Chapter 3

Resources of Innovation in Indonesian Automotive Industry the Role of University and Public Research Institute (PRI)

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CHAPTER 3

Resources of Innovation in Indonesian Automotive Industry the Role of University and Public Research Institution (PRI)

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The study attempts to reveal external resource of innovation in Indonesian automotive industry. More specifically, the study tries: i) to identify the variation of innovation sources in the company's innovation process, ii) to differentiate types of innovation within the company based on internal and external resources; and iii) to find the role of university and public research institution as the external resource of company innovation. Data and information were mapped and analyzed by using the framework of sectoral innovation system (SIS).

The study found that: first, the resource of innovation in Indonesian automotive industry diverged from individual and organization actors both from internal and external resource. The innovation resource mostly came from the internal organization of company. Second, the external resource of innovation in Indonesian automotive industry mainly came from company's competitor that stimulates the creation of new product in sharp market competition. Third, the roles of university and PRI as external resources of innovation in Indonesia were very small. Fourth innovative PRI has shown the potency to be the external resources of innovation for local automotive companies. Fifth, innovation cooperation between industry and PRI was linked by R&D matching grant provided by the government. Sixth, The PRI's support to innovative industry occurred in the form of technical assistance.

The study proposes some policy implications for the development of Indonesian automotive industry. With regard to the role of university and PRI in the future, the study implies that: i) university needs to improve the graduates quality in automotive engineering and perform the industrial application of research output, ii) innovative PRI should be promoted to commercialize its product innovation, and iii), Innovation cooperation between local automotive industry and PRI should be strengthened and the PRI's support to locally innovative industry should be expanded in the future.

Key words: Sectoral, innovation system, automotive, knowledge source, policy

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1. Introduction

1.1. Background and Objective

In the era of globalization, R&D activities inside company itself have shifted toward the utilization of external resources. The success of corporate innovation is determined by the use of the best knowledge comes from both internal and external resources. Such a drifting has been driven by the fact that source and flow of knowledge and skill are becoming available from outside, whether from individual and organization. The company has adapted to see and find new product and also ways to increase efficiency and effectiveness through inter-company collaboration, cooperation with supplier, and alliances with competitor. The collaboration becomes an imperative step to create profit in the paradigm the so-called open innovation. (Chesbrough 2006)

The utilization of external knowledge source occurs through interaction among business, university and other organizations such as customer, supplier, university researcher, and competitor. Through such an interaction the company imports the best knowledge with lower cost and faster process from the best resources in the world, rather than by generating and creating within their own company. However, the utilization of external knowledge source through collaboration can leak key technology to competitors. This is one of the reasons for the company's slow interest in collaborating on innovation. Generally, big companies supported by advanced technology research tend to collaborate with university and research institution as their source of external knowledge, while small and medium companies doing innovation for minor and gradual improvement generally rely on business services as their source of external knowledge. The utilization of external knowledge has become indicator of company's innovative performance. Chen's research finding confirmed that the higher the openness to collaborate the better the innovative performance of Chinese firms (Chen *et al.* 2008)

Other important reasons for the utilization of external knowledge in innovation are as follows: i) the company can focus on innovation activities in areas where they have a clear competitive advantage; ii) the use of R&D funds will increase in the most promising innovation activities; iii) the capacity of R & D will improve through

investment in R&D cooperation, without sacrificing their own innovation and technology products; and iv) the culture of collaboration with external innovators in developing the joint technology will improve.

Furthermore, the benefits of company's openness as the source of external knowledge for other companies are as follows: i) the company's profit will rise by giving a license or develop spin-off companies; ii) overhead and the additional cost of HRD will reduce, i.e. the recruitment and training for business expansion, so that company personnel can focus on the higher value of innovation activities; and iii) the culture of knowledge sharing through cooperation with other companies will enhance, and technology commercialization cost and risk will reduce.

This study is concerning the external resource of innovation in Indonesian automotive industry. The study will assess the state of knowledge resources from companies, universities, and research institutions. There were several previous studies on innovation in Indonesian automotive sector. However, these studies did not focus on the external resources of innovation viewed from innovation system and evolution perspective. The states of studies related to innovation in the automotive industry in Indonesia are excerpted as follows.

Aswicahyono & Kartika (2009) revealed the importance of Japanese investment in the development of Indonesia's automotive industry. Large shareholding of principals play important role to develop the automotive industry investment in Indonesia. Hiring local engineers have important function to improve technology learning to enhance local capability. Viewed from value chain, Indonesia should strive to be the attractive location of investment activities that generate high value of the Japanese automotive industry. Indonesia should attempts to shift from mere assembly to become either the regional research center or logistics service center in the global production of MNCs. Indonesia should: i) create high-quality of R&D personnel graduates from world-class university in engineering field, and ii) improve the quality of transportation and telecommunications services, those are functional to support the MNC's global production network.

Layton (2007) found out the importance of Indonesian automotive component industry to improve its quality of non-OEM component. The automotive component

industry should: i) apply the industry standard-based brands and seals of quality; ii) increase the downstream technology transfer to upgrade the product of component industries; iii) promote the selected high value of component products into the new mid-market. The application of high value standards and market based products will effectively integrate the non Original Equipment manufacture (OEM) automotive component industry from second and third tier to the higher tier. It is because the Indonesia products may not compete in price, the standardization of non-OEM product quality is a justified strategy in facing of cheaper imported products in the expanded Indonesian market.

Ricardo & Hastuti (2009) showed the results of survey on the Indonesian automotive component industry that generally performs medium level of innovation activities, namely tooling-up (improving the equipment's technological performance) and industrial engineering (making some changes and engineering on existing machinery equipments). Only certain medium scale industry performs high-level innovations such as experimental research and development, including purchasing (acquisition) of machinery with improved technological performance. There are some constraints of innovation activities in component industry namely: lack of personnel knowledge to conduct innovation activities, lack of fund to finance the expensive innovation, and risk of low sales because of loosing in price competition with imported non-OEM component products.

Riyanto, *et.al.* (2009) revealed the patterns of innovation in automotive component SMEs including product, process and organizational innovation. Product innovation tends to occur at the local small and medium enterprises (SMEs) that produces component to fulfill the demand for after-market parts. The companies exploit their creativity to meet the needs of after-market parts. Process innovation tends to occur in the SMEs by joint venture, which manufactures OEM parts according to designs and specifications determined by principals. The companies practice the innovation process such as designing process technology and shortening production process (time line) for the increase of productivity and competitiveness. Organizational innovation also tends to occur in the SME by joint venture which obtains technology management transferred from the principal. The company acquires knowledge through training on the

implementation of JIT and TQM concepts to enhance efficiency and competitiveness. The joint venture SMEs works in vertical specialization of production that is integrated with the principal, in which the key inputs of production such as trademarks, designs and specifications are defined and owned by the principal.

Dhewanto & Umam (2009) claimed that the public research institution (PRI) in Indonesia has not succeeded to commercialize automotive technology products due to low in quality and standard demanded by market. The LIPI research center for electricity and mechatronic has build and produced "electric car" the so called "Marlip", resulted from extensive research since 1998. The car has 80% local content and being available in 8 variants. The car commercialization has to find the industry for mass production. Industry has not seen PRI as external resources to acquire technology. It is therefore, government stimulus is needed to encourage industrial willingness to realize industry-university partnership.

The objective of study is to reveal external resource of innovation in Indonesian automotive industry, with special attention to the role of university and PRI. The study will answer three questions: i) what are the variations of innovation sources in the company's innovation process; ii) what are the types of innovation within the company based on internal and external resources, and; iii) how are the role of university and PRI as the external resource of company innovation. Data and information will be mapped and analyzed by using the framework of sectoral innovation system (SIS). The findings will contribute to enrich empirical evidence of the theory of innovation systems and evolution as the foundation of sectoral innovation system.

1.2. Analytical Framework

This study uses the analytical framework of sectoral innovation system (SIS) developed by Malerba (2004). Viewed from system perspective, SIS emphasizes the processes of relation, interrelation, interaction, interconnection in the system evolution. Seen from time horizon, the evolution in SIS explains how: i) the process of variation and selection inside the system occurs in the mid-term, ii) the process of adaptation in developing system capability takes place in the long term. The strength of SIS model lies in its ability to explain how and why the innovation process occurs in one sector.

How and why the processes of creation, absorption, distribution and utilization of knowledge and innovation occur in one sector or company. SIS model explains the differences between sectors or companies based on differences in the accumulation of knowledge and innovation capabilities in each sector or company. Theoretically, the SIS model is an analytical tool derived from the theory of innovation systems and system evolution.[3]

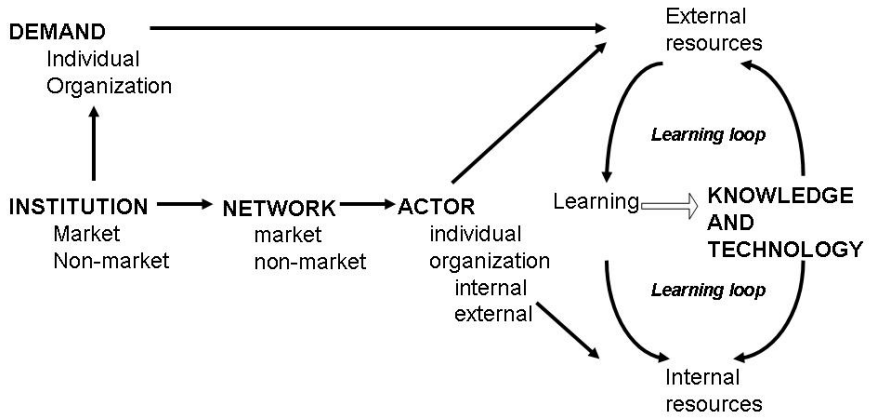
SIS model contains three main components namely: i) knowledge and technology, ii) actor and network, iii) institutional and demand. The interaction of three components in the system is exhibited in diagram below. The learning process in accumulating knowledge and technology is formed by two "learning loops", namely learning from external and internal resources. The actors, both individual and organization are external as well as internal resources in learning to accumulate knowledge and technology. Meanwhile, demand is the resources of external learning to accumulate knowledge and technology. The interaction among actors of individual and organization occur through networks, those are market and non market networks. The relations in the network are created and influenced by institution, namely market and non-market institution. The whole processes of innovation in SIS always consider and analyze the influence of actors, networks and institutions. See Figure 1.

