen et al. (2012) were studied, whereby some of the scale items were closely related to motor vehicle since customers might experience their main features (e.g. seat, interior space and air-conditioning system). For conformance, literatures from Hazen et al. (2016), Sebastianelli and Tamimi (2002), Sinclair et al. (1993), Kianpour et al. (2014), Chen (2007), Curkovic et al. (2000), Sweeney and Soutar (2001) and Hazen et al. (2012) were referred to and three scale items were utilized in this study. For durability, existing literatures (Hansen and Bush, 1999; Hazen et al., 2016; Brucks et al., 2000; Larson, 1993; Sinclair et al., 1993; Shaharudin et al., 2011; Hazen et al., 2012) also supported the development of the measurement scale items since they examined the durability factor for product quality such as part breakdown and failures within a certain period. For reliability, all the scale items were based on previous scholars (Hazen et al., 2016; Brucks et al., 2000; Larson, 1993; Sinclair et al., 1993; Hazen et al., 2012) in order to evaluate the reliability of parts (including plastic parts) associated with time. For serviceability, automobiles were evaluated by customers on how to clean and inspect promptly as well as how to obtain accurate spare parts in services (Hazen et al., 2016; Brucks et al., 2000; Larson, 1993; Sinclair et al., 1993; Kianpour et al., 2014; Chen, 2007; Shaharudin et al., 2011; Hazen et al., 2012). All the processes were closely related to maintenance, service and repair at the service center.

For ownership cost, elements associated with costs, which included the reasonability of maintenance cost, service or repair cost, spare part cost and fuel consumption, represented the main running expenses after product purchase. Hence, Sweeney and Soutar (2001), Shaharudin et al. (2011) and Kuo et al. (2009) survey instrument were adapted for this study. For aesthetic, Garvin's (1987) explanation related to aesthetic was considered in order to develop suitable scale items for aesthetic. Most of the scale items in this study were also applied by Sinclair et al. (1993), Kianpour et al. (2014), Yuen and Chan (2010) and Shaharudin et al. (2011). For perceived quality, Garvin's (1987) introduction was very supportive in understanding the concept. Subsequently, the survey instrument by Hansen and Bush (1999), Sinclair et al. (1993), Kianpour et al. (2014) and Shaharudin et al. (2011) were adapted.

With respect to measurement scale items for the customer satisfaction and customer loyalty, existing empirical studies consisting of questionnaires have been referred to before being adopted to suit with this research field. For customer satisfaction, measurement scale items that have been used to measure customer satisfaction were referred from Sweeney and Soutar (2001), Devaraj et al. (2001), Caruana (2002), Hallowell (1996), Roberts et al. (2003), Olorunniwo et al. (2006), Yang et al. (2004), Janda et al. (2002), Cronin, Jr. et al. (2000) and Kuo et al. (2009). The scholars described how satisfied a customer was with the product or service was closely related in measuring customer satisfaction. The scale items require judgment from customers in order to measure the customer satisfaction relationship with other constructs (e.g. product quality factors).

For customer loyalty, a similar practice has been applied to identify suitable measurement items for customer loyalty. These items were also proven to be applied by several other researchers (Sweeney and Soutar, 2001; Yuen and Chan, 2010; Caruana, 2002; Olorunniwo et al., 2006; Janda et al., 2002; Parasuraman et al., 2005; Kuo et al., 2009). The customer loyalty construct consists of items related to respondents' perspectives in terms of saying positive things about the product or organization such as recommending the product or organization to other people and encouraging other people to select the product or organization. Appendix XI shows the measurement scale items and the related literatures. Throughout those measurement scale items, respective hypotheses were able to be tested empirically so that an effective research could be demonstrated for future reference. Prior to conducting this survey, an online survey company was appointed to manage the distribution of questionnaire nationwide.

4.5.2 Survey instrument development and content validity

An original questionnaire consisted of two sections; demographic section and evaluation of measurement scale items. Only customers who have purchased a Japanese car of more than five years and driving the same car every month (e.g. at least once a month), whereby the cars were among the six Japanese car manufacturers (Toyota, Honda, Nissan, Subaru, Mitsubishi and Mazda) are eligible to answer the questionnaire survey questions. The demographic section also consisted of other elements such as gender, age, and model of the vehicle. For the second section, the measurement scale items were listed with a ten-point Likert-type scale, ranging from 1 (strongly disagree) to 10 (strongly agree). The questionnaire was initially drafted in Japanese to ensure good similarity with the referred literatures.

Academicians and automobile users had engaged in the survey instrument verification or pre-test toward producing readable questions, understandable content, and no ambiguity (Dillman, 2000). Both groups suggested significant comments for further refinement on the consistency, structure of instrument, and easy-to-understand sentences. Upon completing a pre-test, a pilot study was conducted by involving a group of customers to evaluate the content validity and readability. The main purpose was to ensure no difficulties or no confusion from one question to another since every customer has different interpretations. Considering all the compiled feedback, the survey instrument had been further enhanced and argued that all measurement scale items fit the survey's purposes and were collectively validated.

4.5.3 Data collection

Prior to conducting this survey, an online survey company was appointed to manage the distribution of questionnaire nationwide. Only customers who have purchased a Japanese car of more than five years and driving the same car every month (e.g. at least once a month), whereby the cars were among the six Japanese car manufacturers (Toyota, Honda, Nissan, Subaru, Mitsubishi and Mazda) are eligible to answer the questionnaire survey questions. The online survey was conducted in early December 2016. In total, 1002 questionnaires were returned and 968 were found useful for analysis since the excluded 34 questionnaires (1002-968 = 34) provided inappropriate answers (e.g. same answer for all questions). The 968 automobile users (n = 968) were from all regions in Japan had provided full response to the survey questions for EFA and CFA. Thus, demographic results displayed the respondents' background and the car characteristics.

4.5.4 Total sample and response rate

However, response rate could not be measured due to the respondents who participated in the survey were invited by the appointed national panel online survey company to participate in the surveys until targeted sample size were achieved. The total useable samples for this study, was 968 respondents. Hence, total population was not fixed and unlikely to be used in measuring the response rate.

4.5.5 Respondent profile

Out of 968 respondents, this study has split the sample into two prior to performing two analyses: exploratory factor analysis (n = 300) and confirmatory factor analysis (n = 668). The reason for splitting the sample was to ensure both analyses used different sample sizes (e.g. Rugutt, 2013) since both of them had different purposes. EFA was conducted as a pre-test to examine the measurement scale items and identify the number of factors while CFA was to confirm whether the scale items retained in EFA were really fit, valid and reliable to the data. This concern was highlighted by Rugutt (2013) who emphasized the importance of splitting the data into two separate analyses, as well as underlining that the second sample set of data for CFA should require a larger size than the first sample set of data for EFA. Besides, the application of split-sample size for EFA and CFA was also practiced by various recent scholars (e.g. Yu and Richardson, 2015; Schroder et al., 2015; Koch et al., 2015; Pontes and Griffiths, 2015).

From the survey data, 75% of respondents were male. Among the total respondents, middle aged respondents (40 to 59 years old) contributed 60% to the survey data, followed by retired or elderly respondents (34.3% for EFA, 30.4% for CFA) and youth (6.4% for EFA and 9.4% for CFA). Since the conducted survey was a public-based survey throughout Japan, the most interested respondents were working people (e.g. employee of a company, medical staff, salesman and civil servant) whereby less than 0.5 % was student. Almost all respondents had more than 10 years of driving experience and frequently drive for many purposes monthly. Due to very long driving experience, the participated customers were anticipated to have the knowledge to evaluate every scale item in the survey instruments in order to produce better findings that are closer to the reality.

In terms of vehicle characteristics, this study targeted various vehicle manufacturers and vehicle models. The respondents drove Toyota, Honda, Nissan, Subaru, Mitsubishi and Mazda. The respondents were identified to drive various types of models such as compacts or hatchbacks (27.0% for EFA and 26.2% for CFA), minivans (28.0% for EFA and 22.5% for CFA), sedans (17.0% for EFA and 14.4% for CFA) and mini cars, wagons and SUVs, with 91% of the cars being the gasoline engine type, followed by hybrid (7%) and diesel (1%). Thus, this study examined the customers' point of view, regardless of any kind of vehicle manufacturer (the six Japanese car manufacturers) or vehicle model, even though some customers may utilize popular or luxury cars, which may differ in terms of vehicle performance, features, aesthetic or other product quality factors.

Hence, considering the variety of the customers' background, vehicle manufacturers and vehicle models, this survey represented the initial generalization of survey results with regards to automobile experience in Japan. Table 4.1 shows the demographic data of survey respondents.

Table 4.1: Demographic data of survey respondents

	EFA (n=300)	CFA (n=668)
Gender	Percent	Percent
Male	76.3	75.0
Female	23.7	25.0
Total	100.0	100.0
Age	Percent	Percent
60 years old or more	34.3	30.4
40 to 59 years old	59.3	60.2
18 to 39 years old	6.4	9.4
Total	100.0	100.0
Driving experience	Percent	Percent
More than 10 years	97.3	95.1
Between 5 to 10 years	2.3	4.2
Less than 5 years	0.4	0.7
Total	100.0	100.0
Frequency of driving	Percent	Percent
Several times a week	36.0	36.7
Everyday	31.7	33.8
Few times a week	20.0	18.1
Few times a month	10.0	8.7
Once a month	2.3	2.7
Total	100.0	100.0
Vehicle model	Percent	Percent
Compact or hatchback	27.0	26.2
Minivan	28.0	22.5
Sedan	17.0	14.4
Others (e.g. Mini car, Wagon and SUV)	28.0	36.9
Total	100.0	100.0
Engine type	Percent	Percent
Gasoline	91.3	91.8
Hybrid	7.0	6.7
Diesel	1.3	1.3
Others	0.4	0.2
Total	100.0	100.0

4.5.6 Tests for non-response bias

In order to assess non-response bias, the early and late respondents were compared (Armstrong and Overton, 1977) by selecting the first 10% of respondents and the last 10% of respondents. T-test was used for these two types of samples and concluded that significant difference did not exist. Both methods had proven that non-response bias was not an issue in this research.

4.5.7 Exploratory Factor Analysis (EFA)

A total of 300 samples' data was analyzed through EFA using the principal components extracted method (Curkovic et al., 2000) and varimax as the rotation method. The 300 samples' data was likely suitable because the minimum requirement for EFA is 300 (Sweeney and Soutar, 2001).

