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Demand for Modularization among Malaysian Manufacturers

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Abstract This paper present the effect of using modularity process and product on demand perspective based on customer perception. Modularity has influence the firm performance and create a demand of customer. Customer can have their own choice because modularity process creates a variety to fulfill customer needs. Modularity allowed the components to recombined and coupling in the maximum number of ways which are the way to deliver customers a great variety. From this way, the module provider is free to perform design innovations and improvements as long as they comply with the standard interface. Therefore, modularization must happen at the product at technological level and at the same time need to be supported by modular organizational structure in order to be successful strategy. Modularity effect the demand perspective based on dynamic market, entrepreneurial strategic intent, production, heterogeneity of inputs, customer ability and willingness, differentiation, and customer services and satisfaction.

Keywords Modularity, Demand, Manufacturing Industries

1. Introduction

Managing modular architectures is an area of intense interest both to scholars and practitioners[1, 2, 3]. In increasingly dynamics market modularity of products enables managers to exploit economies of scale and scope and to enhance product variety to meet heterogonous customer needs[4, 5]. According to Worren et al.[6] found that internal product modularity had an impact on enhancing the number of variants of a product, but did not influence the pace of innovation. While, Schilling,[7] defined that modularity as the degree to which a system's components can be separated and recombined. Modularity refers not only to the extent of coupling components, but also to the existence of architectural rules, which define how components are combined in an overall system. In addition, Baldwin et al.[8] argued that modularity is a structural means of achieving functional integration in complex systems. They discusses about three features of modularity which the modules are distinct parts of a larger system, independent of one another, and modules function as an integrated, seamless whole.

Scholars of the resource-based view of the firm point out that firm have individual sets of core modularity capabilities that distinguish them from competitors, as mentioned by Leonard-Barton[9]. It is because products often are made up of components that draw from different underlying production technologies, distribution and marketing requirements or other required skill sets, a firm's core modularity capabilities may put it at a performance or cost advantage in producing some components, while putting it at a disadvantage in producing others[10]. A firm that specializes in those products in which it excels may earn higher returns than one that has its returns averaged across components in which it excels and those in which it does not[11]. The greater difference between the modularity capabilities that firms possess, the greater the benefits they reap from specializing in different components for fulfill customer need[12]. In this essence, Jacobides[13] noted that the greater differentiation in firm modularity capabilities can make modular solutions an attractive option for producers. According to Lanctot et al.[14] argued that great differentiation in firm modularity capabilities can lead to increased pressure for modularity from customers as well. When differential capabilities among firms yield components with differential performance and value, the customer prefers to be able to choose from among various vendors in order to assemble the technology solution that provides the best fit with his or her needs. Alternatively, when there is little difference between the modularity capabilities that firms possess, the products may be more similar in terms of function and performance or value[7]. Thus, it will reduce the value of being able to mix and match components.

Over-designed products are typically expensive, but under-designed products tend to dissatisfy customers and lose sales. Furthermore, Chase et al.[15] suggested that product quality is measured by quality of conformance,

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quality of design and reliability. While, Garvin[16] argued that quality of conformance is the degree to which the product meets product design and operating specifications. It is similar to the assessment of manufacturing conformance to specifications and is always done after manufacture of the product or its components. Quality of design consisting of performance features and styling refers to the value of the product that matches customers in the market place[17]. According to Chase et al.,[15] reliability referred to the consistency of performance over time and the rate of failure. In addition, Hargadon et al.[18] suggested that modular product design improves product quality as it requires firms to specify the relationships between components at an early stage of the product development process. The quality of each component can also be quickly tested and identified at modular level because the product modules are so independent of each other, as mentioned by[19, 20].

However, the common modules may reduce product differentiation in modular product design[21]. If product quality depends on the size, mass or shape of the modular products which is because of redundant physical components may reduce the performance of quality[22]. According to Kim and Chhajed,[36] K. Kim and D. Chhajed, Commonality in product design: Cost saving, valuation change and cannibalization, *European Journal of Operational Research* 125[36], pp. 602–621. Article | PDF (274 K) | View Record in Scopus | Cited By in Scopus (45)Kim et al[23] suggested that if common modules are used in both premium and economic products, it will reduce the perceived difference in quality between the products in different classes and adversely affect the profits if there is higher expectation for the difference in quality between the classes.