First, knowledge and technology are the essence as well as boundary of SIS. The boundary of SIS covers the area of knowledge, technology, engineering, design, and operation. Knowledge in SIS is viewed from access and accumulation of knowledge. The access of knowledge can occur toward internal and from external sector. The access of knowledge toward internal resource (i.e. it is accessed by a competitor) will reduce the appropriateness. Access of knowledge and technological advancement from the external resources (i.e. universities, research institutions, suppliers, users) affect the sector's opportunities in innovation. Meanwhile, the accumulation of knowledge and technological capability are the results of knowledge creation and acquisition of

[3] About the integration of these two theories into a model of SIS see Malerba (2004:11-15). It is important to note that the SIS model is not relevant to explain the cluster and strategies of each sectors or companies, because the SIS does not analyze external conditions and others combinations of input factors in producing outputs such as products, productivity and competiveness derived from theories of economics and management.

knowledge in long run that comes from the whole process of innovation. The mechanism of knowledge accumulation occurs through the process of creation, absorption, acquisition and utilization of knowledge. Then, the accumulation of technological capability is the results of learning in internal resources (learning by doing, using, and searching) and learning from external resources (learning from the progress of S&T, actors' interaction, and technology spillover).

Figure 1. Sectoral Innovation System Interaction



Source: Malerba (2004)

Second, actor and network are the elements and structure of SIS. The actor is the agents of systems those compose of individual and organization. Individual actor includes consumers, businessmen, and scientists. The actor of organization comprises of companies with their internal units (i.e. R&D, production, and marketing) and external organs (i.e. users, suppliers, universities, research institutions, financial institutions, government agencies, business associations, business principal). While the network describes the ways of various actors connected in the system. The network provides road to access knowledge and technology in the system. The variations of access are characterized by market and non-market relationship. The relationships through market can be occurred through licensing, joint venture, contract, subcontract, integration, acquisition, alliances, collaboration, cooperation, competition. While non-market relationships can be taken place through consultation, dispatching of personnel to learn,

training, meeting, service, lobbying, information exchange, command, collective action, partnership.

Institution and demand are the *third* component. Institution is the law, rule, standard, norm, tradition and convention that shapes interaction and influence the actors' action in the system. The interaction of actors in the system occurs through binding contract and non-binding agreement. The binding contract can be formed by formal law (IPR, patent, trademark) and government regulation (incentive, procurement, preference, deregulation, and facility), then non-binding agreement form such as convention. Besides, market institutions such as monopoly, oligopoly and competition, furthermore non-market institutions comprises of the sociopolitical factors i.e. political guidance, collusion, and nepotism that could affect the action of actors in the system. The national institution may influence the patterns of sectoral development in a country (i.e. sectoral shift of national planning and policy directed by national agency). Furthermore, demand is an agent that interacts with producers. The agents are represented by consumers, corporations, and government sector. The interaction of agents with producer is formed and influenced by both market and non-market institutions. The demand has function as the pull factor of innovation, especially innovation for solving the problem of demand (i.e., innovation based on input from users and suppliers).

The application of SIS framework in this study has some advantages to achieve the objective of studies. i) it facilitates to indentify the variations of elements combination in the company's innovation based on interactions in the system; ii) it assists to categorize the type of innovation within the company based on internal and external resource, and; iii) it makes the ways to analyze the role of university and PRI as external resources of innovation for automotive industry. The analysis based on information from interviews and secondary data of ten companies, universities, PRI, business association, and government agency.

1.3. The Structure of Report

This report is structured as follows. The second section will explain past trends and current developments in Indonesian automotive industry. The description focuses on mapping the main factors that has shaped the dynamics of the Indonesian automotive industry in the long run. The third section will explain the evolution of Indonesian automotive industry, viewed from dynamic capability. The patterns of evolution will be explained by the dynamic of company's ability in absorbing knowledge, developing network and capacity building. This section becomes the foundation of innovation sources that will be described in next section. The fourth section will elaborate the findings of study; focus on the combination of system elements (both internal and external resources) that have contributed to innovation in the Indonesian automotive industry. The fifth section will analyze the findings emphasize on the role of university and PRI as an external resource of innovation in the Indonesian automotive industry. Then the sixth section contains conclusion especially about the role of university and PRI as external resource of innovation in automotive innovation. And lastly, the report will be ended up with policy implication as the ways forward to strengthen the role of university and PRI as external resource of innovation in the future.

2. Overview of Indonesian Automotive Industry

2.1. General Trend

In the long run, the general trend of automotive production in Indonesia showed three patterns, which associated with national economic growth in the year 1976-2010. *First*, car production rose slowly from about 100 thousand to the stable number at around 150 thousand per year in 1976-88. This situation was consistent with stable economic growth of 5-6% in that period. *Second*, car production increased rapidly from around 100 thousand to the peak number about 400 thousand in 1989-1997. This condition was coherent with high economic growth of 7-8% in that period. Then production dropped drastically to around 50 thousand due to economic crisis with

negative growth of -13% in 1998. *Third*, car production rose again from about 50 thousand to around 600 thousand per year in 2000-2008. This condition was in line with economic growth constantly increased after recovery in the early 2000 toward a stable growth between 5-6% in last five year.[4]

In the short run, the fluctuations of car production related to the impact of government policies towards economic development and automotive industry. In the 1970s, the policy of prohibiting car import in form of complete build up (CBU) encouraged the establishment of assembling company to assemble complete knock down (CKD) components. The CKD components were imported by the sole agent of brand holder (ATPM). In the 1970's, there were 20 assemblers producing more than 50 brands. Three major assemblers groups were TAM, IM and KTM. Then in 1976, government policy, that was called deletion program, encouraged the use of local components by applying high tariff to imported components. Production of car increased, although local companies were only able to produce simple components, but the main component and the complex one was still remain imported. The car production depressed due to the expensive price of imported components, which were triggered by the devaluation of rupiah exchange rate policy in 1983 (27%) and 1986 (31%).

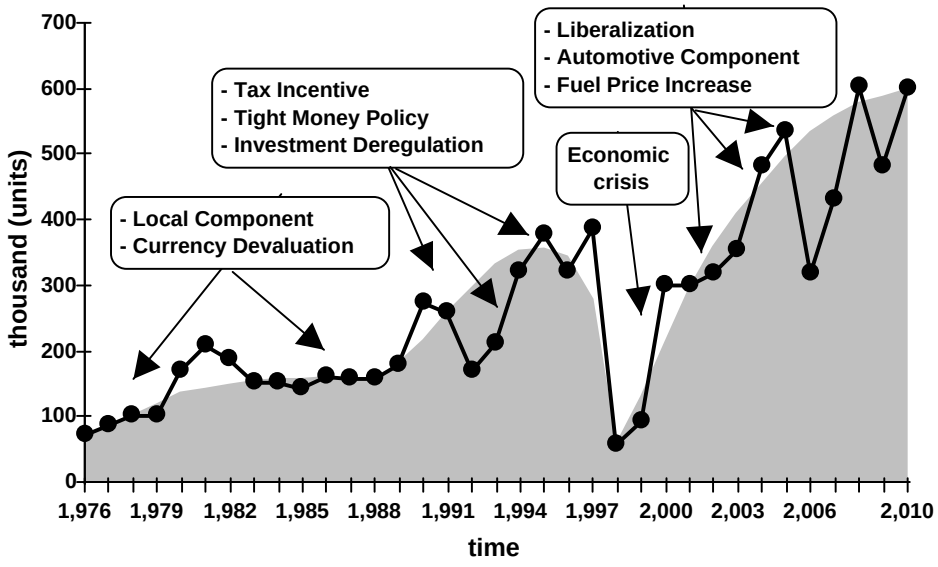
In the 1990s, car production increased rapidly, although it was temporarily depressed by tight monetary policy in the early 1990s. There were several policies that had encouraged automotive production. *First*, automotive policy package of 1993, namely the reduction of import tariff and providing the incentives associated with the use of local content. The higher the local content becomes the lower the tariff of the residual imported content. *Second*, the package of investment policy of 1995, namely the deregulation of automotive investment to produce a new car and setting the year of 2003 as the time limit of import tariff reduction. This policy encouraged the emergence of ideas, such as: i) designing a new car by own creation (Maleo sedan), ii) producing a new car (car people) with high local content, and, iii) producing a new car (national car) with Indonesian brand (Timor). The designated company was able to produce Timor

[4] About factors that influence the dynamic growth of Indonesian economy in the long run, see also Aminullah (2007)

brand supported by providing import tax exemption associated with company planning (it was not realized) to fully use the local content in stages within certain period. This special incentive in automotive policy was questioned by others car producers.

In 1997, economic crisis hit production car to the bottom line. Due to economic crisis, the idea of producing the new car's by self creation was no longer relevant. The national car production was unable to compete and terminated according to the recommendations of WTO body on dispute settlement. After the economic crisis of 1997, Indonesia's automotive production again rose sharply as the impact of liberalization policy in automotive sector by non-tariff barriers removal and tariff reduction. The increasing trend of automotive production since the 2000s has been supported by government policy to encourage exports, strengthen the domestic market, and improve the industrial structure by developing automotive component industry. While a temporary declining production occurred in 2005-2006 was suppressed by the increase of fuel price at that time. See Figure 2.

Figure 2. Trend of Automotive Production in Indonesia (1976-2010)

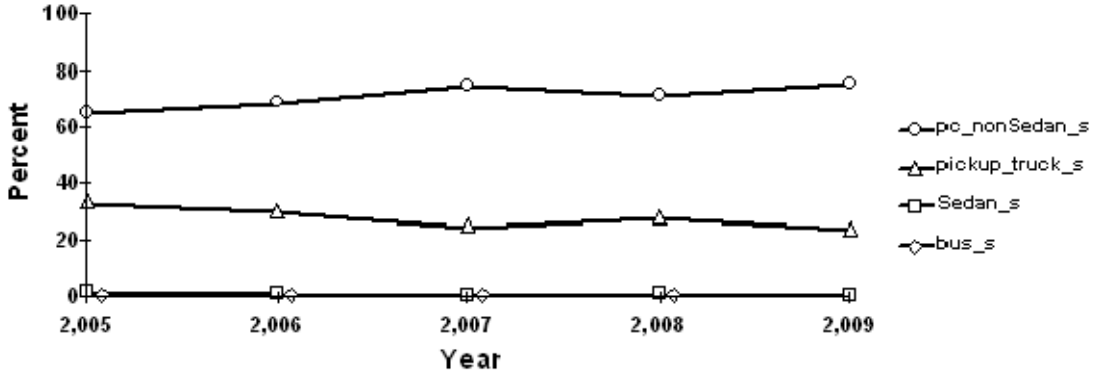


Source: The Association of Indonesian Autonotive Industries (Gaikindo)

2.2. Recent Situation

The recent situation was the latest trend from 2005-2009, the automotive industry in Indonesia was still very dependent on the production of passenger car non-sedan, which was referred as car category I generally used as commercial car as well as multi-function passenger car (MPV). The production share of passenger car category I was around 68%, subsequently followed car category III (pickup and trucks) about 30%, and the remaining was car category II and IV (sedan and bus) around 2%. The production of commercial car tended to increase in the last five years. The commercial car was designed solely to meet Indonesia's domestic market, making it difficult to export. See Figure 3.