4.5.8 Kaiser-Mayer-Olkin (KMO) Measure and Bartlett's Test of Sphericity

As indicated in Table 4.2, the KMO value is 0.943 while the chi-square value of Bartlett's test was 21,341.116 at a p-value of < 0.05. Hence, multi-collinearity was also unlikely a concern and all measurement scale items were strongly appropriate to be analyzed through factor analysis.

Table 4.2: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.943
Bartlett's Test of Sphericity	Approx. Chi-Square	21,341.116
	Degree of freedom	1891
	Significance level	.000

4.5.9 Reliability analysis (alpha)

The general reliability is .974, which demonstrates that the survey instrument was very reliable, constant and had no instability issues.

4.5.10 Total variance explained

As shown in Table 4.3, nine factors were extracted with 75.89% of total variance explained. All factors yielded Eigen values of more than 1.0 (e.g. Hair et al., 1998). For example, the first factor accounted for 15.37%, followed by the second factor with 11.65%, and the third factor with 8.29%. The factor loading for all variables was also positive and exceeded the 0.5 cut-off point (e.g. Tabachnick and Fidell, 2007). Table 4.3 shows that nine new factors with high factor loading variables (factor loading >0.05) were identified: Reliability (11 items), Performance (8 items), Ownership cost (6 items), Serviceability (7 items), Customer loyalty (4 items), Features (5 items), Aesthetics (6 items), Customer satisfaction (5 items), and Perceived quality (4 items).

Hence, the sufficient factor loading for the variables indicated that all variables contributed significantly to each respective factor. In order to evaluate the reliability, reliability coefficient or Cronbach's alpha was measured for each factor. From Table 4.3, it can also be seen that the reliability coefficient for all factors were higher than the cut-off point of 0.7 (Nunnally, 1978), which means that the measurement scale had a relatively high reliability. For example, reliability consisted of 11 variables with factor loadings ranging from 0.628 until 0.862, and a reliability coefficient of (α value) 0.954.

Furthermore, a basic relationship between constructs can be identified as initial evidence through the factor correlation matrix. Based on the correlation matrix results, there were positive correlations between all constructs and significant at 0.01 level (2-tailed). For example, correlation between performance and reliability is 0.439 at p-value < 0.01. Table 4.4 displays the factor correlation matrix for all constructs.

Table 4.3: Results of exploratory factor analysis

(a) Factors 1-3

	Factor loading	Eigen value	Variance explained	Reliability coefficient (alpha)
Factor 1. Reliability		26.050	15.367	0.954
Your car has few failures.	0.862			
Your car functions without problems or failures.	0.858			
Your car has no breakdown after routine maintenance.	0.850			
Your car has less part breakdown within the first five years.	0.832			
Your car can be used for a longer time.	0.773			
Your car's parts can be used for a longer time.	0.728			
You feel that your car has no issues.	0.718			
Your car's plastic parts can be used for a longer time.	0.688			
Your car has appropriate warranty period.	0.670			
You felt that your car had no immediate problems just after being purchased.	0.663			
Your car has a longer service interval for maintenance.	0.628			
Factor 2. Performance		5.776	11.650	0.945
Your car's performance is good during overtaking other cars.	0.897			
Your car's performance is good during climbing a hill.	0.882			
Your car's acceleration is good.	0.880			
Your car's handling is good.	0.790			
Your car generates less vibration at top speed.	0.784			
Your car's brake system is good.	0.755			
Your car's performance meets your expectations.	0.664			
Your car's audio system is good.	0.544			
Factor 3. Ownership cost		3.805	8.291	0.921
Your car's fuel consumption is reasonable.	0.878			
Your car's maintenance cost is reasonable.	0.853			
Your car's service or repair cost is reasonable.	0.791			
Your car's spare part price is reasonable.	0.783			
Your car consumes less fuel.	0.719			
Your car received good reputation in terms of environment protection design.	0.594			

Table 4.3 (*continued*): Results of exploratory factor analysis

(b) Factors 4-7

	Factor loading	Eigen value	Variance explained	Reliability coefficient (alpha)
Factor 4. Serviceability		2.695	7.263	0.919
Your car is easily inspected by yourself.	0.704			
Your car requires less self-inspection.	0.654			
Your car's interior space is easy to clean.	0.649			
Your car's spare parts are easily obtained.	0.647			
Your car is easy to clean.	0.639			
Your car can go through maintenance service at any service center.	0.609			
Your car can be promptly serviced or repaired at a service center.	0.592			
Factor 5. Customer loyalty		2.197	7.237	0.972
You will encourage persons that seek your advice to use this car.	0.832			
You will say positive things about this car to persons that seek your advice.	0.826			
You will say positive things about the car to family or friends.	0.814			
You will express a good feeling about the car to family or friends.	0.797			
Factor 6. Features		2.105	7.220	0.920
Your car's interior space is spacious.	0.860			
Your car's interior space can be used effectively and efficiently.	0.859			
Your car's interior space is comfortable.	0.825			
Your car's air-conditioning system is good.	0.594			
You could select options of features that satisfy your needs during purchase.	0.547			
Factor 7. Aesthetics		1.659	7.076	0.929
Your car has an attractive exterior design.	0.767			
Your car has an attractive "color-design".	0.757			
Your car has an attractive design.	0.746			
Your car has an attractive interior design.	0.663			
You feel good in terms of sound produced by your car.	0.605			
You feel good when touching many interior parts.	0.528			

Table 4.3 (*continued*): Results of exploratory factor analysis

(c) Factors 8-9 and notes

	Factor loading	Eigen value	Variance explained	Reliability coefficient (alpha)
Factor 8. Customer satisfaction		1.501	6.327	0.928
You are satisfied with the car's operation.	0.710			
The car's characteristics fulfilled your ideal.	0.651			
You are satisfied with the experiences of using the car.	0.647			
You are satisfied with your decision of purchasing the car.	0.646			
You want to buy the same type of car (same car model) the next time.	0.567			
Factor 9. Perceived quality		1.260	5.453	0.934
Your car received good impression based on the impressive advertisement.	0.742			
Your car's brand is well-known worldwide for having a good quality.	0.719			
Your car received good reputation in corporate social responsibility (CSR).	0.719			
Your car received good reputation in general.	0.686			

Notes: KMO = 0.943 (x^2 = 21,341.116, $p < .05$); total variance explained = 75.89 percent; n = 300

Table 4.4: Factor correlation matrix

	Variables	R	P	OC	S	CL	F	A	CS	PQ
1	Reliability (R)	1								
2	Performance (P)	0.439	1							
3	Ownership cost (OC)	0.466	0.356	1						
4	Serviceability (S)	0.707	0.421	0.644	1					
5	Customer loyalty (CL)	0.441	0.469	0.518	0.502	1				
6	Features (F)	0.518	0.644	0.353	0.484	0.482	1			
7	Aesthetic (A)	0.574	0.618	0.457	0.593	0.605	0.669	1		
8	Customer satisfaction (CS)	0.652	0.569	0.446	0.546	0.646	0.615	0.724	1	
9	Perceived quality (PQ)	0.596	0.496	0.568	0.608	0.603	0.541	0.617	0.644	1

Note: All correlations are significant at 0.01 level (2-tailed).

4.5.11 Confirmatory factor analysis

The result for the model fit indices presented the x^2 (df=262) = 4,068.30 with p-value = 0.000; relative chi-square of 4.476, CFI = 0.906, IFI = 0.906, and RMSEA = 0.072. These indices concluded that the measurement model was relatively fit and established unidimensionality. Figure 4.2 shows the measurement model for this survey.

Throughout exploratory factor analysis followed by the measurement model in confirmatory factor analysis, this study identified several measurement scale items which did not directly measure the factors and hence were excluded for further analysis. The respective scale items are also listed in Appendix XI. Thus, the remaining 45 scale items in the fit measurement model strongly represented the characteristics of each factor as follows: performance (6 items), features (5 items), reliability (6 items), serviceability (5 items), aesthetic (6 items) and perceived quality (4 items), ownership cost (4 items), customer satisfaction (5 items) and customer loyalty (4 items). All the remaining 45 scale items can also be identified in Figure 4.3 and Appendix XI.