2. Review of Literature

2.1. Modularity of Dynamics Market

The scholar distinguishes between three factors, which can characterize the level of market dynamics which consist of the competitive intensity, customer uncertainty and technological opportunities[5, 6, 24]. In theorizing and research on modularity, there is no common agreement on which features of the market determine the adoption of modular designs. Therefore, Staundenmayer et al.[24] emphasized about the competitive dynamics, while, Tu et al.[5] focused exclusively on customer uncertainty. Nevertheless, Worren et al.[6] defined that market dynamics as the speed of change of both customer preferences and competitor's products. The researchers add the dimension of technological opportunities, in order to incorporate the key variable in the environment, which determines the shifts between modular and integrated designs[25]. Similarly, Schilling[7] argued that speed of technological change must be considered as an antecedent of modularity and increases the modularity of products. Increasing technological complexity and heterogeneity of consumer demands drive firms to adopt modular designs in order to improve their flexibility and performance[5, 8]. Furthermore, the companies in all industries will benefit from using modular strategies if they are facing dynamic markets, as noted by Sanchez[26]. Modular organizational forms will enable firms to compete successfully in rapidly changing environments. Consequently, the modularity of products, organizations and knowledge may help firms to match the dynamics of their markets[27].

High customer dynamics and competitive intensity makes it beneficial for firms to adopt modular strategies consistently across all the accumulated research findings[5, 6]. Conversely, Sorenson[28] found that several research contributions show that some aspects of the technological dynamics may actually counteract the drive to modular strategies in some situations. Thereafter, as stated by Ernst[29] in the fast moving environment of the semi-conductor industry, firms are reluctant to adopt a single modular architecture, because of the threat of disruptive technological architectures from their competitors. The stabilization of interfaces and parameters may limit the ability of the firm to react the moves of the competitors with a high dynamics of markets. Indeed, firms which use modular architectures in markets with emerging technologies may fall in modularity traps. According to Chesbrough et al.[25] argued that firms must switch modularity and integration to answer shifts in the market dynamics from the settings of emerging technology to the settings of dominant designs and via versa in order to avoid modularity traps. In the emerging technologies the market dynamics is higher and the threat of emergence of a disruptive technology in a competitive firm is higher. Thus, in the settings with industry standards and low opportunities for disruptive technological change firms are more likely to adopt modularity[30]. Therefore, firms adopt increasing modular strategies in markets with opportunities for technological breakthroughs and will reduce their modularity in markets with dominant design and opportunities for only minor technological changes.

Furthermore, Tu et al.[5] investigated that the impact of market dynamics on organizational structure and organizational process modularity. In the markets with consumer and technology uncertainty, the firms which adopt modular manufacturing practices, are able to cope better with the increasing demands for individually customized products. While, Schilling et al.[31] noted that the market context in terms of consumer heterogeneity, competitive intensity and speed of technological change increases the level of the external product modularity of a firm. Thus to stay competitive in dynamic markets firms outsource not only components of their products, but also components of their knowledge[32]. Market dynamics increases the efforts of the firm to use, develop and integrate different knowledge components, whether internal or external into a smoothly functioning knowledge system determines the success of the

firm in developing new products in an innovation-based competition. In addition, Todorova et al.[33] stated that market dynamics motivates firms to adopt internal product modularity, external product modularity, organizational process modularity, organizational structure modularity and knowledge modularity.