Figure 3. Automotive Production Share by Category in Indonesia (2005-2009)



Automotive Production by Category in Indonesia (2005-2009)
in units

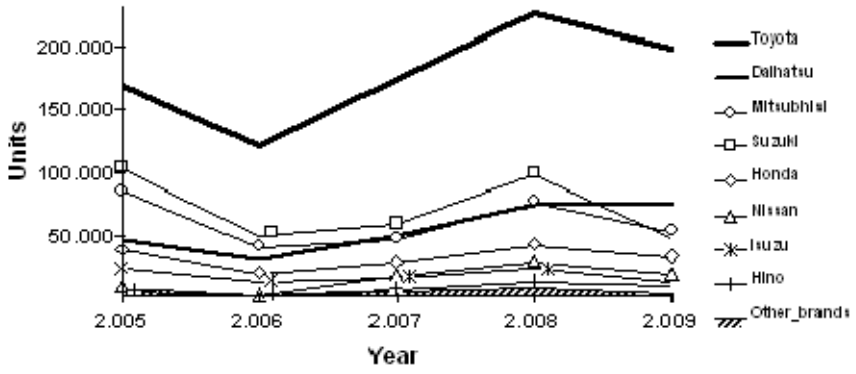
Time	pc_nonSedan	pickup_truck	Sedan	bus	Total_production
2,005	326362	165691	6228	2429	500710
2,006	204313	88433	2008	1254	296008
2,007	307638	100754	1570	1676	411638
2,008	425500	166249	5923	2956	600628
2,009	349805	110316	2367	2328	464816

Source: The Association of Indonesian Automotive Industries (Gaikindo)

Car production in Indonesia was almost absolutely controlled by Japanese brand around 98.5%. Toyota dominated the Japanese car production in Indonesia. The share of Toyota rose from 33% (2005) to 43% (2009) after taking the share of Suzuki and Mitsubishi, which decreased respectively 10% and 5% in the same period. The second place was Daihatsu. The Daihatsu share increased from 10% (2005) to 16% (2009) also

by taking the share of Suzuki and Mitsubishi. While the Honda managed to defend its stable market share of 7%. Top five brands of Toyota, Daihatsu, Suzuki and Mitsubishi hold 87 of Indonesia's automotive production. The remaining 13% are shared by the three Japanese brands (Nissan, Isuzu, and Hino) and nine other brands (Mercedes, Nissan Diesel, Hyundai, BMW, Cheri, Mazda, Peugeot, and Chevrolet). See Figure 4.

Figure 4. Automotive Production by Brand in Indonesia (2005-2009)



Automotive Production Share by Brand In Indonesia (2005-2009)

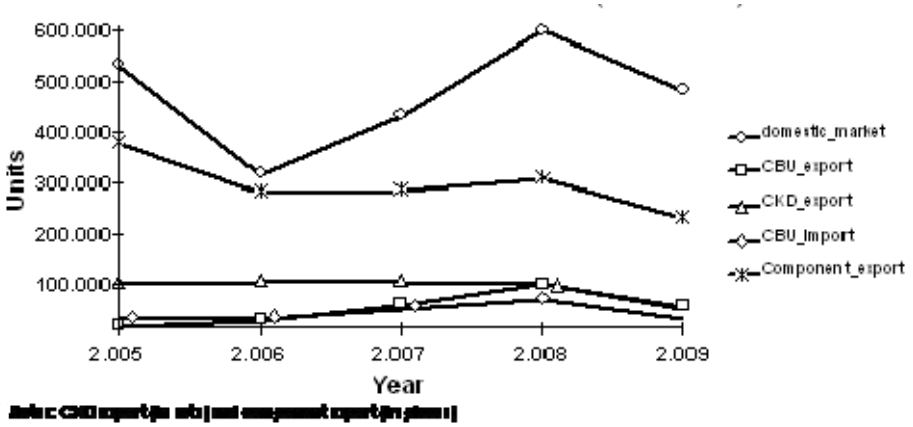
Brand	2.005	2.006	2.007	2.008	2.009
Toyota_	33,79	41,29	41,89	37,61	42,61
Daihatsu_	9,73	11,17	12,24	12,69	16,58
Mitsubhisi_	17,23	14,18	11,70	12,97	11,56
Suzuki_	20,74	17,53	14,58	16,36	10,70
Honda_	7,91	7,11	7,16	7,27	7,41
Nissan_	2,15	1,14	4,50	5,04	4,31
isuzu_	4,90	5,14	4,26	4,07	3,19
Hino_	1,44	1,09	1,99	2,39	2,50
Japan_brands	97,89	98,65	98,31	98,41	98,86
Other_brands	2,11	1,35	1,69	1,59	1,14

Source: The Association of Indonesian Automotive Industries (Gaikindo)

The sales of car in Indonesian domestic market in the last 5 years reached to 500 to 600 thousand per year. The CBU car export from and also import to Indonesia have showed the trend of positive growth. While, the CKD car and the auto components that export from Indonesia have showed the trend of negative growth. The declining trend in the competitiveness of automotive component was shown by negative growth of -10% in the period 2005-2009. Due to lack of competitiveness in export markets, resulting in the Indonesian automotive market was still dependent on the domestic market. This is confirmed by the facts that car production for the domestic market was much larger than

for export, both CBU car and automotive components. Then, seen from the CBU car trade balance, the pattern and volume of CBU car import was not much different from CBU car export. See Figure 5.

Figure 5. Automotive Trade in Indonesia (2005-2009)



Automotive Trade Growth in Indonesia (2005-2009)

Time	_domestic_market	r_CBU_import	r_CBU_export	r_CKD_export	r_Component_expor
2.005					
2.006	-40,27	5,99	73,96	2,46	-25,04
2.007	35,88	63,72	94,57	-0,26	1,88
2.008	39,33	31,82	67,56	-1,83	7,09
2.009	-19,91	-55,02	-43,88	-48,76	-25,21

Source: The Association of Indonesian Automotive Industries (Gaikindo)

Indonesian domestic market is fragmented into 30 car brands and dozens of models. See Table 1. Five top brands (Toyota, Daihatsu, Mitsubishi, Suzuki and Honda) controlled 85% of the domestic market. The remaining 15% was shared by the brands of the Japanese car (Mazda, Nissan Diesel, Subaru, and Lexus), the European car (Mercedes, BMW, Volkswagen, Audi Peugeot, Renault, Land Rover, Jaguar and Volvo), the Chinese car (Photon, Cherry), brand from Korea (KIA, Hyundai, Timor, Ssangyong), the American car (Chevrolet) and the brand of Malaysian car (Proton). Among those brands there were five top models (the Toyota Avanza, Toyota Kijang, Daihatsu Xenia, Suzuki Carry/Futura, Honda Jazz) dominating the domestic car sales. The models changed rapidly in accordance with the dynamic of market demand. The

fragmentation of market by several models to meet the low demand was supported by easing the import of CBU and OEM parts to update the model. Consequently, the domestic components industry was less developed, except to produce non-OEM parts, ancillary parts of low value and generally produced by labor-intensive to meet the demand of after-market.

Table 1. Domestic Market Share by Brands in Indonesia (2005-2009)

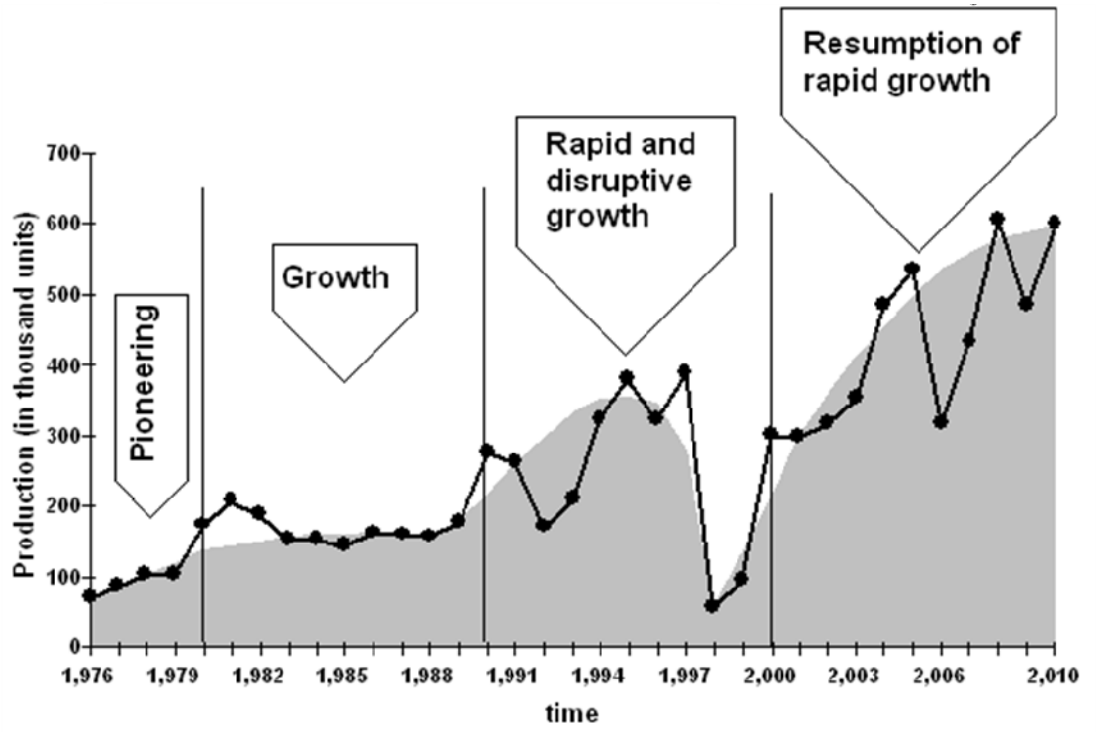
Brand	2,005	2,006	2,007	2,008	2,009
Toyota	34.23	38.79	34.76	35.10	38.61
Daihatsu	8.76	10.35	11.99	12.93	16.03
Mitsubishi	16.70	14.75	14.20	14.50	12.77
Suzuki	16.35	14.04	13.41	12.10	9.24
Honda	10.07	9.41	9.23	8.70	8.18
Top_five	86.10	87.33	83.59	83.32	84.83

Source: The Association of Indonesian Automotive Industries (Gaikindo)

3. Evolution of Indonesian Automotive Industry Viewed from Dynamic Capability

Evolution as shown in the company's life cycle explains the dynamics of company's ability in absorbing knowledge, developing the network and capacity building. The dynamic capabilities play important role in explaining the different patterns of long-term corporate performance. It is become the foundation of innovation resources that will be described in section IV. These capabilities are integrated in the phases of evolution that is reflected by industrial growth in the long run. There are four phases of evolution based on production growth in Indonesian automotive industry in the period of 1970s-2000s, namely pioneering (1970-1980), growth (1980-1990), rapid and disruptive growth (1990-200), and resumption of rapid growth (2000 - present). See Figure 6.