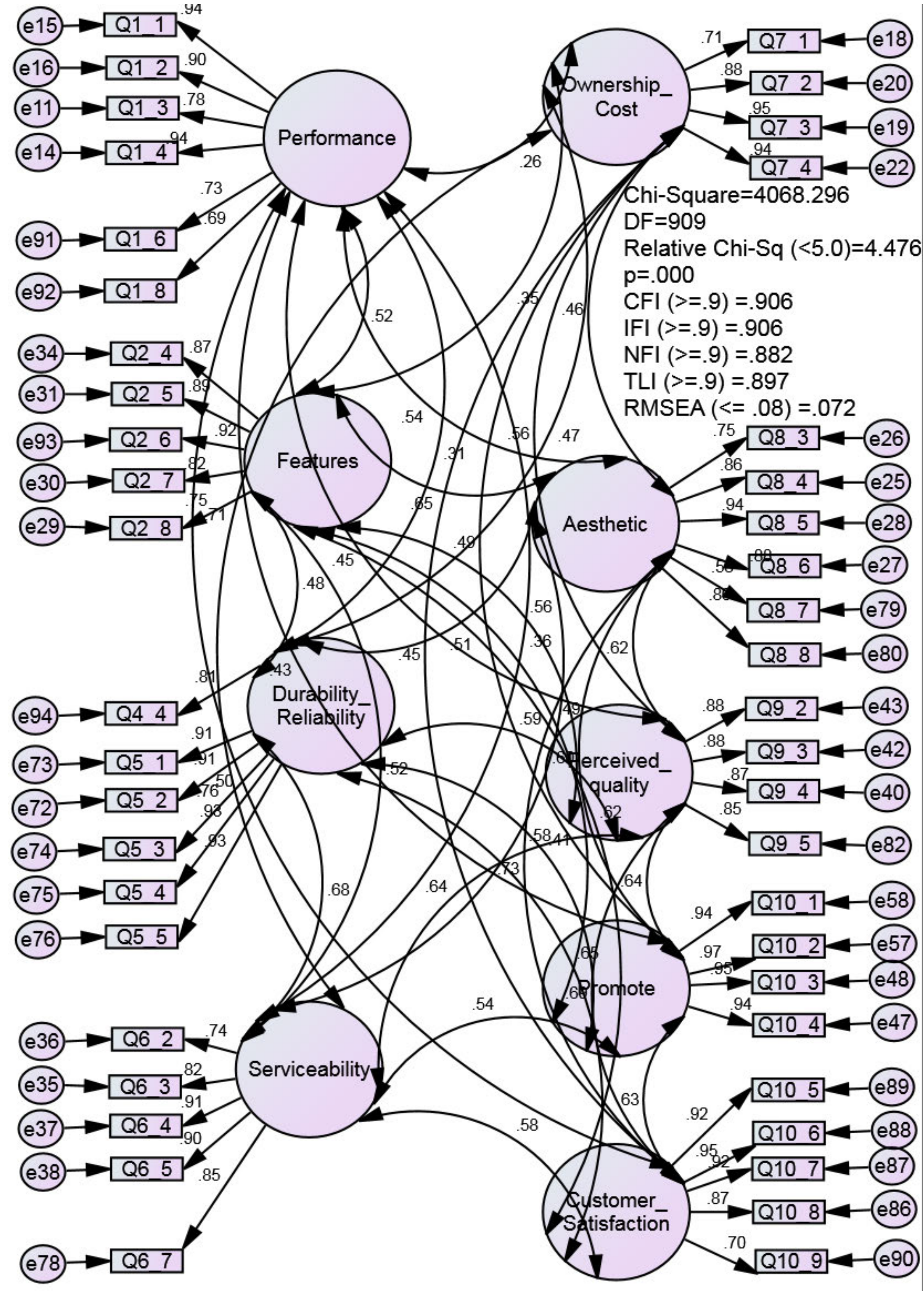

Figure 4.2: Measurement model of Garvin quality dimensions, ownership cost, customer satisfaction and customer loyalty

4.5.12 Test for construct validity

4.5.12.1 Test for convergent validity

In this study, the AVE ranged from 0.673 to 0.898 and construct reliability ranged from 0.924 to 0.972. Hence, convergent validity was established. Table 4.5 displays the average variance extracted (AVE) and composite reliability.

Table 4.5: Average variance extracted (AVE) and composite reliability

Factor	AVE	Composite reliability
Performance	0.699	0.932
Features	0.726	0.930
Perceived quality	0.757	0.926
Aesthetics	0.673	0.924
Reliability	0.735	0.951
Serviceability	0.712	0.925
Ownership cost	0.763	0.927
Customer satisfaction	0.768	0.942
Customer loyalty	0.898	0.972

4.5.12.2 Test for discriminant validity

In this study, each diagonal value exceeded the respective inter-construct correlation; the discriminant validity was supported. Table 4.6 displays the average variance extracted (on the diagonal) and squared correlation coefficients (on the off-diagonal) for study instrument.

Table 4.6: Average variance extracted (on the diagonal) and squared correlation coefficients (on the off-diagonal) for study instrument

Variables	P	F	PQ	A	R	S	OC	CS	CL
Performance (P)	**0.836**								
Features (F)	0.521	**0.852**							
Perceived quality (PQ)	0.449	0.560	**0.870**						
Aesthetics (A)	0.544	0.651	0.624	**0.821**					
Reliability (R)	0.341	0.489	0.597	0.513	**0.858**				
Serviceability (S)	0.359	0.517	0.641	0.579	0.684	**0.844**			
Ownership cost (OC)	0.263	0.347	0.565	0.459	0.477	0.711	**0.874**		
Customer satisfaction (CS)	0.497	0.616	0.686	0.735	0.658	0.582	0.454	**0.876**	
Customer loyalty (CL)	0.428	0.487	0.642	0.597	0.416	0.539	0.494	0.628	**0.948**

4.5.13 Tests for common method bias

Since the extracted factors accounted to 75.89% of the total variance, where the first factor was 15.37% of the variance, it is determined that a single factor did not exist to represent most of the variance. Thus, there is no significant problem for common method bias in this research.

4.6 Analysis and findings

Structural equation modelling (SEM) was applied to evaluate the proposed conceptual model. In order to run a comprehensive analysis, a large sample size was most recommended and with 668 numbers of reliable data, this study exceeded 200 as the minimum sample size (e.g. Hussey and Eagan, 2007). Similar to the measurement model, goodness-of-fit indices were also evaluated to prove the fitness of the structural model. The results for all fit indices are as follows: ratio of chi-square to degrees of freedom (x^2/df) = 4.543, CFI = 0.903, IFI = 0.903, and RMSEA = 0.073. Since the fit indices values were within the cut-off point (Hu and Bentler, 1999), the structural model was statistically significant at a p-value of 0.01. Several hypotheses were tested, which represented a direct relationship between Garvin's quality dimensions, ownership cost, customer satisfaction, and customer loyalty using SPSS version 23 and AMOS software version 23. Subsequently, the mediation test was performed to evaluate the role of ownership cost as the mediator between two constructs.

In this study, Hypothesis 1a indicated that serviceability highly influences ownership cost (standardized coefficient = 0.73, p-value < 0.01). This hypothesis is supported by previous studies (e.g. Sundin et al., 2009), which investigated that serviceability elements such as total labor cost, spare part availability, and Do-It-Yourself (DIY) item contributed to low cost of ownership during maintenance. However, Hypothesis 1b reported that there was no significant relationship between serviceability and customer satisfaction (standardized coefficient = –0.07, p-value > 0.05). This result is contrary with Cavalieri, Gajardelli and Ierace (2007) who explored that after-sales service is important for manufacturers in delivering quality service to customers and subsequently establish customer satisfaction (Kurata and Nam, 2010). According to Hypothesis 1c, this study detected that serviceability influenced customer loyalty. Hence, Hypothesis 1c was supported (standardized coefficient = 0.14, p-value was in between 0.05 and 0.01).

Reliability was hypothesized and no significant relationship was found between reliability and ownership cost (standardized coefficient = –0.03, p-value > 0.05). However, reliability was detected to strongly influence customer satisfaction (standardized coefficient = 0.30, p-value < 0.01). Hence, Hypothesis 2a and Hypothesis 2b were not supported and supported, respectively. The result of Hypothesis 2a is inconsistent with JD Power and Associates (2007), who reported that automobile manufacturers that focused on product reliability had a direct impact to ownership cost. With regard to Hypothesis 2b, Ugboro and Obeng (2000) had considered reliability during measuring customer satisfaction at manufacturing and service industries. Both industries presented that reliability was important upon customer satisfaction.

Hypothesis 3 represented a relationship between performance and customer satisfaction. Since the standardized coefficient was 0.07 at p-value between 0.05 and 0.01, direct relationship existed and thus, Hypothesis 3 was supported (Sebastianelli and Tamimi, 2002). Similar to Hypothesis 3, Hypothesis 4 (features have a positive effect upon customer satisfaction) was also supported (Churchill and Surprenant, 1982) since the path coefficient 0.09 was significant (p-value was between 0.05 and 0.01). Hypothesis 5 presented a positive impact of aesthetics upon customer satisfaction at 0.01 level (standardized coefficient = 0.38) (Kianpour et al, 2014). Perceived quality had a positive effect upon customer satisfaction (standardized coefficient was 0.23 and p-value was less than 0.01), which presented a strong support to Hypothesis 6 (Sebastianelli and Tamimi, 2002).

The structural model also tested Hypothesis 7a, which examined the impact of ownership cost upon customer satisfaction. The hypothesis was not supported (standardized coefficient = 0.01, p-value > 0.05), representing that customers were not really satisfied with any payments in after-sales service. However, there was a significant relationship between ownership cost and customer loyalty that supported Hypothesis 7b (standardized coefficient = 0.18, p-value < 0.01) (Al-Alawi and Bradley, 2013). Similar to previous studies (e.g. Cronin and Taylor, 1992), customer satisfaction is very significant to customer loyalty (standardized coefficient = 0.48, p-value < 0.01). Thus, hypothesis 8 was also supported.

In terms of mediation test, serviceability and customer loyalty were significantly partially mediated by ownership cost (standardized coefficient = 0.10, p-value was in between 0.05 and 0.01). The relationships between serviceability and customer satisfaction as well as reliability and customer satisfaction were not mediated by ownership cost since p-value for both relationships was not less than 0.05. Figure 4.3 displays the produced structural model. In summary, the hypotheses, the path, the standardized coefficient, and the hypotheses (direct effect and mediation) results are listed in Table 4.7 and Table 4.8.