2.2. Modularity Adoption in Developing Entrepreneurial Strategic Intent for Market Demand

Several researchers have conceptualized entrepreneurship in broad terms such as the process of pursuing opportunities[6]. Lumpkin et al.[34] defined that entrepreneurship as a new entry, and which can be accomplished by entering new or established markets with new or existing products. Furthermore, before decided to adopt modularization to use new technologies and product models to enter new markets, a firm adopting extensive outsourcing strategies will need to deal with high levels of tacit knowledge that can be better managed to production, which allows for a more effective management of tacit knowledge[35]. These can be a valuable decision when developing new products or entering new markets. Thereafter, as mentioned by Todorova et al.,[33] there was a linkage between the adoptions of the modular production strategy and the firm's articulated strategic intent for developing new products or entering new markets with customized products that better satisfy individual customer's needs. Companies with strategic plans to develop new technologies, to enter new markets, or to improve their product development processes are more likely to adopt modular designs[36]. Moreover, companies with entrepreneurial strategic intent are more likely to be flexible through other strategies besides modular designs. The variation between companies must be control with different strategic intents in order to improve the power to detect effects of modularity on strategic flexibility[6].

While some firms adopt modular strategies in their quest for competitive advantage, the others may adopt different strategic approaches to increase their flexibility[7, 11]. The strategic intent of the firm mediates the relationship between market dynamics and modularity, also relationship between market dynamics and strategic flexibility. This is because the overall strategic logic of the firms changes in response to the market context and influences in turn the adoption of modular strategies and the strategic flexibility of the firm[37]. Thereupon, Worren et al.[6] noted that the strategic intent may influence flexibility both directly and indirectly through the adoption of modular strategies. The companies can adopt modular strategies in order to increase their flexibility or they can adopt alternative innovation strategies like technology integration[38]. In addition, firms can decide to use both modularity strategies and other innovation strategies, such as improvisation[39].

2.3. Modularity in Process of Production

At first, in which modularity appears for the first time as a new approach to satisfy the market and the way to look at modularity is offered by Starr[40]. The modular production is considered as a new strategy to satisfy the variety request. According to Ulrich[41] and Sanchez[42], it is the essence of the modular concept to design, develop, and produce those parts which can be combined in the maximum number of ways. Thereby, from the reason of modularization, it is the right way to deliver customers a great variety of products to satisfy what they need. Moreover, Sako[43] noted that Starr [40] underlined what the marketing strategy has previously done to meet the market's requests, creating a degree of variety which is not anymore sufficient so satisfy the actual demand. Customers cannot be satisfied by what is only the product of imagination, commercials and advertisements. A new era is then opening, and modularity using third steps of a process of strategic change. Firstly, the steps are control with mass production. Secondly, Product variety with mass production, still based on the mass production model, but better suited to the marketing strategy to satisfy the greater request for variety. Finally, the concept of modular production, in which the production process, previously conceived as a unique, is divided in two pieces, including a variety of inputs which reduced to a more limited set of modules and the process organized to satisfy the variety request producing "combinatorial outputs"[44].

Furthermore, the organizational system of the firm and the market as a complex should adopt modular configurations is based on the strong assumption that the all trajectory is explained by a simple process of expansion from a micro to a macro level[45, 46]. While, Langlois et al.[9] stated that the modularity affect an interacting condition on the demand and supply side. The nature of what consumers believe is the essence of a given product often changes. Consumers may add certain attributes and drop others, or they may combine the product with another product that had been generally regarded as distinct. Alternatively, a product that consumers had treated as an entity may be divided into a group of sub-products that consumers can arrange into various combinations according to their personal preferences[8, 41]. The combination of demand costs and benefits must be finally considered in connection with the life cycle stage of the product[47].