Figure 6. The Stages of Growth in Indonesian Automotive Industry (1976-2010)



There are three types of capabilities that functionally describe the phase of company's evolution. *First,* absorptive capacity is the ability of company to absorb, understand and exploit external knowledge. The variations in absorptive capacities explain the differences in the patterns of company evolution. *Second,* the ability to positioning the network will determine the stability and strength of networks in exploiting external knowledge sources. The more unstable the network is the greater the intensity of interaction and the opportunity to access external knowledge source. *Third,* the company's ability to develop, expand, diversify i.e. to serve new markets. The dissimilarity in companies' expansion creates the diversity among companies and it adds the differences in company evolution. (terWal, *et al.* 2007)

3.1. Pioneering Phase (1970-1980)

In the pioneering phase, the formation of dynamic capabilities in Indonesian automotive industry relies on the inter-firm network relationships with partners, both domestically and internationally. Companies that have stable business network tend to have the support from partners in developing their business. The success of selecting partners is determined by social networks (the role of influential actors) in the network.[5] The dynamics of company's ability to build and strengthen its networks in the pioneering phase is determined also by factors such as opportunity, stimulus and protection from the government's role.

3.1.1. The emergence of automotive industry network

Historically, there are three groups of business that control the production of automotive industry and car market in Indonesia, namely KTM, IM, and TAM. The emergence of three business groups occurred in 1970s.

KTM was founded in 1969 as the agent and assembler of Mitsubishi car, then become the agent of Nissan car. Meanwhile, IM began with Volvo dealer in 1973, and then IM produced Suzuki ST20 in 1978. Furthermore, TAM was established in 1971. TAM was a joint venture of AI and TMC with shares of 51% and 49%, where the AI was the sole agent of Toyota car in 1969 and the dealer of Honda motorcycle in 1970.

The new automotive industry emerged in several ways, namely: *First*, the development of business agent, i.e. MF formerly was controlled by AI then became the agents of Peugeot and Renault. *Second*, the acquisition of weak company was to strengthen the business position. i.e. AI took over GM automotive factory in 1968. *Third*, the development of partnerships with foreign company, i.e. UDT made agreement with GMH to assemble Holden from imported CKD in Surabaya factory in the 1970s. (Chalmers 1996)

In the pioneering phase, the development of business occasionally required the support of social networks mainly the influential actor, both from government or private sector. The success of AI as the sole agent and assembler of Toyota was through

[5] The role of influence actors in changing the government-business network was confirmed by the findings of Adnan. For more details, see Adnan (2010)

personal networks with actor (former economic minister 1950-s) who had a close relationship with Toyota. Thus, AI became the partner of Toyota expansion in Indonesia, by positioning the GM that was controlled by AI as the Toyota assembly plant.

The development of TAM in pioneering phase was recognized by its products such as Toyota Hi-Ace, Toyota Dyna L, T Daihatsu V22 V23 RH and RT. The availability of these products in the market indicated the ability of corporate networks to develop, expand, and diversify. The expansion of company networks created the company's business diversity. TAM imported Toyota Car in CKD and re-assembled in a factory assembly line in 1972. In 1973, TAM played as the dialer of Daihatsu car and Komatsu heavy equipment. TAM built MA as car assembling factory in 1974. Then, in 1976, TAM built MBD an iron processing factory.

Furthermore, KTM business activity in pioneering phase was initially considered as a determinant toward full manufacturing process in Indonesia. KTM focused on the production of commercial car, with production quantity amount to 20,000 in 1977. The KTM's product the so called Colt T-100 pick-up was in the frontrunner, and then it was developed into minibus and car station, namely: Mitsubishi Colt T-120. Besides, KTM also produced Mitsubishi FE101 or FE111 and Datsun 1N-20. While, at that time the IM was still producing motorcycle Suzuki with 2 stroke engine.

3.1.2. Government role

There are some factors including opportunity, support and protection, which were provided through government regulations that had influenced the emergence and development of automotive industry in Indonesia. The first regulation in 1969 was about i) setting the location for the dispersion of assembling companies, ii) the recognition requirements for companies as the general assembler and local assembler, and iii) the obligation of imported commercial cars in CKD form.

In 1972 the government issued some regulations concerning: i) the sole agent company, car and heavy equipment assembling were not allowed to foreign companies, and ii) all activities of sole agent and car assembling need to be united, so that import and car assembling were done by one company. As the result of grouping since then

there were 20 groups of sole agent-assembler. Furthermore, in 1974 the government set the level of CKD provision for commercial car, sedans and station wagons.

Before government enforcing the mandatory use of local components in 1976, the used of local components actually occurred in car category I, there were 6 of the 14 brands used local components. In category II, 5 of 8 brands, used local components. In category III, 9 of 19 brands used local components. In order to speed up the use of local component, government restricted car import by encouraging the use of local components. In 1976 government set 100% in the tariff of import duty and domestic sales tax for sedan, 50% for components and 0% for commercial cars. Furthermore, the government obliged (if it does not comply with then the sanctions imposed), the assembler, and its car agent is within the same group, to use local components in doing car assembling. The government stimulated the growth of local component assembling in Indonesia, by raising CKD sedan tax 200% of the import price, plus 10% import duty, plus 30% luxury tax of the sales price and plus10% user's name customs of the sales price.

In 1977 the government enforced import ban for certain products, although without a clear sanction, including the simple products (paint, batteries and tires) and gave a deadline of universal products (such as shock absorber, window, exhaust, radiator and chassis) within 3 years in 1980, and special products (like wheel drive, clutch and axle) until 1984. In 1978, the government implemented the deletion program of replacement of imported components with the local component, which was associated with import tax. If a certain number of local components did not meet, then a penalty in the form of tax increase was imposed. The purpose of deletion program was also to reduce the number of brands and models of car in the fragmented market. The reality shown the opposite event, in 1974 there were total 12 brands and 21 types, then in 1976 it increased to 42 brands and 130 types, then before the year 1980 it again increased to 51 brands and 147 models.

3.2. Growth Phase (1980-1980)

The growth phase in Indonesian automotive industry is characterized by some following phenomena. The emergence of new car designs is pulled by market demand for new products. The company's ability to absorb, understand and exploit external knowledge in developing new designs increases significantly. The number of brands and models of car become more varied and growing rapidly. Marketing network and service grow and compete tightly. The competition among companies in design, price and service become tensely to get a central position in the market. The ability in doing expansion, acquisitions, diversification, and spin-offs become the indicator of company position. Inter-companies network in a business group is becoming more integrated and stable.

3.2.1. Design and brand competition

Until the early 1980s, the market of commercial car in Indonesia was dominated by KTM products mainly Mitsubishi Colt T-120. Furthermore, IM was initially producing Suzuki motorcycle ST 20 with 2-stroke engine. In 1982, under the license of Suzuki Japan, then IM developed the 4-stroke engine, IM modified the engine to produce Suzuki car ST100, the car successfully occupied the top place after beating Colt T-120. Then, the position of Suzuki ST100 was taken over by Daihatsu Hi-jet and Zebra produced by TAM.

The competition in commercial car occurred among the brands of Toyota Kijang, Suzuki Carry and Daihatsu Zebra. As for sedan, the competition occurred in the brands of Honda Civic, Toyota Corolla, Mazda 323 and Nissan Sunny. They compete on price, incentives and service delivery. Suzuki Carry brand that occupied the top place in 1986 then shifted down in 1987 after the appearance of Toyota Kijang and Daihatsu Zebra.

The sharp competition in design and brand was driven by the imperative use of local components as well as by the support of principal. The high usage of local components was encouraged by incentive in form of tax deduction that resulted in creating some Indonesian version of car designs such as the Toyota Kijang, Daihatsu Hi-jet Zebra, Mitsubishi Colt, and the Suzuki Carry. In 1988 Daihatsu Hi-jet Zebra managed to use about 90 percent local components. TAM created two alternative designs to their car,

that is, the Eagle Wing 1 and Venus, which used the engine Daihatsu Hi-jet. The creation of new designs happened with the support of principal. Meanwhile, for those who did not get the support of principal, including the Datsun Sena, VW Mitra and Dodge Sembrani were finally out of the market. In the late 1980s the market for commercial cars were still controlled by Mitsubishi, Daihatsu, Toyota and Suzuki. These four brands, dominated the market amount to 92.4% of total sales of commercial car (excluding Jip) in 1986.

3.2.2. Government role

The role of government in the growth phase relates to the issue of low economic of scale and dependency on imported component. The low economic of scale needs to be improved by reducing the number of car brands and models. By meeting the economic of scale it will increase investment to support the localization of automotive components.

The amount of production for every brands was low, it was because of small market contested by many brands. Only 10 of 30 brands those were able to sell more than 20,000 units per year. To achieve the economics of scale, in 1980 government announced the rationalization program of car brands and models. The number brands should be reduced from 57 to 30 and from 140 to 72 for the number of models. In 1981, the government set about rationalizing the brands and models by consolidating 22 sole agents and 20 assemblers into 8 groups. Rationalization by grouping the companies was expected to increase the efficiency of assembling that encouraged initiatives to increase local content. However, the program implementation did not work properly.

There were two important factors inhibiting the implementation of rationalization program through companies grouping. *First*, the uncertainty of deletion program implementation that was opposed by a high ranking government official, who wanted the implementation should be left to the market mechanism. *Second*, the non-consistency of policy execution dealt with the automotive actor who closed to influentially political power. For example, rationalization program failed to ban the import of Opel car because of strong reaction from Gaikindo (to protect a politically connected the license holder of Opel) that requested postponement the mandatory use of local components in a sluggish economy.

To spur the making and use of local components, in 1980 the government set the time schedule for the mandatory use of local components. The weakness was lack of policy coherence to improve the competitiveness of automotive components. For examples in 1980, import duty of spark plugs was 20 percent, import duties of raw materials for making the spark plugs from were 10 to 40 percent. With such higher import duties of raw materials, the local component became more expensive and less competitive to imported components. Besides, the number of forged components was distributed due to lack of government control. Such high government intervention led to high inefficiency (Aswicahyono, *et al*. 2000).

The deadline for the mandatory use of local components was as follows. In early 1984 the local components were wheel rim, cabin, chassis and frames for commercial cars category III and IV. In mid-July 1984 the local component comprised of a rear axle and propeller shaft for the commercial vehicle category I and IV. In early 1985 local components included engines (petrol and diesel), axle and propeller shaft for the commercial vehicle category II, III, and IV. In mid-1985 was brake system. And in early 1986, local components included transmission, steering system and clutch system.

In 1987 the government set full manufacturing program by enforcing the master list of car assembly and components. The automotive industry was forced to use 178 components for LCV (Light Car Vehicles) which was equivalent to 73% of the content of whole CKD components in a car.

3.2.3. The development of firm capacity

The ability of companies in expansion, acquisition, diversification, spin-offs reflect the differences in the evolution process of each companies group (KTM, IM, and TAM). The capacity differences among companies depend on the differences in principal support to expand the investment. The more integrated the network of group will be the greater the company capacity to invest.