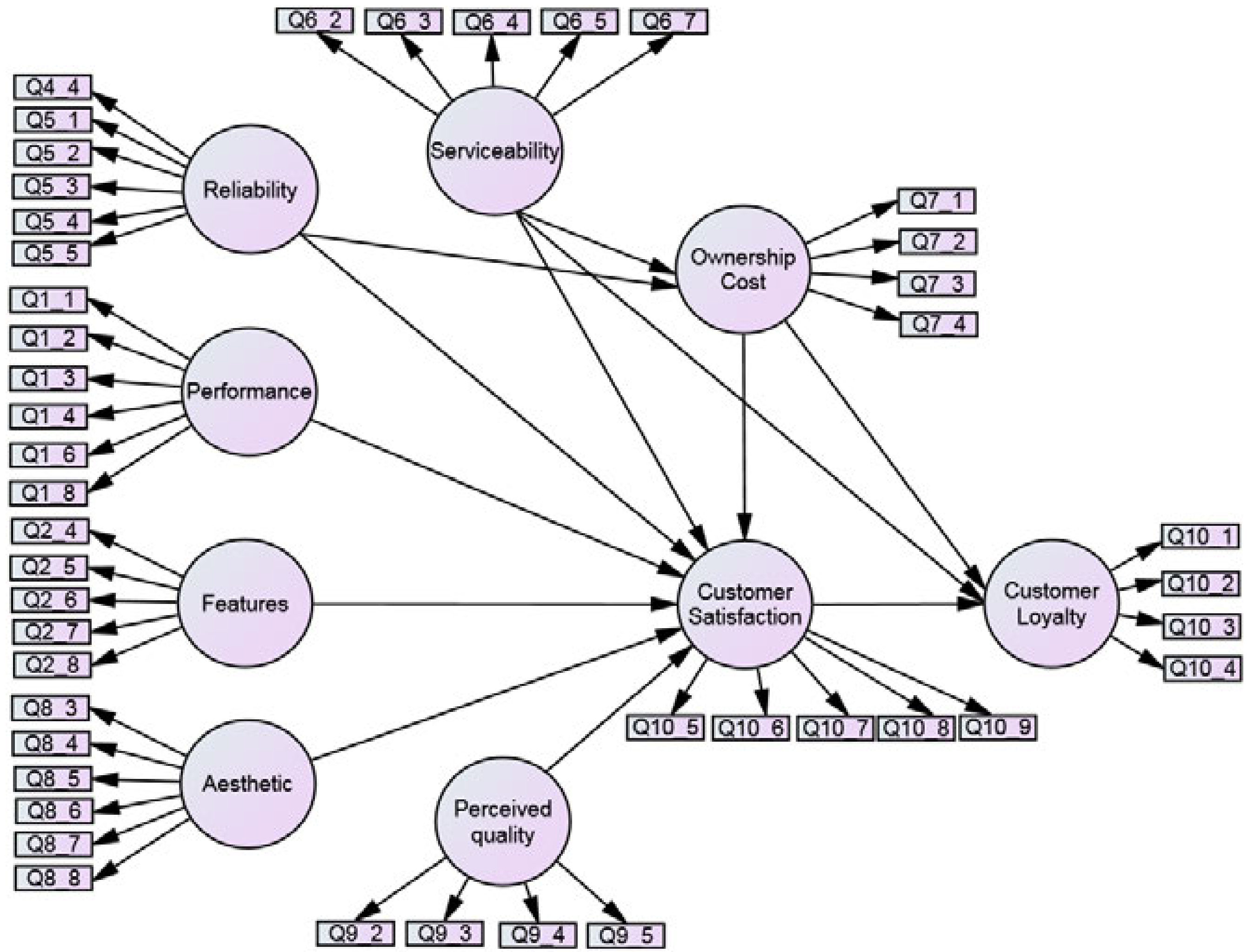

Figure 4.3: Structural model of Garvin quality dimensions, ownership cost, customer satisfaction and customer loyalty

Table 4.7: Summary of hypotheses test results for structural model.

Hypotheses	Path	Standardized Coefficient	Hypotheses supported?
H1a	Serviceability (S)-> Ownership cost (OC)	0.73***	Yes
H1b	Serviceability (S)-> Customer satisfaction (CS)	-0.07	No
H1c	Serviceability (S)-> Customer loyalty (CL)	0.14**	Yes
H2a	Reliability (R) -> Ownership cost (OC)	-0.03	No
H2b	Reliability (R) -> Customer satisfaction (CS)	0.30***	Yes
H3	Performance (P) -> Customer satisfaction (CS)	0.07**	Yes
H4	Features (F) -> Customer satisfaction (CS)	0.09**	Yes
H5	Aesthetics (A) -> Customer satisfaction (CS)	0.38***	Yes
H6	Perceived quality (PQ) -> Customer satisfaction (CS)	0.23***	Yes
H7a	Ownership cost (OC) -> Customer satisfaction (CS)	0.01	No
H7b	Ownership cost (OC) -> Customer loyalty (CL)	0.18***	Yes
H8	Customer satisfaction (CS) -> Customer loyalty (CL)	0.48***	Yes

Path significant at: $^{**}p < 0.05$; $^{***}p < 0.01$,

Table 4.8: Summary of mediation test results for structural model.

Path	Description	Standardized Coefficient	Significant
S->OC->CS	OC mediates the relationship between S and CS	0.01	No
S->OC->CL	OC mediates the relationship between S and CL	0.10**	Yes
R->OC->CS	OC mediates the relationship between R and CS	0.00	No

Path significant at: $^{**}p < 0.05$; $^{***}p < 0.01$,

4.7 Discussion

This research discovered the significance of practicing Garvin's quality dimensions toward ownership cost, customer satisfaction, and customer loyalty. Even though numerous researches have been conducted by experts (e.g. Hansen and Bush, 1999; Hazen et al., 2016; Brucks et al, 2000) with regards to Garvin's contribution, this research presented additional new findings associated with automobile in after-sales service. Besides, the 65 questions used in the survey instrument were proven understandable due to the high response rate from users of the automobile within a short period and no ambiguous questions were highlighted by respondents.

Based on the hypothesis results, the most important quality dimension is serviceability, which displayed strong effect upon ownership cost (standardized coefficient = 0.73, p-value < 0.01). This dimension is considered as a new contribution to this research because customers realized that by utilizing a high serviceability-oriented vehicle, service-related tasks could be performed promptly and efficiently by service personnel at service centers. Subsequently, they could gain reasonable service, repair, and maintenance costs in after-sales service. Moreover, for minor DIY items (such as air filter inspection and interior surface cleaning), customers are also eligible to act promptly without sending vehicles to the service center. This advantage conveyed positive perception from customers since no labor cost will be consumed. Furthermore, easy obtain of spare parts during maintenance, service and repair contributes to additional cost saving because customers have options to compare spare part prices at different automobile part premises. Besides, ownership cost was closely related to fuel consumption. For example, fuel consumption may vary depending on type of cars, which may require frequent maintenance and service in order to ensure all systems are operating efficiently. Subsequently, customers could avoid extra fuel consumption due to inefficient car. Thus, reasonable fuel consumption was required by customers since the cost was financially impacted to their expenses during operating the existing cars.

Furthermore, the relationship between serviceability and customer loyalty was supported by the mediation test conducted, whereby partial mediation was identified from serviceability to customer loyalty since the ownership cost reacted as a mediator. Since serviceability has a direct relationship with customer loyalty and is partially mediated by ownership cost, a strong relation was noticed between ownership cost and customer loyalty. When the customers consume reasonable costs in the after-sales service, they tend to express their happiness through willingness to convey positive messages to surrounding people, especially family and friends or encourage them to purchase the same product.

Besides serviceability, this research also explored that aesthetics were an essential quality dimension, which strongly affected customer satisfaction (standardized coefficient = 0.38, p-value < 0.01). This result shows that customers were interested in experiencing value-added factors in their vehicles such as sound system, and attractive colors and design. Since entertainment increases people's happiness, the best sound system in the vehicle may further increase people's satisfaction. Due to high competition among manufacturers, aesthetics become an essential factor for every new model launched toward introducing attractive designs and colors. Another important quality dimension, which strongly affects customer satisfaction is reliability (standardized coefficient = 0.30, p-value < 0.01).

Customers realized that by utilizing a high-reliability vehicle, it can continuously function as desired for a longer period. However, reliability was found not supported in avoiding high ownership cost. This finding was unexpected because when the number of part failures is minimum, fewer repairs and part replacements due to the malfunction are required. It means that higher reliability of product supports the customers' cost saving.

In terms of performance, this research identified that customers in Japan empirically satisfied vehicles with good performance, which was a crucial factor to smoothen the transportation mode. From the customers' perspective, good vehicle performance was represented by five physical characteristics; easy to overtake other vehicles, good acceleration, easy to climb a hill, less vibration at top speed and good handling. Those characteristics were aligned with Japan since, geographically, Japan has many hills and various types of routes, thus vehicles have to be embedded with high technology systems for high stability and smooth handling during climbing and maneuvering, especially on urban areas, which require low vehicle speeds (Tsugawa, 2001). However, even though performance was related to fuel efficiency, this research revealed that vehicle with less fuel consumption was not directly measured the vehicle performance. Hence, as described in this section, fuel consumption was measuring ownership cost, instead of performance.

Meanwhile, in view of features, the similarity perception with performance exists from Japanese drivers' point of view. Based on the result of the hypothesis, features equipped on vehicles such as good air-conditioning system and interior space significantly delighted customers. Customers realized that all the features designed by manufacturers met their expectation in experiencing convenient and comfortable driving. Perceived quality in this research identified that customers felt highly confident and were willing to purchase vehicles as frequently as it gets advertised in the media. The good reputation of manufacturers through efficient after-sales service and active participation in social events was associated with positive customer impression.

In terms of managerial implications, several approaches are appropriate for the management of automobile manufacturers to ensure that the marketed products are aligned with the market trend. This effort was empirically proven in this study whereby from the customers' perspective, the embedded serviceability aspects on the automobiles formed a very significant and positive relationship upon ownership cost. Hence, a continuous attention is required by service managers to ensure a safe and efficient maintenance of the service and repair processes at service centers. With respect to practical implication, marketing managers shall play important roles in strategizing new methods of business for example, by offering several service packages or service menu instead of stand-alone service, repair, and maintenance, as part of the organization's initiatives to avoid high ownership costs for customers. Subsequently, this study also empirically revealed that customers believe that easy service and low cost of ownership may attract them to stay continuously loyal to the product or organization. This finding was represented by the framework that a positive relationship existed between ownership cost and customer loyalty. Therefore, management is encouraged to continuously support the organization in producing service-friendly products such as easily cleaned and inspected as well as high availability of different levels of spare parts in order to satisfy existing customers by offering an economical service cost during the product life cycle.

Moreover, this study reveals wider opportunities for service centers to strategies any service promotions such as offering steeper discounts on spare parts or free product inspection. Unequivocally, promotions would impact to the extent that customers are more delighted in utilizing the products or even persuaded to purchase genuine spare parts. Subsequently, this impact increases the product demand by attracting a higher number of customers to consistently follow up on routine maintenance, which directly contributes to high profit margin and market share. This study also notified organizations to continue embedding five product quality dimensions; performance, features, aesthetic, perceived quality and reliability in automobiles towards producing a customer-oriented product. The study outcomes revealed that customers felt delighted on the five dimensions to be considered in automobiles. Moreover, product robustness required further enhancement. Hence, managements have to produce robust quality vehicles with high reliability, since it was underscored that customers felt satisfied on reliable vehicles (e.g. fewer failures along its life cycle) and may anticipate influences less service, repair and maintenance in the future.

4.8 Conclusion

This research investigated the influence of ownership cost on automobiles customers' perspective through maintenance, service and repair. This research also found benefit in utilizing Garvin's quality dimensions for understanding customer perspectives of product quality for Japanese automobiles and examined the impact of ownership cost in after-sales service. Since customers provided opinions and comments differently (Brucks et al., 2000), the research displayed additional outcomes in manufacturing context as an extension of previous studies. The employed EFA and CFA were used comprehensively. Based on the EFA results, six out of eight Garvin's quality dimensions (i.e. performance, features, aesthetics, perceived quality, reliability, and serviceability) were extracted whereas the other two dimensions (conformance and durability) did not stand as strong individual factors, but instead were shared in a reliability factor. This finding is aligned with Garvin (1987), who mentioned that durability and reliability were inter-related, and with other studies where they loaded onto one factor (Hazen et al., 2016; Sebastianelli and Tamimi, 2002).