2.4. Heterogeneity of Inputs and Demands in Modularity

The primary action of modularity is to enable heterogeneous inputs to recombined into a variety of heterogeneous configurations[7]. Therefore, the ability to produce multiple configurations will increase the system's fitness by using the modularity process, when there are heterogeneous inputs and heterogeneous demands placed upon the system. Similarly, the more heterogeneous the inputs are that may be used to compose a system, the more possible configurations there are attainable through the re-combinability enabled by modularity[8, 48]. Furthermore, the more heterogeneous the demands made of the system, the more valued such re-combinability becomes. The more

potential configurations there are of a system, the more likely that configurations will be found to meet the heterogeneous demands made of the system[7]. For a simple example, suppose a car which can be assembled from a range of components. The wider the range of components that can be recombined into a car, the wider the range of possible car configurations achievable through modularity and the greater the potential opportunity cost of being locked in to a single configuration[49]. Furthermore, the more heterogeneous the customers for cars are, the less likely they are to agree on a single configuration. By employing modularity, heterogeneous customers can choose a car configuration that more closely meets their preferences[48]. Furthermore, if customers are heterogeneous, but the possible components of a system are perfectly homogeneous, modularity might enable flexibility in scale but might not significantly increase the range of possible functions of the product configuration[50]. Conversely, even if there is a wide range of components, but customers all want the same thing, there is little to be gained through offering a modular system, it will be a simple matter to determine the best combination of components to meet customer demands and to integrate them into a non-modular system. However, heterogeneity in the range of inputs, combined with heterogeneity in customers, creates powerful incentives to adopt a modular system[9].

Customer heterogeneity is an important factor that influences whether a technology will migrate toward increasing or decreasing modularity[7]. When most customers desire roughly the same types of components and their requirements for each individual component are comparable, a firm is able to produce a bundle that is close to optimal for the majority of customers[9]. Furthermore, through integrating the products, the firm may be able to create performance or cost advantages that outweigh the sacrifices customers make in not being able to choose their own components. Alternatively, when customers for a particular technology solution have very different needs, it is more difficult for a single integrated solution to closely match their idiosyncratic requirements[50, 51].

2.5. Changing Customer Needs and Heterogeneity in Modularity

Increasing global competition and new technological developments are allowing customer to pressure the designers to customize products at mass production prices [52]. Moreover, today's changing business environment is characterized by lower customer-switching costs[53]. Therefore, managers must address individual customer's needs by offering customized products, with the increased production costs associated with offering customized product offset by efficient production strategies[54]. The traditional "push manufacturing" system was being replaced by an advanced "pull manufacturing system", where the continued evolution of outsourcing strategies and lean production systems were being implemented in conjunction with the concept of modularity based on a new way of making things[35]. In general, the need to address individual customer's demands and reduce response time has pressured managers to develop strategies in modularization that help build capabilities in meeting increasing customer requirements, by producing customized products at mass production costs[55]. Customers now have more heterogeneous demands for quality, variety, lower prices, and delivery time[56]. Hence, the more heterogeneous demands imposed on the firm, the more valuable will be the ability to deliver variety from flexible production configurations such as modular production[7].

Meanwhile, the necessity to emphasize those industrial products, such as power supply products, that pose a few challenges in both design and manufacturing as well as in marketing for consumer product with the following features that make customer requirement analysis easier[57, 58]. Firstly, customer of industrial products usually has more knowledge of products than those consumer products. Therefore, customers of industrial products can offer more definite information concerning their needs[11]. Next, the market of industrial products, purchase decision making is conducted by concrete factors such as product performance and product cost rather than abstract factors such as aesthetic and ergonomic criteria[58]. Finally, since the number of customers is comparatively limited and customers can often be specified in the market for specific industrial products, a survey of market needs can easily be conducted with acceptable accuracy[57, 58].

2.6. Customer Ability and Willingness Decision in Modularity

Customer ability and willingness to choose and assemble components also be a factor to use modularity. According to Schilling[7] noted that if it is difficult for a customer to choose appropriate components or to assemble those components into the product configuration, then a non-modular product may offer the customer additional functionality by eliminating selection and assembly responsibilities. Furthermore, in order for a customer to choose components of a modular system, the customer must be able and willing to distinguish among the performance, quality and value attributes of different components, which frequently means that the customer must have great understanding of how the components work both individually and together[8]. Based from reading the articles, it was founded that for simple products or those products where quality and performance are easily measured and the interaction among components well understood, the customer may have great confidence in his or her own ability to choose among components.