KTM

In 1983/1984 KTM established CEM engine plant and managed to make some import substitution components for commercial cars. CEM as a subsidiary of Mitsubishi group was a joint venture between MC, MMC and KTM with the share of each companies 40:40:20. Then the KTM set up a second engine plant in 1985.

IM

In 1981, after the IDH Group injected fund from investor (the owner of Volvo agent company), the group turned into IM. In 1984, the IM group developed companies NM and UPM as the car assembler of Mazda, Hino, as well as Binter motorcycle. Then the IM took over the agents of Datsun, Nissan, and Volkswagen. IM was in a strong market position after the entry into IDH group in 1982. IM was a sole agent as well as assembler of some car brands with its core business as the Suzuki car assembler under the company ZIM.

TAM

TAM in the AG established the first Toyota engine plant in 1985. AG consists of AI, TAM and AHM and some companies those were included in the AI, such as AO in field of automotive component. AG built TEI a machinery manufacturing plant in 1982. Three factories MA, MBD and TEI merged into the TAM in 1988. After the merger, TAM started to build automotive machine plant. TAM continued to revitalize its product quality by building the new factory in 1989 and 1996.

3.2.4. Dynamic capability under market pressure.

The growth of Indonesian car market encouraged large investment in the early 1980's. The fall in oil price and global economic recession created market conditions that pushed companies operated far below capacity in 1985. For example GKD a producer of chassis for commercial car operated by 22% of capacity. In a car engine industry, from the existing of seven companies in engine assembler only one company was healthy, i.e. SEI, while the rest operated far below capacity. Company TEM had a

total capacity of 72,000 units of machine per year and 2 shift work in 1985, operated only one shift work. Then production of engine by MDII was 30% of capacity. Such a low productivity reflected low performance of automotive industry (Okamoto & Sjoholm 2000).

Almost all car brands experienced a declining production drastically due to market pressure from the sluggish economy, except for a few car brands that were not affected by recession, i.e. the Toyota Kijang and Suzuki Jimny. In 1985 Suzuki was ranked 4th after Mitsubishi, Toyota and Daihatsu, except for the case of Jeep Suzuki brand managed to dominate the market by 50%, followed by 30% for Daihatsu Taft and the rest divided between the Toyota Landcruiser and the CJ-7. The year 1987 was Toyota Kijang first export to overseas like Brunei and Papua New Guinea. At the same time TAM also exported auto components to Taiwan and Venezuela until the late 1980s.

Among the various brands of sedan car, Honda still controlled the market in the recession with the market share about 25.4% of sedan car in Indonesia. The enforcement of sales tax for luxury goods with the average rose 10 percent, did not affect the marketing of sedan car, even some of brands and models were getting strong its market position, i.e. BMW. This was supported by the after sales excellent service of Astra that took over the sales of BMW car from company TS.

3.3. Rapid and Disruptive Growth (1990-2000)

The rapid and disruptive growth in Indonesian automotive industry showed rapid growth at the beginning (1990-1997). That was characterized by: market expansion, the increase of new entrants, the emergence of design innovations, intensified price competition, gradual deregulation to increase efficiency. But this early rapid growth followed by suddenly declining growth (1998-2000) because of the inability of company to overcome shock from the economic crisis. As the results, the demand fell drastically, the company was operating under capacity, with a very high cost, eventually went bankrupt, and industrial growth was interrupted.

3.3.1. New Entrant in Automotive Industry

In this phase, the market of automotive business was increasingly competitive with the emergence of new brands, such as taxi cab Proton imported from Malaysia. In addition, the government responded to the idea of establishing a national car industry with its own brand. The Government encouraged local entrepreneurs to find alternative principals who were willing to work together to encourage the development of the national automotive industry. In 1996 the government selected and determined that the principal from Korean automotive, namely KIA Motors. The company was provided with tax break facility to build Timor as national car brand. The tight market competition in developing new car industry was unavoidable with the entry of Hyundai brand from Korea, in cooperation with local entrepreneurs to produce Hyundai car under Indonesia brand, namely Bimantara Cakra and Bimantara Nenggala.

In 1990, new car industry ever initiated by IM that developed, produced and marketed the sedan car branded as “people car” (MR90). The new car development was supported by the principal from Japan, however it was unsuccessful in the domestic market, due to: i) the technology was regarded as absolute for the similar kinds of sedan and, ii) lack of government support for the car to compete in domestic market. The development of Indonesian branded car was not limited to sedans, but also in the truck category. The TXC a giant factory in field machinery, with the support of imported technology from Austria and England, was able to produce car truck namely Perkasa. The presence of this truck factory had the support from government procurement in the form of trucks purchasing to meet the needs of specific public sector, such as military truck and fuel tank vehicle. All new entrants in automotive industry practically went bankrupt after hitting by economic crisis 1998.

3.3.2. Technological Innovation

IM launched sedan car MR-90 that was claimed as the indigenous product of Indonesia. Furthermore, the company of Group BB designed and built its own car prototype, called Beta. Then, a consortium of government agencies consisting of BPPT, Pindad, Bappenas, Ministry of Industry and private parties of JM conducted a study and a very serious activity since 1992, and planned to launch a sedan car “Maleo” in August

1995. The technology was derived from British Leyland. The prototype in the form of clay models was successfully prepared. However in mid 1995, the government signaled that the project was temporarily postponed.

On the other hand, TAM expanded its factory in 1992 and then developed a third generation of Toyota Kijang with eight variants consisting of 2 types of chassis (long and short). In 1996, TAM also launched a fourth-generation of Toyota Kijang, features with a more aerodynamic exterior design. In 1991, KTB also launched the Mitsubishi Colt T120SS which was technologically improved from the previous model of Colt T120. Moreover, KTB had claimed that the local content of Colt T120 SS more than 80%, because the various OEM components for the car had been produced by the group of KTB. Then, IM declared that they successfully managed transfer of technology in the automotive industry because they were able to produce OEM engine blocks and cylinder head which were used in Nissan MR90, Suzuki Carry and Suzuki Jimny. In this phase, the sole agent companies applied the full pressed body technology for car assembling.

3.3.3. Government Role

The government policy in this phase could be distinguished by two types. From the early to the mid 1990's, the government tended to continue the policy of economic liberalization as it had been running since the mid-1980s. The government lifted the import ban for car in CBU form. Although, the government determined the import duty of 200% for the CBU car that has been produced in the country, but if not, then it will be subject to additional import duty of 100%. With this policy, the imported luxury CBU car such as Jaguar sedan and station wagon Ferary and the Land Cruiser, Pajero, Cherokee, Ranger Rover and Discovery in reality continued to augment car market in the country.

In 1996 the government issued a controversial policy of giving privileges to TPN company to became an assembler of Korean car and make it as a national car. The policy created criticism from automotive business in country as well as abroad especially the automotive principal from Japan. As consequence, the government eventually withdrawn the policy in the early 1998, by revoking the decision of appointing TPN as a sole producer of national car.

3.3.4. Competition and Economic Crisis

The market of commercial car for the category I was still controlled by two business groups namely TAM with Toyota Kijang and Daihatsu Zebra then IM with Suzuki Carry. As for the sedan category that had traditionally been contested by the HDI with Honda Civic, KTM with Mitsubishi Lancer, TAM with Toyota Corolla and Toyota Starlet then IM with Suzuki Baleno. These brands had been challenged by suddenly arise of sedan Timor (national car). In 1997 Timor successfully managed to dominate the sedan market around 40.8%.

The economic crisis that occurred since October 1997 had serious impact on the growth of automotive industry in 1998-1999. Car market drastically showed decreasing sales by 85% in 1997. The figure of car sales was about 15-20% of the number before the crisis, which was around 60 thousand in 1998 and 90 thousand units in 1999. The situation resulted in very inefficient production with very far below capacity, heavily indebted financing, and the downfall of stocks market value. Finally due to economic crisis all new entrants in the automotive industry pulled away and old players tried to survive with the help of its principals.

3.4. Resumption of Rapid Growth (2000-present)

The insolvent companies caused by the economic crisis went out from business. The companies that still had hope to live after the crisis were saved by fund injection from its principals. Eventually, the companies have regained their market position after changing the shareholders toward totally controlled by foreign investment (MNCs). Since the year 2000, the era of MNCs operation has developed the technology capability of Indonesian automotive parts firms (Rajah & Amin, 2010). The MNCs have worked based on the most efficient global supply chains, by managing regional automotive component supply among subsidiaries operating in several countries. The MNC tends to transfer technology with lower risk i.e. to its subsidiary rather than third parties. If the technology in form of general knowledge that is possibly accessible, then the transfer of technology is done through licensing from MNC to company subsidiaries, they are generally automotive component companies. If the technology is difficult to access due

to un-codified and difficult to understand, it is still produced by the principal to prevent rapid imitation.

3.4.1. Rapid Growth and Competition

After experiencing the market fall with automotive production was only (15%) in 1998 and (20%) in 1999 of the production before the crisis. Within two years after the economic crisis, Indonesia's automotive market return exceeded 300 thousand units in 2000 and experienced a slight and consistent increase by the year 2005 to around 400 units. Towards the end of 2010, car production in Indonesia is estimated to number 700 thousand. This figure shown the automotive industry in Indonesia start to proceed a rapid growth again.

As in previous years, the market leader of automotive competition in Indonesia rotated among the giant brands originating from Japan. Throughout this phase, the production Toyota car remains the market leader with the backbone of Toyota Kijang Innova and Toyota Avanza. To better control of the market, TAM also made a joint production and marketing with its owned business group by launching twin car from Toyota Avanza namely Daihatsu Xenia. To maintain customer loyalty, TAM encouraged customers association namely AXIC (Avanza-Xenia Club). For the luxury sedan category Toyota Camry replaced the market position of Volvo as the car for high ranking government officials. Then in Van category TAM also is successfully selling luxury Toyota Alphard that that became the car some members of parliament and police.

On the other hand, IM launched its new product innovation, Suzuki APV a larger version of its minibus Suzuki Carry. Furthermore, IM also launched its new products Suzuki Aerio the sedan hatchback category. IM was also success for the SUV category with the Honda CRV. IM once ruled the market with Nissan Terano jeep category. For the sedan category with a capacity below 2000 cc engine has been controlled by Honda Jazz since the mid 2000s. In this rapid growth phase, KTM launched the Mitsubishi Kuda. As for category of sedans and jeeps KTM does not manage to repeat its success as in the 1970s and 1980s. Meanwhile, the Korean car Hyundai and KIA still survive in the market with a small segment. Then, the car from Malaysia and China are also entering the market but they have not been able to compete with Japanese car.

3.4.2. Government Role

Different from the previous phases, since 2000s the government no longer interfere substantially in the development of automotive industry. The regulations issued by the government are more related to lowering tariff, opening domestic market as well as export promotion, and then no longer regulate the use of local components.