Through CFA, this research reported the hypothesized structural model results. Using a large sample size from actual automobile users throughout all regions in Japan, the tested structural model was deemed fit. The model interpreted the linkage between the six extracted quality dimensions, ownership cost, customer satisfaction, and customer loyalty. Twelve hypotheses were tested and nine hypotheses displayed significant relationship between two constructs. Most importantly, six out of the nine hypotheses had a strong positive relationship (p-value < 0.01) and the remaining three hypotheses significantly yielded at p-value between 0.05 and 0.01.

Hence, customer requirement remains one of the important criteria for a manufacturer in displaying the latest characteristics with reasonable costs. Products with visible characteristics are more attractive in prompt decision making and influencing customers for immediate purchase. That is the reason customers realized that the importance of serviceability can significantly avoid high ownership cost. Other than that, the serviceability-embedded design represents a product with easy service, repair and maintenance at service centers and then contributes to lower labor costs. Due to these reasons, they are willing to recommend to people about the advantages of purchasing the same product.

Regarding ownership cost, this research explored ownership cost as a new dimension. For instance, ownership cost plays an important factor toward influencing customer loyalty. Due to this reason, ownership cost is clearly recognized as one of the effective factors in customer's purchasing decision and might be a powerful instrument in marketing strategy. Proactive manufacturers may entertain their customers promptly, politely, and consistently to establish a strong relationship with them. Hence, overall customer satisfaction should be monitored by manufacturers to increase the number of loyal customers and attract new customers. Since this research investigated the influence of ownership cost on automobiles customers' perspective through maintenance, service and repair, Appendix XII and Appendix XIII display the summary between this research as well as the existing research literature, and the comparison table respectively.

This research also has its limitations. Due to time and financial constraints, this study only analyzed the customers' perspective on automobile in a single country. Since 90% of the respondents owned gasoline engine vehicles, the results were mainly representing how the customers judged the importance of ownership cost and other products' quality dimensions upon the gasoline engine vehicle. Hence, further studies specifically on customers of EV, HV and PHEV are anticipated to reveal new research findings which may significantly support the reduction of ownership cost and high protection of environment. Since foreign vehicles also exist in Japan, a new empirical study on foreign vehicles associated with serviceability characteristics may important in order to determine the buying factors (i.e. reason of purchasing foreign vehicles). Besides that, future studies on other products that require periodical maintenance (e.g. air-conditioner and photocopy machine) might be appropriate in order to explore new outcomes and subsequently extend the literature of ownership cost in after-sales services.

CHAPTER 5

Conclusion

In conclusion, this research empirically examined the impact of design for serviceability practices upon producing product service support artifacts (PSSA) and service operations performance as well as the roles of after-sales service cost and ownership cost in mediating serviceability dimension upon customer satisfaction/loyalty. Furthermore, three conceptual frameworks were developed representing the relationships among organizational practices, product service support artifacts, and service operations performance, the relationships among serviceability-oriented dimensions, after-sales service cost, and customer satisfaction/loyalty, as well as the relationships among quality dimensions, ownership cost, customer satisfaction, and customer loyalty.

Since all three inter-related researches revealed significant outcomes to service operations performance and customers, there were several key messages from customers that may be essential for manufacturing companies towards producing better quality products and services in the context of serviceability. The following key messages in Table 4.9 are strongly supported by the hypotheses results**.**

Table 4.9: Customers key messages to manufacturing companies

Research	Key messages to manufacturing companies	Hypothesis results
1 (in Chapter 2)	By considering customers' feedback in design stage and during service operations at service centers, service operations performance can be enhanced.	H4b: CF -> OP (β=0.64***)

	It was supported by suppliers since their involvement was mediated by the produced product service support artifacts so that the service operations performance can be further enhanced.	H5a: SU -> PSSA (β=0.35***)
2 (in Chapter 3)	By establishing a fully-equipped service centers and providing user-friendly product service support artifacts (i.e. user manual and routine maintenance book) to customers, the after-sales service cost can be reduced and subsequently may increase customer satisfaction/loyalty.	H1: Tangible -> After-sales service cost (β=0.61*** & β=0.59***) H6: After-sales service cost -> Customer satisfaction/ loyalty (β=0.35*** & β=0.45***)
3 (in Chapter 4)	By addressing serviceability characteristics in the design stage, company can avoid high ownership cost on the manufactured products so that customers will continuously utilize the product until its end of life.	H1: Serviceability -> Ownership cost (β=0.73***) H7b: Ownership cost -> Customer loyalty (β=0.18***)

Customer perspective is definitely important when providing immediate and efficient service or repairs during routine maintenance on purchased products and malfunctioned products, accordingly. Based on the survey results from all three studies, 33 out of the 37 direct relationships between constructs were supported. This highlighted that serviceability is relatively fully considered by manufacturing companies towards gaining continuous user-friendly service and performance of service operations at service centers as well as exemplifying that customers are critically concerned with efficient service, repairs and maintenance in after-sales service.

The other main outcome is that competitive after-sales service costs such as costs of routine maintenance, repairs, and spare parts contribute to customer satisfaction and loyalty, which indirectly generate long-term business for organizations. By experiencing user-friendly service and repairs, it is believed that a serviceability-oriented product could continue to offer economical after-sales service costs in the after-sales service industry. Besides serviceability, other product quality dimensions are found to be significantly important with customer satisfaction. This research observed that customers in Japan recognized products i.e. automobiles and air-conditioners, as high-quality products. The products were designed according to the latest standard or specifications, and manufactured at well-structured production plants towards producing reliable and robust products for the market.

Hence, manufacturers pursuing strategies based on after-sales service, servitization or product-service systems are well-advised to adopt the framework of serviceability practices developed in this study, as product serviceability is a foundational condition for success with such strategies. This research demonstrates the strategic value of designing products for serviceability and guiding top management in adopting the necessary management and design practices to support product service operational performance goals. This is crucial for firms pursuing strategies of after-sales service quality, servitization, or product-service systems for environmental sustainability. Thus, the three derived serviceability frameworks would provide a holistic view of the organizational and technical practices that support the successful design of a product for serviceability during NPD at manufacturing companies as well as deliver important messages to the top management about customer requirements upon serviceability-oriented products. Thus, the outcomes of this research represent the scenarios in Japan and are appropriate to be generalized to other potentially similar research fields.

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Appendices

Appendix I. Measurement scale items and supporting literatures for research 1 survey

Factors and scale items	
TM. Top Management Commitment	Supporting literatures
TM1.Top management discusses serviceability-related issues in management meetings. TM2.Top management rewards employees for their contributions to serviceability. TM3.Top management supports improvement of serviceability from initial product development stage onward. TM4.Top management allocates the necessary resources to carry out serviceability activities effectively. TM5.Top management pays attention to employee input regarding serviceability issues.	Saraph et al. (1989), Flynn et al. (1994), Chow and Lui (2001), Talib et al. (2013) and Lee et al. (2011)
TC. Teamwork and Communication	
TC1. Our company has cross-functional team activities for sharing knowledge about serviceability issues. TC2. Our company has good communication among employees regarding serviceability issues. TC3.Our company works together as a team on serviceability issues. TC4.Our company generates good ideas for problem-solving related to serviceability.	Badri et al. (1995), Arauz and Suzuki (2004), Prajogo and Sohal (2006), Talib et al. (2013), Samson and Terziovski (1999) and Wahid et al. (2011)
IA. Design Information and Analysis	
IAI.Our company uses computer-based virtual analysis of the product installed with other surrounding parts in order to evaluate the product design for improved serviceability. IA2.Our company uses the findings from computer-based virtual analysis of the product installed with other surrounding parts in making decisions related to serviceability. IA3.Our company creates service procedures (including diagrams and tools used) from computer-based virtual analysis of the product installed with other surrounding parts. IA4.Our company shares important serviceability-related findings with the research or design department regarding computer-based virtual analysis of the product installed with other surrounding parts.	

IA5.Our company shares important serviceability-related findings with management regarding computer-based virtual analysis of the product installed with other surrounding parts.	
IA6.Our company uses actual assessment of the prototype product installed with other surrounding parts in order to evaluate access to the product for serviceability.	
IA7.Our company uses actual assessment of the prototype product installed with other surrounding parts in order to finalize clear service procedures.	
IA8.Our company uses actual assessment of the prototype product installed with other surrounding parts in order to finalize the design regarding serviceability before the product is produced and marketed.	
IA9.Our company shares important serviceability-related findings with the research or design department regarding actual assessment of the prototype product installed with other surrounding parts.	
IA10.Our company shares important serviceability-related findings with management regarding actual assessment of the prototype product installed with other surrounding parts.	
CF. Customer Focus	
CF1.Service personnel are involved in cross-functional team activities relating to product serviceability.	Flynn et al. (1994), Wahid et al. (2011), Wickramasinghe and Gamage (2011), Talib et al. (2013), Lee et al. (2011), Prajogo and Sohal (2006) and Samson and Terziovski (1999).
CF2.Service personnel give input when decisions are made relating to product serviceability.	
CF3.Service personnel share their experience and skill in order to achieve good product serviceability.	
CF4.Suggestions from service personnel are evaluated in order to achieve good product serviceability.	
CF5.Our company identifies customer needs and expectations relating to serviceability.	
CF6.Our company develops service procedures based on customer needs and expectations.	
CF7.Our company conducts customer satisfaction surveys or market research relating to serviceability.	
CF8.Our company gives full attention to customer interests relating to serviceability.	
SU. Supplier Involvement	
SU1.Our company builds good relationships with suppliers regarding serviceability from the design stage through after-sales service.	Saraph et al. (1989), Flynn et al. (1994), Badri et al. (1995), Chow and Lui
SU2.Our company provides serviceability-related technical assistance to suppliers.	