However, where quality or performances are difficult to assess, the customer may be more likely to rely on a credible external source to choose components[59]. Even for a given product system, customers may vary in their degree of knowledge and motivation in choosing components[7]. For

example, although the average audio equipment customer usually buys a pre-assembled single vendor stereo system which using brand name and limited technological information to assess overall system quality, more sophisticated audiophiles often purchase stereo components individually, from multiple vendors. It is because in order to assemble a system that more closely matches their performance and price requirements[60]. According to Holt et al.[61] suggested that where component quality is difficult to assess, customers may choose bundled or integrated products that are believed to provide an acceptable average quality across the components. Furthermore, where the nature of the interaction between components is uncertain, the customer may seek a product that has been assembled already to optimize its performance, thus making integrated solutions more attractive. Hence, even when customers are willing and able to discriminate among components, they may be unwilling or unable to assemble the product configuration[7, 62].

2.7. Differentiation in Firm Capabilities from Technological in Heterogeneous Input Concept

The firms will choose to specialize in different things, if more technological options are available to the firms[63]. Furthermore, when these attributes are combined with the adoption of modular product designs, a circular dynamic may be engaged that propels a technology even further down a modularity trajectory[7]. Firstly, the more different the sets of skills are among competitors, the more attractive modularity becomes, because it enables disparate technologies to be combined. Secondly, the use of modular product designs also enables firms to further specialize and increasing their differentiation from competitors[49]. Finally, the more firms travel down isomorphic learning paths, the more they develop disparate technologies.

The inputs into a product system include both the technological options available to achieve particular functions and the resources and capabilities of the firms involved in the production process. Hence, the heterogeneity in these inputs will increase the value to be obtained through modular product configurations[7].

When there are diverse technological options available to be incorporated into a product configuration, modular product designs will be more attractive to both customers and producers[64]. The diversity of available technological options might compel customers to seek more flexible solutions and make being tied to a single vendor less attractive. Firstly, the number of available product configurations achievable through modularity is a direct function of the number of available components from which the customer may choose[65]. A wider range of modular components quickly multiplies a customer's product configuration options, greatly increasing the flexibility gains to be reaped from modularity[66]. Secondly, commitment to a single, integrated product system imposes an opportunity cost equivalent to the next best option available. When many different options are available, this opportunity cost is likely to be higher, because the next best solution is likely to be better than the next best solution when there are few options available[7]. Thirdly, when there is a great diversity in available technologies, the customer faces more ambiguity about which option is actually best. The customers sacrifice less by being committed to a single vendor, and they face less uncertainty about the optimality of their technology choice when there is little diversity in the technological options[7, 66]. Diversity in the technological options available makes modularity more attractive to producers as well[65].

Otherwise, it is usually difficult and costly, for a firm to support multiple technologies; it is because the firms must choose one or two technology designs, gambling on those they believe to be the best match with their capabilities and the consumer requirements[67, 68]. According to Schilling, [7] as with customers, a large number of diverse options can increase a firm's ambiguity about which technology to support. Furthermore, integrated systems are offered, if the various technologies are incompatible and products are based on the technologies. The firm might face a win-or-lose scenario which the firm either becomes a customer's sole supplier of an entire product system or it does no business with the customer at all[7, 69]. Under conditions of modularity, the firm does not face such a win-or-lose scenario. Moreover modularity enables compatibility between disparate technologies, lowering the risk to the firm of gambling on a particular technology[7]. The firm does not have to compete for a customer's business for an entire system, it can compete for a customer's business for a particular component, focusing on a technology in which it excels and allowing other vendors to supply other technologies[70, 71].