The government's role since then has limited as a facilitator by creating the climate of healthy competition. As appeared in the 1999 automotive policy package, which aimed to encourage export of automotive products, promote the domestic market after economic crisis and strengthen the structure of automotive sector by developing the components manufacturing industry. Incentive program was abandoned and import duty was reduced by half. The car assembling company and component industry those conduct training and R&D in the field of car technology get tax facilities in accordance with law and regulation.

It is expected that through this policy the automotive industry will be highly efficient and competitive, with the focus of development on upgrading the automotive components industry, expanding the automotive industry for commercial car with capacity less than 5 tons, and building the automotive industry for sedan car with the capacity to 1500 cc. The industrial expansion was supported by progressive investment policy that since 2007 it has been no longer required local partner majority ownership and the permit of land management increased from 30 to 80 years.

The implications of this policy are: *first*, various types and brands of luxury car in CBU form re-entry into the domestic market, such as Jaguar and Lexus. *Second*, the number of CBU car importer increases and the competition becomes increasingly tight, because local products have to compete with imported products that has forced the local manufacturers to improve products quality. Furthermore, in line with post-crisis economic recovery, and followed by stable economic growth in last 5 years, the quantity of automotive production and sales has grown rapidly again as described in previous section.

4. The Resources of Innovation in Indonesian Automotive Industry

4.1. Types of Innovation and Source of Knowledge: Ten Companies

4.1.1. Company 1: TAM

i. Innovation in business organizations

TAM was established in 1971 by AI and TMC. AI previously was a trading company in the automotive business. TMC was a Japan corporation in automotive industry, which played a key role in the innovation of TAM business organization.

Business organization of TAM is integrated from upstream to downstream. Business of TAM includes production plant, component manufacturing and distribution. The products produced by TAM comprise of Toyota, Daihatsu, Isuzu, Nissan Diesel Trucks, Lexus, Peugeot, and BMW. TMC conducts technology transfer to TAM through the establishment of various plants both for body assembling and component manufacturing. MA company was an assembling plant of Toyota car established in 1974. TM company was a printing and welding plant established in 1977. TEI company produced car engine established in 1982. During the year 1980-1984, TAM managed to build eight automotive components plants such as chassis, brakes, and engine block.

TAM organization did vertical integration in 1988. Three assembling companies merged into TAM to increase efficiency and maintain quality of automotive components. TAM also conducted horizontal integration, i.e. by setting up several subsidiaries such as AIC company in the field of credit financing, then A2000, M88, and GA companies in the fields of distribution, marketing and assurance. Besides, TAM applied the strategy of cross-ownership among their companies. So that, companies under TAM get multiple benefits of product quality, cost efficiency and market control against competitors. (Sato 1996)

To meet the market demand, TAM organization has the customer division which specially serves the request from the government. Through the Government Sales Order (GSO), the special service of TAM car sales to the government will be perceived as not

the same with other services of car sales agents. In short, to win the competition in automotive industries TAM is not only provided good quality, price and service but also institutionally embedded the special service in business organization.

ii. Innovation in industrial management

TAM was the pioneer in the implementation of Japanese industrial management in Indonesian automotive industry, those are quality control -- called Astra Total Quality Control (ATQC), human resources management (skill and career development system), moving inventory system (kaizen), and management system of organization (retail support system). (Nakamura 1999) The source of knowledge is obtained by TAM from its principal TMC through transfer of skill and expertise in automotive production line. The ways of knowledge transfer are through personnel dispatching to be trained in Japan and in-house training at AETC (Astra Education Training Center) owned by TAM. TAM has a series of innovation in management system of organization, i.e. innovation in the field of consumer credit, product distribution, marketing and insurance by established subsidiary companies namely AIC, A2000, M88, and GA.

Knowledge and expertise absorption through learning by doing with the assistance of principal has successfully built TAM into a learning organization. TAM always follows the progress of industrial technology through learning by using the equipments of car assembling industry as well as industrial management. Knowledge and Innovation technology acquired by TAM employees spread throughout the company that created gradual and consistent improvement of company performance.

iii. Innovation in product design (Toyata Kijang)

The success story of n product innovation is called Toyota Kijang a commercial car in Indonesia backed by its principal. TMC developed design and engineering for its partner and subsidiary in stages from the first generation (1977) to fifth generation (2004). Innovation was followed by an increase in TAM investment in Indonesia. Innovation of Kijang also had more advantages than its competitors in the same class (Daihatsu Hijet, Suzuki Carry and Mitsubishi Jetstar). In addition to its competitive

advantage in price, Kijang had other advantages such bigger engine, more comfortable, and more powerful that its competitor.

TAM was a pioneer in developing innovative minibus with a bonnet (cap) by putting the engine in front. TAM produced Toyota Kijang minibus as commercial car for the first time in 1977. The early shape of Kijang as a pickup (Kijang Buaya) competed with Mitsubishi Colt which had dominated the market. Although this first generation still had weaknesses such as without glass windows and key for door lock, the market was able to accept the presence of Kijang.

Second-generation innovation of Kijang was marketed in 1981. Kijang engine capability increased from 1200 cc to 1300 cc, later to 1500 cc. The view of bonnet more attractive than before, doors fitted with glass windows and already had the key for door lock. The second generation was referred to as Kijang Doyok.

Third generation innovation of Kijang entered the market in 1986. The concept of Kijang shifted significantly from commercial car toward passenger car. TAM succeeded to export third generation of Kijang to Brunei and Papua New Guinea in 1987. TAM issued two types of Kijang in this generation called Super Kijang (1986-1992) and Grand Kijang (1992-1996). TAM provided the third generation of Kijang in several variants such as: L-types (long chassis), S-types (short chassis), LX (special type) and SX (standard Type) using 4-speed transmission and conventional dashboard.

The improved version of third generation entered the market in 1992. TAM technology introduced full pressed body. The power of 5K engine increased from 61 hp to 63 hp by using a 5 speed transmission, which previously used 4 speeds. Since 1992 TAM introduced the 7K engine with capacity of 1800 cc and Toyota original body with pressing machines and spot welding method. For the grand type, there are some changes, especially in the addition of double blower and power steering.

Fourth-generation innovation of Kijang hit the market in 1997. This model introduced the new design of more aerodynamic called "Kijang Capsule". TAM issued two types of engines, that was 7K type engine 1800cc and 2L type diesel engine 2500cc. Kijang diesel attempted to compete with Isuzu Panther that dominated the market. At the end of 2000 TAM began to market Kijang with Electronic Fuel Injection (EFI). There are two options, namely Kijang EFI, 7K-E engine and capacity 1800cc and Kijang

1RZ-E with capacity of 2000 cc. The fourth generation of Kijang induced innovation in marketing as shown by the success of Kijang entered export market in form of CBU (to Papua Nugini, South Pacific) and CKD (to South Africa, Malaysia, Philippines, and Taiwan). Kijang CKD with 7K and 5K cylinder blocks machines were exported to Japan.

Fifth-generation innovation of Kijang Innova entered into the market in 2004. The model of Toyota Kijang Innova was the project IIMV (Innovative International Multi-purpose Vehicle) TMC Japan in Indonesia. TMC reorganized the production and procurement among its subsidiaries in ASEAN region. Toyota Motor Thailand (TMT) with Vilux Vigo plays the role as the main Toyota plant, Toyota Motor Manufacturing Indonesia (TMMI) plays the role in producing engines, Toyota Autoparts Philippines produces transmission and constant velocity joint, T&K Auto Parts in Malaysia produces steering gears, Siam Manufacturing in Thailand produces diesel engine, and Toyota Motor Asia Pacific (TMAP) in Singapore plays the role in the distribution of Toyota Kijang Inova to Asia and the Middle East.

The fifth generation has several advantages: a more aerodynamic body shape, a comfort level with a luxury sedan, driving position more accurately, the location of shift knob easily grip and more user friendly of instrument panel. This generation applied VVT-i 2000 cc, with type 1TR-FE DOHC 16 valve, it has greater power 136 hp, and designed with direct ignition system (DIS). This generation also applied accelerator technology without cable or throttles control system-intelligent and supplemented by longitudinal engine with rear wheel system.

iv. Innovation in component technology

Fifth generation innovation of Kijang was supported by several key components that have undergone innovation. *First*, suspension. Innovation in the front and on the rear suspension was done to better absorb shocks so as to be more comfortable. *Second*, steering. Innovation on the steering stability is more reliable so that the car is easy to control the speed of 120 km/h at the S-shape bend and turn rotate 270 degrees. *Third*, engine. Innovation in engine with VVT-I that created the combustion process relatively more efficient and lower waste gas emission. Innovation in D4D Diesel engine with the

use of common-rail injection system that produced the low level of vibration and a smoother engine sound that could be produced along with the lower level of exhaust emissions. Innovation in Engine Immobilizer System used transponder chip so that the machine will reject if the ID code key is a false key. *Fourth*, control system. Innovation in Electronics Throttle Control System (ETCS) to make this generation equipped with gas pedal sensor, which can change every motion of magnetic into electrical signals to be sent to the ECU. Therefore, in the event of malfunction in one of the sensor, the ECU will command the throttle body work on limp mode (at least) so the car can still run.

4.1.2. Company 2: DHS

Organization innovation: competitiveness by strategic alliance

DHS started entering the Indonesian market in 1976 when the AI was appointed as sole agent, importer and sole distributor of DHS car in Indonesia. The existence of DHS development is closely related to the progressive AI management. In 1978 the steel plate pressing factory was established as a joint venture AI, DHS, NC. Then the machine factory DEMI was established in 1983.

The position of AI as the sole agent and importer of DHS was replaced by NAM in 1987. Then in 1992, ADM was established as a merger of 3 companies, namely AT, BY, NAM. Aluminum casting plant KIIC was built in 1996. A product of ADM that was dominant in its class was the Daihatsu Zebra in the mid-1980s. Later, DHS became less successful in domestic market because it was perceived by the public had a lower quality than Honda, Toyota, Mitsubishi and Suzuki.

In 1998, AI bought the assembling plant of GM, ADM have four factory steel plates those are pressing plant, machinery, aluminum casting and assembling. But the economic crisis in 1998-1999 caused car price increased more than 3 times. Due to the consumer's low purchasing power and facing the Korean car with relatively cheap price became serious challenge to AI. Given the brand of Toyota and Daihatsu held by AI, and then the principals of Toyota and Daihatsu committed a joint investment amount to 90 million to develop Avanza Xenia (AX). Both car were manufactured by the same factory, and distributed by AI since the beginning of 2004.

The strategic alliance of two carmakers contained complementary elements of organization to create company competitiveness. Toyota is strong in the efficiency of production operations (pioneering in JIT and high labor productivity), quickly and successfully in product development, and strong market domination with a broad distribution network. Meanwhile, Daihatsu has been successful in creating small-car, specialist in efficient and inexpensive car. The combination of Toyota and Daihatsu is pool of benefit the family car (relatively spacious room), and excellent after sales service with the benefits of small car (fuel efficient).