SU3.Our company educates suppliers to achieve better performance relating to serviceability. SU4.Our company is willing to discuss suppliers' problems relating to serviceability.	(2001), Prajogo and Sohal (2006), Wahid et al. (2011), Talib et al. (2013) and Prakash (2011).
PSSA. Product Service Support	
PSSA1.Our company is able to produce easy-to-understand procedures for product service. PSSA2.Our company is able to produce safe work procedures for product service. PSSA3.Our company is able to produce accurate procedures for product service. PSSA4.Service personnel are able to utilize existing tools and equipment for product service. PSSA5.Service personnel are able to utilize existing facilities for product service. PSSA6.Service personnel are able to avoid purchase of unnecessary tools and equipment for product service.	
OP. Service Operations Performance	
OP1.Service personnel are able to easily access the product for service. OP2.Service personnel are able to service the product right the first time. OP3.Service personnel are able to perform needed services at the appropriate time. OP4.Service personnel are able to perform easy disassembly of the product. OP5.Service personnel find that the cost to service, repair, or maintain the product is more competitive than others. OP6.Service personnel find that the cost to service, repair, or maintain the product is acceptable to the customer. OP7.Service personnel find that the product has many individual parts or spare parts available to support quick service, repair or maintenance.	Oh and Rhee (2008), Doll et al., (2010), Laroche et al. (2010), Parasuraman et al. (1985), Abu-El Samen et al. (2013), Synnes and Welo (2015), Salaheldin (2005) and Ganguli and Roy (2010).

Appendix II. The summary between research 1 and the existing research literature

Authors	Type of study	Industry (s)	Design for X (category)	Research findings
Livingston (1988)	Case study	Electronic	Design for supportability	• Organization performed a detail study in design stage solely associated with total product lifetime costs. • Design goals were set including ease-of-use, ease-of-cleaning, less-frequent or easier maintenance procedures which can be conducted by customer, clear diagnostics and ease-of-repair.
Hull and Cox (1994)	Case study	Electronic and computer	Design for serviceability	• Design for serviceability remains as essential requirement in product design. • Product design decisions were made by multi-functional teams; reliability and serviceability are designed into the products. • No information on how support is evaluated during new product development (NPD).
Knezevic (1999)	Case study	Aerospace	Design for maintainability	• Acknowledged the importance of after-sales requirement in business process. • Maintainability is one of the main factors in achieving a high level of operational availability.
Goffin (1998)	Case study and survey	Medical and electronic	Design for supportability	• Covered all product (after sales) supporting activities, covering both maintenance and repair. • Do not evaluate support requirements until half way of new product development cycle.
Goffin and New (2001)	Case study	Telecommunications, automobiles, vending machines, aerospace and domestic appliances	Design for after-sales	• Design stage must consider all elements of after-sales.
Markeset and Kumar (2002)	Case study	Automated production system	Design for maintainability	• Lack of cross-functional communication associated with maintainability and supportability. New product development process was also not thoroughly investigated. • Maintenance and product support concepts need to be designed and developed right from the design phase.

Appendix II (*continued)*. The summary between research 1 and the existing research literature

Authors	Type of study	Industry (s)	Design for X (category)	Research findings
Ionzon and Holmqvist (2005)	Case study	Production and construction equipment, lifting and transport equipment, automobile and railway	Design for serviceability	• Only two firms fully considered service requirements in design stage. • Not discover how all the firms practicing NPD and design for serviceability.
Tan, Matzen, McAloone and Evans (2010)	Case study	Electrical, furniture	Design for serviceability/ maintainability /supportability / service	• Developed and provided integrated design solutions and services to deliver added value and achieve a closer relationship to their customers.
Szwejczewski, Goffin & Anagnostopoulos (2015)	Case study	Aerospace, automobile, industrial machine, electrical, home appliance	Design for after-sales	• After-sales is an important element of the business, service requirements are systematically evaluated during NPD through the involvement of after-sales personnel and the use of field service data to set design goals.
Erialdi Syahrial, Hideo Suzuki and Shane J. Schvaneveldt (2017)	Survey	General machinery, electrical machinery and equipment, transportation equipment, precision instrument and medical instrument	Design for serviceability	• Design information and analysis which correspond to design for serviceability as well as two anticipated after-sales service benefits (product service support artifacts and service operations performance) drawn a new business model toward extending serviceability literature in the manufacturing context.

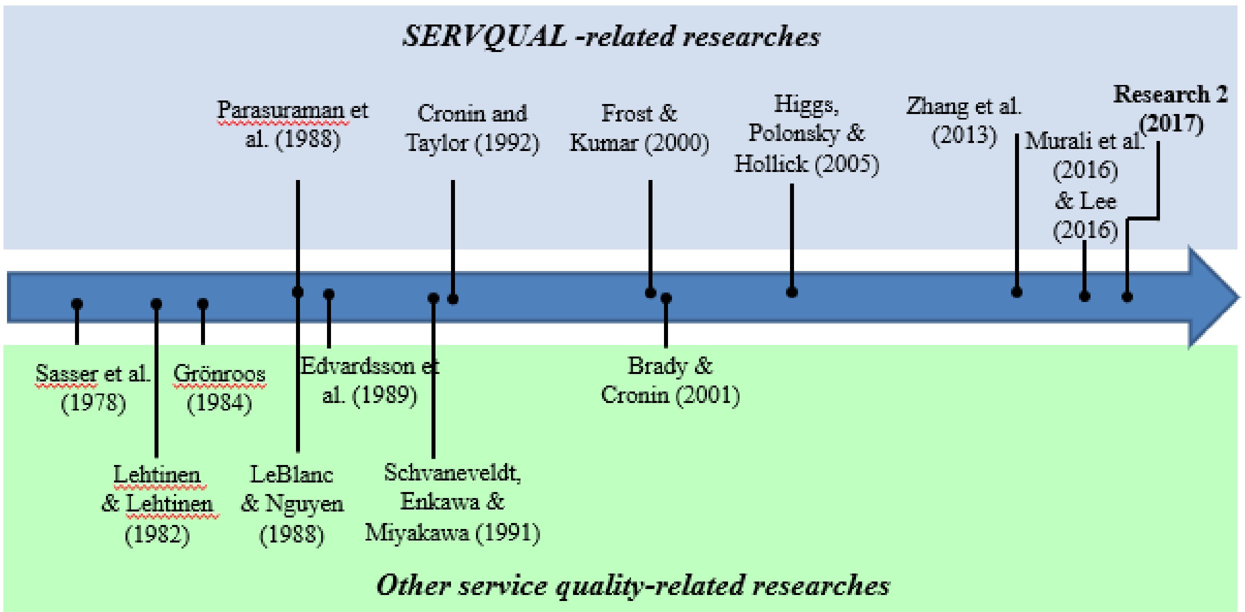
Appendix III. Comparison table between research 1 and the existing research literature

	Research type		Investigation about serviceability	
	Case study	Survey	Management and teamwork awareness	Specifically on IA (virtual analysis and actual prototype practices)
Livingston (1988)	○		○	
Hull and Cox (1994)	○		○	
Knezevic (1999)	○		○	
Goffin (1998)	○		○	
Goffin and New (2001)	○		○	
Markeset and Kumar (2002)	○		○	
Ionzon and Holmqvist (2005)	○		○	
Tan et al. (2010)	○		○	
Szwejczewski, Goffin and Anagnostopoulos (2015)	○		○	
Erialdi Syahrial, Hideo Suzuki and Shane J. Schvaneveldt (2017)		○	○	○

Appendix IV. Summary of service quality-related researches

Scholars	Research field	Service quality (SQ) dimensions
Sasser et al. (1978)	Service operations	material, facilities, and personnel
Lehtinen and Lehtinen (1982)	Labor intensive services	physical quality, interactive quality, and corporate quality
Grönroos (1984)	Marketing	technical quality, functional quality, and corporate image
LeBlanc and Nguyen (1988)	Banking	corporate image, internal organization, physical support of the service producing system, staff-customer interaction, and degree of customer satisfaction
Parasuraman et al. (1988)	Service organizations	SERVQUAL (tangibles, reliability, responsiveness, assurance and empathy)
Edvardsson et al. (1989)	Internal cost in service	technical quality, integrative quality, functional quality and outcome quality
Schvaneveldt, Enkawa and Miyakawa (1991)	Service organizations	performance, assurance, completeness, ease of use, and emotion/environment
Cronin and Taylor (1992)	Service organizations	SERVPERF (SERVQUAL, customer satisfaction and purchase intention)
Frost and Kumar (2000)	Airline	INTSERVQUAL (Internal SERVQUAL)
Brady and Cronin (2001)	Service organizations	personal interaction quality, physical service environment quality, and outcome quality
Higgs, Polonsky and Hollick (2005)	Art	ARTSQUAL (SERVQUAL and other dimensions such as appropriateness of lighting and information on artists)
Zhang, Xie, Huang and Hi (2013)	Car rental	SERVQUAL, customer satisfaction and customer loyalty
Murali, Pugazhendhi and Muralidharan (2016)	Home appliance	SERVQUAL, customer satisfaction, customer retention and customer loyalty
Lee (2016)	Medical	HEALTHQUAL (empathy, tangible, safety, efficiency, degree of improvement)

Appendix V. Timelines of service quality-related researches



Appendix VI. Measurement scale items and supporting literatures for research 2 survey

Factors and scale items	Supporting literatures
Q1_1. Service personnel are fast in repairing the product.	Zhang, Xie, Huang and He (2003), Garvin (1987), Brito, Aguilar and Brito (2007)
Q1_2. Service personnel are fast in servicing the product.	Parasuraman, Zeithaml and Berry (1985), Garvin (1987), Cronin and Taylor (1992)
Q1_3. Service personnel are polite in explaining the product before purchase.	Zhang, Xie, Huang and He (2003), Garvin (1987),), Cronin and Taylor (1992), Devaraj, Matta and Conlon (2001), Brito, Aguilar and Brito (2007), Dholakia, Singh and Westbrook (2010), Izogo and Ogba (2015)
Q1_4. Service personnel are polite in explaining the product after purchase.	Zhang, Xie, Huang and He (2003), Garvin (1987),), Cronin and Taylor (1992), Devaraj, Matta and Conlon (2001), Brito, Aguilar and Brito (2007), Dholakia, Singh and Westbrook (2010), Izogo and Ogba (2015)
Q1_5. Service personnel explain what services should be performed on the product.	Brucks, Zeithaml and Naylor (2000), Zhang, Xie, Huang and He (2003), Cronin and Taylor (1992), Parasuraman, Zeithaml and Berry (1985), Dholakia, Singh and Westbrook (2010), Izogo and Ogba (2015)
Q1_6. Service personnel are willing to consider your needs	Zhang, Xie, Huang and He (2003), Parasuraman, Zeithaml and Berry (1985), Cronin and Taylor (1992), Brito, Aguilar and Brito (2007), Izogo and Ogba (2015)
Q1_7. Service personnel are never too busy to respond to your request.	
Q1_8. Service personnel give quick response.	Brito, Aguilar and Brito (2007),
Q2_1. Service personnel inform you of time to service your product.	Brucks, Zeithaml and Naylor (2000), Cronin and Taylor (1992), Dholakia, Singh and Westbrook (2010),
Q2_2. Service personnel inform you of time to repair your product.	Brucks, Zeithaml and Naylor (2000), Cronin and Taylor (1992), Dholakia, Singh and Westbrook (2010),