The factors increasing the pressure to migrate toward modular technology solutions are the speed of technological change[42, 72]. When the technology advances rapidly, both customers and producers desire flexibility in order to respond to the rapidly changing heterogeneity of inputs and demands. High speed technological change can both increase the rate at which new and heterogeneous inputs proliferate and by rapidly expanding the scope of possibilities for customers to nurture the rapid evolution of heterogeneous demands. Continually, Sanchez,[49] argued that this is because the product design must be able to adapt quickly to fulfill heterogeneous demands or to incorporate heterogeneous inputs, which make a modular solution becomes very attractive. Furthermore, for customers, modularity reduces switching costs and enables them to upgrade particular components as new technology becomes available, without replacing the entire system[49, 53]. Technological change may also make modularity more attractive to producers to increase customer pressure for modularity. According to Henderson et al.[73] modularity enables a producer to incorporate new technologies into its products as they become available, while still being able to combine components within the existing product

architecture. As long as new technology generations are compatible with the standard interface, components based on the new technology may still integrate with the installed base of components based on the previous technological generation[19]. Therefore, as noted by Garud et al.,[67] modularity will increases the ease with which both customers and producers may upgrade their technology, and it may slow the obsolescence of other parts of the product system.

In addition, Schilling[7] stated that the factors that create urgency in the contexts of product systems not only speed of technological change, but also competitive intensity. Such factors increase the likelihood of the system responding to pressures to become more modular, as noted by Alternatively, when there is low urgency when a firm is so powerful that is experiences less urgency, the product system might be pushed or retained at a point on a trajectory that seems a poor fit with the balance of the demands of the synergistic specificity of the system[74]. For example, firms might wish to prevent the adoption of modular product designs because modularity would decrease their market power or architectural control. If a product market has heterogeneous inputs and heterogeneous demands a high degree of competitive intensity will increase the likelihood of one or more competitors opting to offer a modular product in an effort to differentiate themselves competitively[49]. Through offering modular products, firms may create product configurations that more closely fit customer needs, and thus enable them to penetrate more market niches[42]. Furthermore, if those modular products meet the heterogeneous demands of customers better than tightly integrated products, many other competitors may be forced to follow suit[31, 66]. Modular products may erode a firm's market power and architectural control, but if competitive intensity is fierce, firms are more likely to bow to market pressure, as noted by Schilling et al.[7]. Competitive intensity also puts great pressure on firms to lower costs. Modularity may impact the end cost to customers through its influence on both switching and product costs[42]. When customers choose a non-modular solution, they are making a commitment to a single source and forfeiting the many other options that would be achievable through reconfiguring heterogeneous inputs. Once a solution is chosen, the customer bears significant switching costs to change vendors[35]. Modularity enables purchasing from multiple sources, thus decreasing switching costs[13, 26]. If a customer decides to change to a product from another vendor, that customer need only change components not the entire system[3].

Modularity also can impact the price customers pay for products by influencing both firm costs and margins. In a market characterized by product design modularity the component vendors might benefit by increased specialization[75]. While, a firm that produces all of the components of a system faces greater fixed and variable costs, it must have the equipment required to produce a variety of components, not all of which will be based on the same manufacturing technologies[40, 76]. It might have to employ more people in order to ensure a wider range of available skills and likely will have higher inventory costs because it must hold both the raw materials for a wider range of products and the range of end products themselves[5]. The firm that specializes in producing only one or a few components can avoid these costs and can focus on those components that best leverage its core capabilities and maximize its performance[7]. Furthermore, modularity can increase the degree of competition among component providers both because it lowers customer switching costs and lowers entry barriers by enabling competitors who only produce one or a few components but not the entire system to enter the market[11, 49]. Thereafter, the greater pressure on firm profit margins will be translated into lower costs for consumers. For example, in the minicomputer, which customers found that modular minicomputers or networked workstations, as a modular alternative more attractive than conventional minicomputers. It is because they enabled changes to be made to the system without changing the whole system or relying on a single vendor lowered switching costs, thus, increased competition between minicomputer and microcomputer providers in lower prices or lowered margins[7, 59]. Furthermore, both the microcomputers and the modular minicomputer components were less expensive to produce than highly customized minicomputer solutions lowered production costs[49].