Since its launching in 2004, by 2010 domestic demand for AX car remained high, besides it was exported to neighboring countries and Africa. But the product sold in domestic market was regarded having lower quality than that of export market. After facing customer complaints for AX lower quality, in mid-2006, new AX was marketed with the latest engine versions, and new appearance. The next twin products developed by Daihatsu and Toyota in Jeep category are Daihatsu Terios and Toyota Rush which was issued in mid 2007. Similarly, the twin product Terios and Rush have been marketed under the management of AI. Overall the AX car leads car sales in 2010, while Daihatsu Terios and Toyota Rush continue to increase its market position.

4.1.3. Company 3: IM

i. Innovation in product design and engineering (Suzuki Carry)

The product innovation originated from a top management of IM in 1976 that initiated and proposed to the principal (Suzuki Motor) to assemble and sell car by expanding it from a motorcycle engine. (Pane 2005). In 1978, IM launched Suzuki ST20 a pickup car. This car had a 550 cc capacity with 3 cylinders, which was the development of Suzuki ST10 that existed in Japan. In 1975-1976, IM selected its major market segments for Suzuki ST20 in south and north Sulawesi by ignoring the market in Jakarta and Java Island that was controlled by Mitsubishi. The success of innovation Suzuki ST20 was to build brand image as a tough car after a lot of clove farmers used it to explore the mountainous terrain in Sulawesi.

After success with ST20, IM continued next product innovation by proposing to the principal in Japan to produce minibus car with a basic design similar to the ST 20. The principal finally agreed and then sent the Suzuki Carry ST 100 in CKD to be assembled

by IM. Suzuki ST 100 with a 1000 cc was the improvement of Suzuki ST 80 that circulated in Japan before. In the next steps IM played its role not only as an assembler of imported component but also producing the engine of ST 100, making the car body, producing chassis and various other components such as wheel, excel and interior by using parts supplied by local companies.

The success of Suzuki ST100 was also supported by government policies that provided incentive in form of abolition of import duty for commercial car (minibus category). In this category the market of Suzuki competed with Daihatsu Zebra from TAM and Mitsubishi Colt100 from KTM. Brand image of Suzuki engine was persistent and strong that brought Suzuki dominated the segment of public transportation. This segment was the main business of Suzuki in the domestic market, as well as export market in some neighboring countries.

Further innovation in design and engineering was Suzuki ST150 developed from ST100, by upgrading the engine to be 1,500 cc and larger body size. The need to increase the engine power of ST150 came from the competition from Daihatsu Zebra. The machine of ST150 was designed by IM engineers by changing the engine block material from cast iron to aluminum casting engine. However, Suzuki ST150 or Suzuki Futura was not able to replace the position of Suzuki ST100, that is a car always searched by strong consumer interest. Consequently, to meet the needs of market, IM keep producing Suzuki ST100 in addition to ST 150. Next innovation based on good brand image of the ST100 machine, IM requested and got permission from principal to transplant the engine in Suzuki Katana jeep in 2000, later also as the car engine of Suzuki Karimun.

Next innovation of Suzuki sourced from the effect of consumer complaint. The deletion program that required car manufacturers to use local components including car body, that pushed the establishment of local car body assembling companies in several large cities such as Semarang, Solo, Malang, Palembang and Ujung Pandang. Due to consumer complaints about low quality of body car made by car body assembling, then the government approved the car manufacturer companies to take part in making the car body. Then the full pressed body was produced by subsidiaries of car manufacturers such as SMI, TEC, and MKM.

ii. Innovation in developing the new car (Mazda MR 90)

The idea to build a new car by automotive player sourced from public discourse on national car in the late 1980s. This idea was not an empty discussion but something possible to realize, especially after the government applied the deletion programs and policy instruments for supporting the localization program. Top executive of IM believed to be able to realize the idea of new car based on its success in building the Suzuki ST from motorcycle technology. Then IM decided to build the national car through Mazda brand license. Given the public's desire to have a sedan type car, IM managed to convince the principal to transfer the technology of engine making and stamp machine for car body making to IM.

Under the guidance of Japanese experts, IM engineer and technicians obtained practical training and guidance in building their own car. IM launched Mazda MR90 in 1990. This car was believed to become a national car that had local content of more than 60%. Therefore IM requested to the government support in the form sales tax exemption. Unfortunately, the government refused to grant tax exemption because the regulation on sedan car was obliged to pay the luxury sales tax.

Mazda MR90 failed to gain government support, causing the car failed to compete with other car of minibus category which obtained sales tax exemption. Meanwhile, if MR90 was regarded as sedan, its interior design was not eligible to compete with sedan generally. The unclear position of MR as the passenger car either non-sedan or sedan category, it caused MR90 was not too successful in market. Only the procurement from some government institutions facilitated the marketing of MR90 as official car. Because of production remained below capacity, in order to meet the production capacity of MR90 engine, then IM also sought permission from the principal to use the car machine in sedan Mazda van-trend.

4.1.4. Company 4: KTM

Innovation in product modification (Colt Jetstar1000)

The NMN was originated from MM which had imported Mitsubishi since 1956. KTM as the dealer of Mitsubishi managed to attract Mitsubishi to invest in building the

factory in 1972 and 1974. KTM was previously the agent of Mitsubishi in Indonesia through NMN company established 1970.

KTM sent their some managers in the early 1970s to Japan to study and understand the details of automotive factory. The transfer of knowledge in that way was done every year. The more local personnel who understand the automotive factory was the better for the KTM company. In addition, Mitsubishi also put experts from Japan to guide, monitor and improve the ability of local personnel in assembling and producing Mitsubishi car in Indonesia. In 1973, KTM established KRM company to assemble Mitsubishi car that was called Colt. In the mid-1970s, KTM claimed that the Mitsubishi Colt used 51% of local content.

Mitsubishi Colt pick-up launched in the early 1970s and then developed into a minibus which was a favorite car that controlled the domestic market in 1970-s. In the year 1987-1988 KTM successfully exported Mitsubishi Colt Jet-star 1000. Besides, as an assembling company, KTM has also developed a subsidiary that manufactured automotive component to meet the Mitsubishi needs. Some OEM parts were produced, but many products were spare parts for after market needed by workshop for car maintenance. In 1983, KTM together with its principal established CEM company to manufacture car engines in Jakarta.

In Sedan category, Mitsubishi Lancer and Gallant were the favorite car in Jakarta in mid-1980s. Its design and technology was 100% from Japan, although some spare parts have been able to be assembled in the MKM a subsidiary of KTM in a joint venture with the principal.

*4.1.5. C*ompany *5: MKM*

Innovation in component production (localization)

MKM was founded by KTM in 1975 and later developed MKM-2 in 1981. Both were component and auto parts manufacturer of Mitsubishi car in Indonesia. The establishment was directed by the automotive experts from Mitsubishi Japan and supported by the Indonesian personnel who obtained training in Japan. The company provided the series of training to local workers to become skillful and expert in producing various components of car that were used as OEM as well as spare parts which were used for after-market.

MKM operated as the factory of components for KTM a car producer in Indonesia. MKM produced OEM products such as engine blocks, axel, and wheel-rim with machine and printing equipment brought from Japan. Raw materials such as iron, copper, and aluminum are almost 100% imported from abroad. Based on portion of components produced locally in a car, the local content of Mitsubishi car has been able to reach 40% -60% since the 1980s, especially for non-sedan passenger car like the Mitsubishi Colt T1000. As for the sedan and Pajero jeep and Strada are almost 100% in form of CBU.

MKM provided the opportunity for local companies to produce components that were required by MKM. There were two ways of local company to become sub-contractors of MKM. *First*, the MKM actively search to find the factory readily to produce the component according to specification determined by MKM. *Second,* certain company offers its capability to produce a certain component. The production processes of complex parts use the printing machines imported by local company from MKM principal in Japan. Although the supplier of MKM were able to produce its own components, but the products were solely produced for MKM because design and specifications based on license from Mitsubishi Japan.

MKM always stimulates idea generation and creativity among workers, and it becomes the work ethic in the company group. Every person is required to submit a suggestion for performance improvement and problem solving to the management every month. This has spurred the innovation in work place by creative employee. In addition, it is related with performance evolution of employee annually. For the applicable ideas that bring brilliant improvement will be honored with incentives by the company.

4.1.6. Company 6: SSA

Innovation in marketing management (brand image)

SSA was a trading company that imported Volvo in CBU then marketed by IM. Volvo's success in the market in part was due to government support that had set Volvo as the high-ranking official car since 1974. Demand for the latest series of Volvo 740, 960 and S90 in accordance with the taste of official in every periods. This policy

continued until the year 2001, since that time the provisions of official car for the high-ranking officials have converted into Toyota Camry.

Volvo car and its components for maintenance are imported goods. The transfer of technology does not occur in the car trading. Volvo technicians from the IM group only develop the skills on service and maintenance under the supervision and technical guidance from the principal. In the marketing field, Volvo kept maintaining its brand image as the car for high ranking official. In order to convince the customer, SSA management displayed the testing of car safety and comfort in Jakarta in 1980. In the event IM invited businessmen and high ranking officials to witness the safety of Volvo as the safest car despite having the hardest impact testing. The event was to attract the premium target market.

4.1.7. Company 7: JM

Innovation in marketing management (support for consumer satisfaction)

Landrover car was originally imported by ISC since 1950, later it was taken over by the HMN that had imported Morris Berenti since 1950. In the late 1980s HMN was taken over by JM. Landrover car always enters the Indonesian market in CBU form. JM as car importer and marketer needs limited transfer knowledge only such as maintenance and car service. All spare parts of Landrover are imported from the principals in the UK. Just to meet the needs of car consumers on the accessories of Landrover, then JM helps its consumers to assemble and modify the generic parts, such as car interiors including seat upholstery, door, or other accessory. Technicians of JM obtain technical expertise from UK factory in the form of in-house training for doing car maintenance and service. Furthermore, JM also has developed its subsidiary to produce certain automotive parts for after-market. While the components for OEM equipment are imported from the principal.

JM technician never involve in design and engineering, because whole design of Landrover car are determined by the principal. Since the 1970s, design of steering has been modified to the right position to meet the needs of market in Indonesia. Characteristic of this car is a 4x4 type of standard form, but provides room for creativity to modify to be the fire truck, caravan, a hunter car or off-road. The car the owners

generally make modifications in their respective workshops, but the Landrover through JM facilitate various needs such as cranes and other equipments.

With its typical design and supported by the fans of Landrover from abroad that brought the Landrover owners in Indonesia established LRCI (Land Rover Club of Indonesia) in 1987 and later revitalized in 1997. This club is the association of car owners who have an agenda of social activities, support for disaster mitigation, sports, touring, and road greening to reduce global warming. For consumer satisfaction, JM supports the activities of this club by providing some facilities in form of sponsorship, funding, goods and networking

4.1.8. Company 8: IMPM

Innovation in marketing management (stimulant for consumer satisfaction)

Honda car was initially imported by IMR as the sole agent of Honda brand since 1973, then it was taken over by the PM which was a subsidiary of IMR. PM as the sole agent of Honda had assembled Honda car in its factory since 1975. PM assembled components, which was produced and imported by HM a subsidiary of Honda Japan. The components produced by HM -- to be assembled by PM -- must pass quality testing by Honda factory in Japan

To improve knowledge and skill regarding car assembly, Executives of PM and its staff interact directly by observing assembling process at the Honda factory in Japan. To ensure the quality of Honda car in Indonesia, the principal placed experts from the Japanese in Indonesia. Similarly, the CEO of IMR has representatives in the principal of Honda.