Q2_3. Service personnel solve problems right the first time.	Brucks, Zeithaml and Naylor (2000), Garvin (1987), Parasuraman, Zeithaml and Berry (1985), Devaraj, Matta and Conlon (2001), Izogo and Ogba (2015)
Q3_1. Service personnel have knowledge to answer your questions.	Zhang, Xie, Huang and He (2003), Garvin (1987), Parasuraman, Zeithaml and Berry (1985), Izogo and Ogba (2015)
Q3_2. Service personnel have technical skills to solve problems with the product.	Parasuraman, Zeithaml and Berry (1985), Garvin (1987), Brito, Aguilar and Brito (2007),
Q3_3. Service personnel smoothly perform routine maintenance procedures on the product.	-
Q3_4. Warranty claims can be handled smoothly by service personnel.	Brucks, Zeithaml and Naylor (2000),
Q4_1. Long time interval between each routine maintenance period.	-
Q4_2. The product has extended warranty options available.	Brucks, Zeithaml and Naylor (2000),
Q4_3. The product warranty covers many items.	-
Q4_4. Service center has modern facilities.	Parasuraman, Zeithaml and Berry (1985), Cronin and Taylor (1992), Izogo and Ogba (2015)
Q4_5. Understandable 'quick guide' label is available on the product.	-
Q4_6. Understandable warning label is available on the product.	-
Q4_7. User manual is up-to-date.	-
Q4_8. Routine maintenance book is easy-to-understand.	Zhang, Xie, Huang and He (2003),
Q4_9. The product has a user manual for customer reference.	Zhang, Xie, Huang and He (2003),
Q4_10. Schedule for routine maintenance is available.	Cronin and Taylor (1992),
Q5_1. Service personnel give you individual attention.	Brucks, Zeithaml and Naylor (2000),Cronin and Taylor (1992), Brito, Aguilar and Brito (2007), Dholakia, Singh and Westbrook (2010), Izogo and Ogba (2015)

Q5_2. The product is made safe after maintenance procedures.	-
Q5_3. Service personnel accept your suggestions for further consideration.	Zhang, Xie, Huang and He (2003), Parasuraman, Zeithaml and Berry (1985),
Q6_1. I am satisfied with the product.	Devaraj et al., (2001), Caruana (2000), Hallowell (1996), Roberts et al., (2001), Olorunniwo et al., (2006), Yang et al, (2004), Janda et al., (2002)
Q6_2. I will say positive things about the product to other people.	Parasuraman, Zeithaml and Malhotra (2005), Janda et al., (2002)
Q6_3. I will recommend this product to persons that seek my advice.	Parasuraman, Zeithaml and Malhotra (2005), Janda et al., (2002), Izogo and Ogba (2015)
Q6_4. I plan to buy the same product in the future.	Cronin and Taylor (1992)
Q6_5. I am satisfied with service personnel of the service center.	-
Q6_6. I will say positive things about the service personnel of the service center to other people.	Parasuraman, Zeithaml and Malhotra (2005), Janda et al., (2002)
Q6_7. I am satisfied with the service center.	Roberts et al, (2001)
Q6_8. I will say positive things about the service center to other people.	Parasuraman, Zeithaml and Malhotra (2005), Janda et al., (2002)
Q7_1. Routine maintenance cost is reasonable.	Brucks, Zeithaml and Naylor (2000), Zhang, Xie, Huang and He (2003), Garvin (1987), Brito, Aguilar and Brito (2007)
Q7_2. Less replacement of parts is required during routine maintenance.	-
Q7_3. Individual spare parts can be purchased to replace a malfunctioning component.	Brucks, Zeithaml and Naylor (2000),
Q7_4. Malfunctioning product components can be replaced immediately with available spare parts.	Brucks, Zeithaml and Naylor (2000),

Appendix VII. The summary between research 2 and the existing research literature

Authors	Key dimension (exogenous)	Other dimensions (endogenous)	Research findings
Rigopoulou, Chaniotakis, Lymperopoulos and Siomkos (2008)	Delivery, Installation	Overall satisfaction, Repurchase intention and Word of mouth	• Investigated the effect of after-sales services on customers' satisfaction as well as on their behavioral intentions, namely "repurchase intention" and "word-of-mouth" (WOM). • After-sales service quality affected satisfaction, which in turn affects behavioral intentions. An understanding of the effect of after-sales services in satisfaction and post behavioral intentions is important to services marketing managers.
Zhang, Xie, Huang, He, (2013)	Tangibles, Reliability, Responsiveness, Assurance and Empathy	Customer satisfaction and Customer loyalty	• A service quality evaluation scale for the car rental industry in China was designed based on PZB's SERVQUAL model. • Contribution of empathy to the total service quality ranks the top and empathy has a strong impact on customer satisfaction and customer loyalty.
Murali, Pugazhendhi and Muralidharan (2016)	Tangibles, Reliability, Responsiveness, Assurance and Empathy	Customer satisfaction, Customer retention and Customer loyalty	• Focused on the investigation on the performance of after sales operations of leading firms engaged in manufacturing home appliances. • Examined the relationships among service quality, customer satisfaction, customer retention and customer loyalty and has identified the dimensions of service quality that are significantly correlated with customer satisfaction and other related outcomes.
Erialdi Syahrial, Hideo Suzuki and Shane J. Schvaneveldt (2017)	Tangibles dimension of serviceability, Assurance dimension of serviceability and Responsiveness dimension of serviceability	After-sales service cost and Customer satisfaction/ loyalty	• This research sheds new light on our understanding of serviceability by analyzing empirically the perspectives by which customers view product serviceability, as well as its influence upon customer satisfaction/loyalty. • After-sales service cost was identified as a new dimension of product serviceability that helps clarify the mechanism by which serviceability influences customer satisfaction/loyalty.

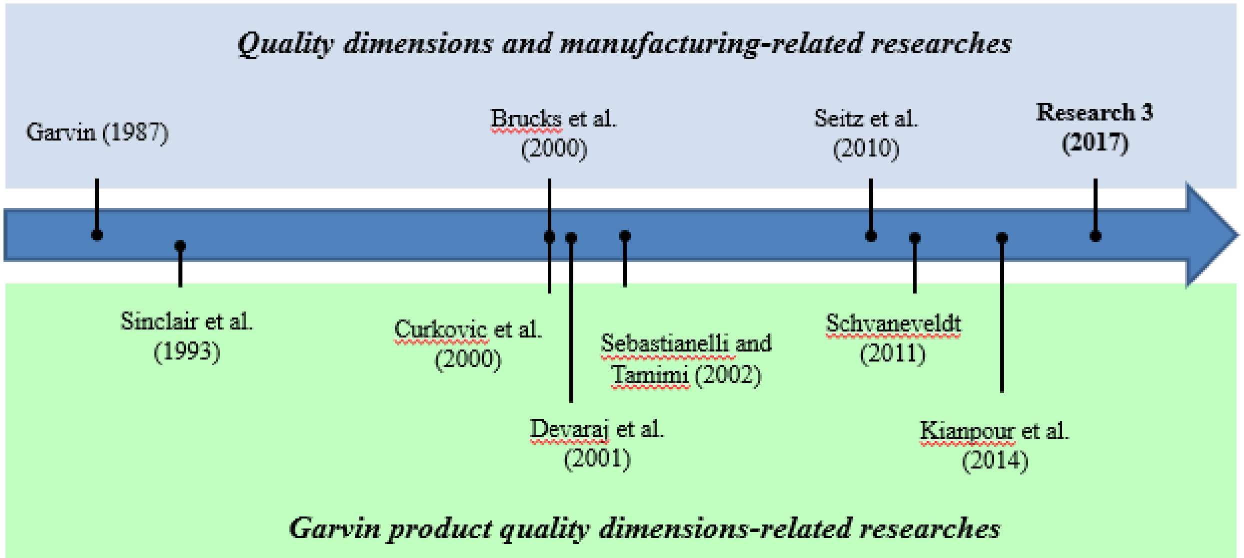
Appendix VIII. Comparison table between research 2 and the existing research literature

	Service quality dimensions (by Parasuraman et al., 1988)	After-sales dimensions	Customer satisfaction/ loyalty	After-sales service field	Investigation on serviceability-related practices (maintenance, service and repair)
Rigopoulou, Chaniotakis, Lymperopoulos and Siomkos (2008)		○ (Delivery)	○	○	
Zhang, Xie, Huang, He, (2013)	○		○	○	
Murali, Pugazhendhi and Muralidharan (2016)	○		○	○	
Erialdi Syahrial, Hideo Suzuki and Shane J. Schvaneveldt (2017)	○	○ (After-sales service cost)	○	○	○

Appendix IX. Summary of quality dimension-related researches

Scholars	Research field	Quality dimensions (QD)
Shewhart (1931)	Quality management	Objective and Subjective
Juran (1962)	Quality management	5 QD: general excellence, quality of design, quality of conformance, market-place quality, and consumer preference
McCall (1979)	Software products	11 QD: correctness, reliability, efficiency, integrity, usability, maintainability, testability, flexibility, portability, reusability and interoperability
Garvin (1987)	Manufactured products	8 QD: performance, features, conformance, durability, reliability, serviceability, aesthetics and perceived quality
Brucks, Zeithaml & Naylor (2000)	Manufactured products	6 QD: ease of use, versatility, durability, serviceability, performance, and prestige
Cox & Dale (2002)	Website design	7 QD: clarity of purpose, design, accessibility and speed, content, customer service and relationships
Madu & Madu (2002)	Website-based business	15 QD: performance, features, structure, aesthetics, reliability, storage capability, serviceability, security and system integrity, trust, responsiveness, product service differentiation and customization, web store policies, reputation, assurance, empathy.
Vidaver-Cohen (2007)	Trading	8 QD: performance, product, service, leadership, governance, workplace, citizenship and innovation
Seitz, Razzouk, &Wells (2010)	Manufactured products	10 QD: reliability, ease of use, serviceability, brand reputation, energy saving features, discounts or promotions, recommendation by the sales person, prior experience with brand, price and size