2.8. Modularity on Customer Services and Satisfaction

Bundling service with products may lead to customer satisfaction, when most physical products can be quickly imitated and efficient production processes are common in the marketplace[77]. Services include information, training programs, technical support and all kinds of after sales service[78]. According to Frohlich et al.,[79] customer service refers to technical support, after-sales service and broad distribution. Technical support means the ability to provide technical support for customers, which often augments the value of manufactured products. While, after sales service refers to the ability to provide after sales service, which deepens and extends the relationship with customers. Broad distribution refers to the ability to distribute products to customer assigned locations on a global scale.

Modular product design improves a firm's ability to provide customer service by quickly solving technical problems and delivering common parts and services to clients. The problems of the product are easily identified and resolved by swapping a new module for a damaged one, with higher separateness of the product modules[7]. Moreover, Ulrich and Tung, 1991 Ulrich, K.T., Tung, K., 1991. Fundamentals of product modularity. Proceedings of the 1991 ASME Winter Annual Meeting Symposium on Issues in Design/Manufacturing Integration, Atlanta, pp. 1–14. Ulrich[22] suggested that if modular product design is applied, firms can localize quality problems at modular level,

and thus technical support can detect and solve any problems faster. In addition, as stated by Karmarkar et al.,[80] when product modules have well specified interfaces, manufacturers can provide upgrades, add-ons and optional components for customers to advance the products they own without adversely affecting the use of the product. Thus, to distribute the product across different regions, the firm can select a small number of approved modules to be combined with the product without adversely affecting the configuration[23]. Thereafter, the well-specified interfaces of product modules can easily be assembled in a short lead time. Thus, for the delivery of physically large sized products, firms could deliver the product modules, instead of finished goods, to the customer's required location, and quickly assemble the modules into the finished goods on the spot[18]. This may increase the efficiency of broad distribution[79].

Customer satisfaction is the degree to which customers perceive that they received products and services that are worth more than the price they paid[81]. According to White's,[82] defined that a set of variables that influence customer satisfaction including quality, delivery speed, delivery dependability, cost, flexibility and innovation. While, Lau Antonio et al.[23] provided measure of competitive capabilities that include cost, competitive pricing, premium pricing, value-to-customer quality, product mix flexibility, product innovation, and customer service. According to Griffin,[83] provides a similar set of measures, including the price offered quality of products, product line breadth, order fill rate and frequency of delivery. The perception of experienced managers to assess customer satisfaction, including retention, ratio of price to value, quality, product reputation and customer loyalty[84].

Moreover, Novak et al.[80] found that product architecture resulting from modular design provides the ability to build several modules in parallel and then assemble them in the production process. Thereafter, as mentioned by Cooper,[85] a firm is able to employ a postponement strategy such as the ability to store modules in a variety of geographic regions and then assemble them, thereby offering a wide variety of end products with very responsive delivery times. According to Worren et al.[6] stated that product modularity is a precursor to mass customization and the flexibility facilitated by product modularity to be a resource in the sense of the resource-based view of strategy such as modular designs and the following flexibility may not be easily imitated. In addition, Sanchez et al.[11] suggested that modular architectures increase strategic flexibility relative to integrated products and improved firm performance.

3. Conclusions

The study penetrates more on demand perspective including of firm and customer in the modularization process. The customer gained the benefits of heterogeneous demands such as lower prices, quality and delivery time. Modularization process give the customer many options or great variety of the products by the firms through recombined, extent of coupling components and existence of architectures rules which the components are combined in an overall systems. Customer have needs to be fulfill from their request of the product, they will not satisfied if the product homogenous and same with the others producer. Otherwise, through the modularization process, the customer will get the satisfaction from customer services when they received the products that are worth more than the price they paid. They are willing to pay more to get what they needs. Thereafter, the firms are able to deliver variety to fulfill customer needs from flexible production configurations. The firms may stay competitive in markets if they know how to combine the components of their products and have knowledge whether internal or external in developing new products. The firms can localize quality problems from the modular level and technical support can detect to solve the problem occurred quickly. Modular product designs have the higher separateness which can identify the problems immediately and change for a new module for a damaged one.

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