Appendix X. Timelines of quality dimension-related researches



Appendix XI. Measurement scale items and supporting literatures for research 3 survey

Factors and scale items	Supporting literatures
Q1_1. Your car's performance is good during overtaking other cars. Q1_2. Your car's performance is good during climbing a hill. Q1_3. Your car generates less vibration at top speed. Q1_4. Your car's acceleration is good. Q1_5. Your car's brake system is good. Q1_6. Your car's handling is good. Q1_7. Your car consumes less fuel. Q1_8. Your car's performance meets your expectations.	Bruck et al. (2000), Chen (2007), Shaharudin et al. (2011)
Q2_1. Your car's security function is good. Q2_2. Your car's audio system is good. Q2_3. Your car's seat is good for sitting. Q2_4. Your car's interior space is spacious. Q2_5. Your car's interior space can be used effectively and efficiently. Q2_6. Your car's interior space is comfortable. Q2_7. Your car's air-conditioning system is good. Q2_8. You could select options of features that satisfy your needs during purchase. Q2_9. Your car has up-to-date features. Q2_10. Your car's features meet your expectations.	Hazen et al. (2016), Kianpour et al. (2014), Shaharudin et al. (2011), Hazen et al. (2012)
Q3_1. You felt that your car had no immediate problems just after being purchased. Q3_2. You feel that your car has no issues. Q3_3. The conformance for your car is acceptable. Q3_4. Your car is frequently recalled.	Hazen et al. (2016), Sebastianelli and Tamimi (2002), Sinclair et al. (1993), Kianpour et al. (2014), Chen (2007), Curkovic et al. (2000), Sweeney and Soutar (2001), Hazen et al. (2012)
Q4_1. Your car's parts can be used for a longer time. Q4_2. Your car's plastic parts can be used for a longer time. Q4_3. Your car has a longer service interval for maintenance. Q4_4. Your car can be used for a longer time.	Hansen and Bush (1999), Hazen et al. (2016), Brucks et al. (2000), Larson (1993), Sinclair et al. (1993), Shaharudin et al. (2011), Hazen et al. (2012)

Q5_1.	Your car has less part breakdown within the first five years.	Hazen et al. (2016), Brucks et al. (2000), Larson (1993), Sinclair et al. (1993), Hazen et al. (2012)
Q5_2.	Your car has no breakdown after routine maintenance.	
Q5_3.	Your car has appropriate warranty period.	
Q5_4.	Your car has few failures.	
Q5_5.	Your car functions without problems or failures.	
Q6_1.	Your car is easy to clean.	Hazen et al. (2016), Brucks et al. (2000), Larson (1993), Sinclair et al. (1993), Kianpour et al. (2014), Chen (2007); Shaharudin et al. (2011), Hazen et al. (2012)
Q6_2.	Your car's interior space is easy to clean.	
Q6_3.	Your car's spare parts are easily obtained.	
Q6_4.	Your car requires less self-inspection.	
Q6_5.	Your car is easily inspected by yourself.	
Q6_6.	Your car can go through maintenance service at any service center.	
Q6_7.	Your car can be promptly serviced or repaired at a service center.	
Q7_1.	Your car's fuel consumption is reasonable.	Sweeney and Soutar (2001), Shaharudin et al. (2011), Kuo et al. (2009)
Q7_2.	Your car's maintenance cost is reasonable.	
Q7_3.	Your car's spare part price is reasonable.	
Q7_4.	Your car's service or repair cost is reasonable.	
Q8_1.	You feel good during touching many interior buttons.	Sinclair et al. (1993), Kianpour et al. (2014), Yuen and Chan (2010), Shaharudin et al. (2011)
Q8_2.	You feel good when touching many interior parts.	
Q8_3.	You feel good in terms of sound produced by your car.	
Q8_4.	Your car has an attractive "color-design".	
Q8_5.	Your car has an attractive exterior design.	
Q8_6.	Your car has an attractive interior design.	
Q8_7.	Your car has unique design.	
Q8_8.	Your car has an attractive design.	
Q9_1.	Your car received good reputation in terms of environment protection design.	Hansen and Bush (1999), Sinclair et al. (1993), Kianpour et al. (2014), Shaharudin et al. (2011)
Q9_2.	Your car received good impression based on the impressive advertisement.	
Q9_3.	Your car received good reputation in general.	
Q9_4.	Your car's brand is well-known worldwide for having a good quality.	
Q9_5.	Your car received good reputation in corporate social responsibility (CSR).	

Q10_1. You will say positive things about this car to persons that seek your advice. Q10_2. You will encourage persons that seek your advice to use this car. Q10_3. You will express a good feeling about the car to family or friends. Q10_4. You will say positive things about the car to family or friends. Q10_5. You are satisfied with the experiences of using the car. Q10_6. You are satisfied with your decision of purchasing the car. Q10_7. You are satisfied with the car's operation. Q10_8. The car's characteristics fulfilled your ideal. Q10_9. You want to buy the same type of car (same car model) the next time. Q10_10. You want to buy a car from the same manufacturer for the next time.	Sweeney and Soutar (2001), Devaraj et al. (2001), Caruana (2002), Hallowell (1996), Roberts et al. (2003), Olorunniwo et al. (2006), Yang et al. (2004), Janda et al. (2002), Cronin, Jr. et al. (2000), Kuo et al. (2009), Yuen and Chan (2010), Parasuraman et al. (2005)

Appendix XII. The summary between research 3 and the existing research literature

Authors	Key dimension (exogenous)	Other dimensions (endogenous)	Research findings
Sinclair, Hansen and Fern (1993)	Performance /Features, Reliability, Conformance, Durability, Service/ Perceived Quality, Aesthetics, and Economics.	-	• Confirmatory factor analysis failed to support the eight dimensional structure. • However, subsequent exploratory factor analysis supported the existence of most dimensions. Seven factors were specified rather than Garvin's eight.
Brucks, Zeithaml and Naylor (2000)	Ease of use, Versatility, Durability, Serviceability, Performance, and Prestige.	Perceived quality, Price and Brand name	• Generalizable typology of quality dimensions for durable goods that includes ease of use, versatility, durability, serviceability, performance, and prestige was developed. • Consumers used brand name or price more often when judging quality dimensions. Price and brand name are key marketing variables that may signal aspects of quality to consumers.
Curkovic, Vickery, and Droge, (2000)	Product quality and Service quality	-	• Examined the dimensions of quality for first tier suppliers in the automotive industry. • Product quality, consisting of design quality (features, product performance, etc.), conformance to specifications, product durability, and product reliability. • Service quality consisting of pre-sale customer service, product support (post-sale customer service), and responsiveness to customers.
Devaraj, Matta and Conlon (2001)	Warranty, Service quality, Brand and Price	Service satisfaction, Product quality, Quality belief and Loyalty	• Examined product and service quality using a model that integrates it into the prediction of repurchase behaviour. • Brand loyalty and repurchase intentions were affected by both the quality of the vehicle manufactured and the quality of service delivered by the dealer during repair and maintenance incidences.

Appendix XII *(continued).* The summary between research 3 and the existing research literature

Authors	Key dimension (exogenous)	Other dimensions (endogenous)	Research findings
Sebastianelli and Tamimi (2002)	Garvin quality dimensions	-	• There was a link between the five definitions of quality and the eight dimensions of product quality. • The empirical study yielded durability, serviceability and reliability loaded on factor 1, performance and conformance loaded on factor 2 and perceived quality, aesthetics, and features, were the three product quality dimensions that loaded on factor 3.
Schvaneveldt (2011)	Garvin quality dimensions	Societal quality	• Proposed societal quality as another dimension of quality which extends Garvin's original set of eight dimensions.
Kianpour, Jusoh and Asghari (2014)	Garvin quality dimensions and Environmental friendly	-	• Explored consumers' opinions on the demand side to examine environmentally friendly capability as a new dimension of product quality. • Customer responded that environmentally friendly is an important part of a product along with other dimensions of product quality.
Erialdi Syahrial, Hideo Suzuki and Shane J. Schvaneveldt (2017)	Garvin quality dimensionns	Ownership cost, Customer satisfaction and Customer loyalty	• This research investigated the influence of ownership cost on automobiles customers' perspective through maintenance, service and repair. • This research also found benefit in utilizing Garvin's quality dimensions for understanding customer perspectives of product quality for Japanese automobiles and examined the impact of ownership cost in after-sales service.

Appendix XIII. Comparison table between research 3 and the existing research literature

	Product quality dimensions	Intermediate factor	Customer satisfaction	Customer loyalty	Investigation on maintenance, service and repair
Sinclair, Hansen and Fern (1993)	○				
Brucks, Zeithaml and Berry (2000)	○				
Curkovic, Vickry and Droge (2000)	○				
Devaraj, Matta and Conlon (2001)	○		○	○	
Sebastianelli and Tamimi (2002)	○				
Kianpour, Jusoh and Asghari (2014)	○	○ (Environmental friendly)			
Erialdi Syahrial, Hideo Suzuki and Shane J. Schvaneveldt (2017)	○	○ (Ownership cost)	○	○	○

List of Achievements

Articles in publications (related to thesis)

1. Syahrial, E., Suzuki, H., and Schvaneveldt, S.J. (2017), "The Impact of Serviceability-Oriented Dimensions on After-Sales Service Cost and Customer Satisfaction", *Total Quality Management & Business Excellence*, available at: https://doi-org.kras1.lib.keio.ac.jp/10.1080/14783363.2017.1365595, pp. 1-25 (published online: 19 December 2017).

2. Syahrial, E., Suzuki, H., Schvaneveldt, S.J. and Mitsuki, M. (2017), "Customer Perceptions of Mediating Role of Ownership Cost in Garvin's Dimensions of Quality", *Journal of Japan Industrial Management Association*, Vol. 69, No. 2E.

Article in review stage (related to thesis)

1. Syahrial, E., Suzuki, H., and Schvaneveldt, S.J. (2017), "Designing products for serviceability: Antecedents and impacts on service operations performance", *International Journal of Quality & Reliability Management*, manuscript no. IJQRM-10-2017-0213.

Presentation at international conference

1. Syahrial, E., Suzuki, H., and Schvaneveldt, S.J. (2016), "Serviceability Practices and Their Impact on Operational Performance: An Empirical Analysis", *27th Annual Production and Operations Management Society (POMS) Conference*, 6th – 9th May 2016, Orlando, Florida, United States of America.