In the mid-1980s, Honda car (Civic and Accord brands) once dominated the sedan market in Indonesia. The Honda rival was the Toyota Corolla, Toyota Corona, Mitsubishi Galant and Lancer. In the early 1990s sedan market competition increasingly fragmented with increasing sales of Mazda 323 and 626. In 1990s, the sedan market competition was getting sharper with the entry of Korean car, sedan Timor (KIA) and Hyundai.

To win the sharp market competition, Honda always keeps innovating in terms of appearance such as body shape, display lights, and accessories consisting of power

windows, electric mirrors and dashboards that stimulate consumer tastes. Honda continues to be advanced in the technology of brakes, steering, transmission, rust prevention systems. For each of these technological advancement, PM keep constantly updating its technology. The role of principal was crucial in the process of this technology transfer. However, the principal did not interfere in managing the marketing of Honda car in Indonesia. Combination of marketing strategy that stimulates consumer taste with a touch of information technology remains a basis of the sales of Honda sedan.

4.1.9. Company 9: TPN

Product innovation (Timor)

In 1996, the Indonesian government issued a national car policy. TPN obtained authority to realize the national car in cooperation with KIA of Korea. Government's basic policy was to accelerate the mastery of automotive technology in domestic industry. Automotive industry have to switch from merely components assembling into making own car gradually. The strategy for achieving the objective were by increasing in local content with a decreasing in imports of components as well as raw materials for components making.

The government expected TPN achieved the local content by 20% in the first year. The second year was expected to increase to 40% and in the third year by 60%. In practice there was a time delay of TPN local content targets. The target of 20% local content should had been achieved in 1997, then it was delayed until January 1998. The government also required TPN used components and equipment made in Indonesia through compensation and purchase (counter trade). The amount required was at least 25% of imported CBU car.

Complaints against the national car policy came from various parties, especially the automotive players who questioned the national car policy to the WTO. After the policy of giving special incentives was declared illegitimate in WTO fair trade regulations, the government finally terminated the national car policy (Mobnas). Consequently TPN was obligated to pay import duties and luxury tax of car sold by TPN. In short, such a

hasty product innovation through shortcut to realize the idea of a national car was a thing not realistic in the global supply chain of automotive industry.

4.1.10. Company 10: GRM

Innovation in product modification (minibus Mitra)

GRM produced VW since 1971 then assembled VW181 that was the type of car known as the VW Safari for sub-districts official in Indonesia the 1970s. In the 1980s VW was ranked second best-selling car brand in Indonesia. The success of VW was concentrating on BTV (Basic Transport Vehicle). BTV was a cheap product and powerful vehicle for developing countries that was designed in 1970. BTV had the engine position in front so that the luggage space can be filled and emptied in the rear. The introduction of BTV to Indonesia took place at the initiative of the VW principal, which impressed by Morris, the modified England car, for the transport of goods and passengers in Jakarta, which was a means of public transport across Indonesia since the 1950s. Then, a prototype of BTV was exhibited in Indonesia in 1972 and received good response from the public.

Production of minibus Mitra a BTV version by GRM involved other party, namely PS, the company manufactured the panels of car body, then GM company assembled the Mitra minibus in its factory. Although minibus Mitra was frequently redesigned, finally the mitra was sold in the form of mini passenger car the so-called oplet, ambulances, police car, car carriers and pickup

4.2. Summary of Evidence from Companies Studied

The aforementioned description on the types of innovation and source of knowledge in the companies studied, can be summarized as follows: i) sources of knowledge in product innovation came from market competition (Toyota Kijang), the idea of experienced entrepreneurs (Suzuki), the principal (Mitsubishi Colt T100); ii) source of knowledge in process innovation came from advancement in automotive engineering research (fifth generation of Toyota Kijang); iii) source of knowledge in organizational innovation came from company's needs to increase competitiveness, productivity and

efficiency in market competition (alliance of Toyota- Daihatsu, and vertical integration of TAM); and iv) source of knowledge in management innovation come from principal through transfer of skill and expertise in automotive production line. The company's needs in management innovation for solving the problem that exists the production and organization by applying Total Quality Control, the system of HRD, moving inventory system (kaizen), and other management systems such as retail support system, consumer credit system .

Seen from human resource development, companies business policies in the past have successfully build personnel competency as assembling technician and product salesman in respective subsidiaries companies. The best use of knowledge acquired through in-house training was successfully implemented to develop management and organization innovation. However, the subsidiaries companies were still less successful to conduct product and process innovation, because the design and engineering research was constantly conducted and determined by principal.

The role of government in localization program by regulating the automotive component supply was less successful in the past, due to the component's low economic of scale to be produced locally. Government program to promote the production of national car through gradual increase of local component was failure due to three factors namely, less government support, less government commitment, and loss government credibility. Furthermore, less effective fiscal policy (tax deduction and exemption) is due to low economic of scale that created inefficient production in the past. Then, incentives through monetary policy (low interest rate) to create demand in the economy was driven more by investment, while at present it is driven more by consumer spending.

In the past, some of policy failures to achieve the policy objectives due to; i) policy incoherency, i.e. imposing contradictory objective of tax for similar products and its component materials, and ii) policy inconsistency, i.e. unfair preferential treatment in national car. While, the consortium of inter-government and automotive company to develop and produce national car product that reflect public-private partnership was failure due to less government commitment to continuously support it.

5. The Role of University and PRI as External Resources

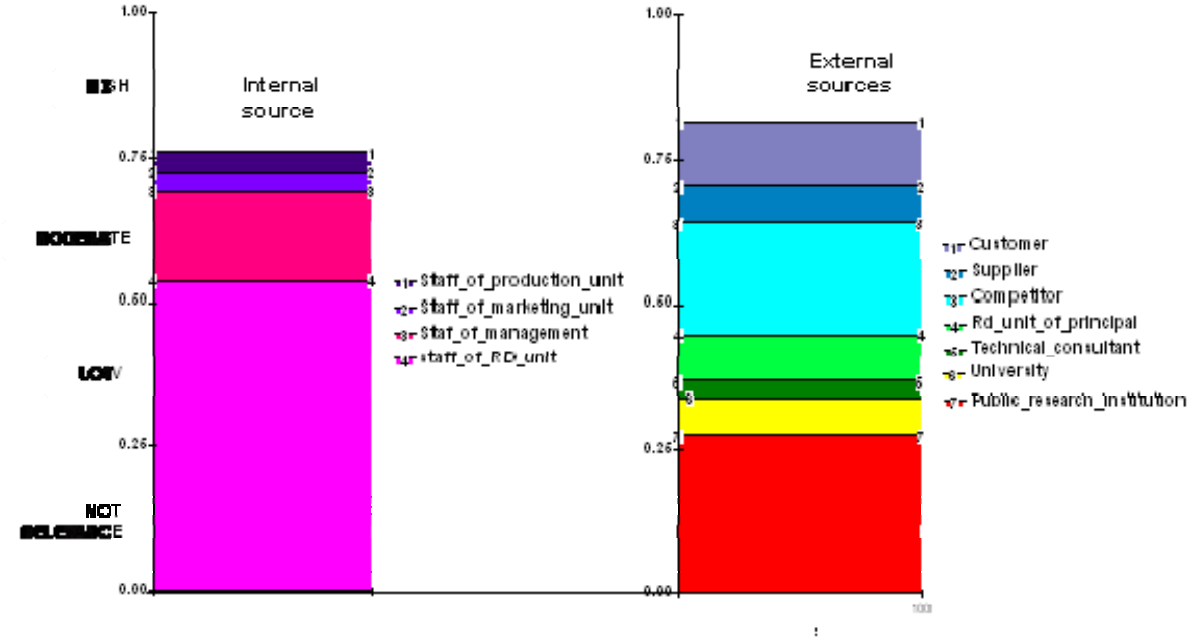
5.1. Limited Role University and PRI based on Survey Results

The previous section of IV.2 clearly explained that the role of university and PRI as external resources of innovation in Indonesia is very small (if not unavailable). This finding is also supported by the results of innovations survey in Indonesian manufacturing industry in 2009.[6] The survey revealed that: i) cooperation between universities and industry with government research institutions is very low or not relevance at all, ii). the role of university and PRI as the source of information for industrial innovation is very small. (Pappiptek LIPI, 2010: 50-51)

Furthermore, based on survey results, the situation of automotive industry sector is described as follows. The source of information for innovation in automotive industry are mostly from the staff of production and marketing units (as the internal sources) then the customers and suppliers (as the external source). Meanwhile, university and government research institution almost no relationship (and not relevance) as the source of information for innovation in automotive industry. (See Figure 7)

[6] The innovation survey collected information from 1341 medium and large enterprises as respondent. There are 46 automotive assembling factories and automotive component companies as respondent in the innovation survey.

Figure 7. The Relevance of Information Sources for Innovation in Indonesian Automotive Industry



Source: The data of Pappiptek-LIPI 2010 was re-processed by author

5.2. The Dominant Role of University

The dominant role of university is as the provider of educated people, mostly automotive engineers with bachelor degree. The educated people that enters the labor market tends to work in the sector more quickly generate revenue, such as in finance and management, due to limited job opportunities for engineers in the automotive sector. The automotive assembling and most components industries tend to use the skilled labor graduated from polytechnics or vocational training school. The low demand for automotive engineers due to several reasons: job availability in assembling line is generally enough by employing technician and mechanics, the more high value job such as design and engineering are already done by principals abroad, most of engineering job in the MNC subsidiaries are handled by foreign engineers, and local engineers who worked in the automotive industry tends to pursue careers in non-automotive areas such

as marketing, distribution and other business divisions to increase sales value MNC companies.

The relationship between automotive industry and university generally occur through industrial assistance to universities and it tends as a part of corporate social responsibility (CSR). The assistance provided by industry in form of automotive machines is used by students as material practices in the laboratory of university. The automotive engineering research in university generally focuses on academic purpose rather than industrial application. *The results of academic research are available in forms of student theses and the papers of lecturers so far have not applied and utilized to help innovative capability of local automotive and component industry*. The areas of academic research in mechanical engineering research at three leading Indonesian universities are described below.

Department of mechanical engineering in university-1 is geared toward producing engineers that has the ability to do research, design, development, testing, control, and manufacture many different equipments or devices. The graduates are expected to have the ability to apply knowledge of mathematics, science and engineering to identify, formulate and solve mechanical engineering problems. There are four research groups in mechanical engineering university-1. *First mechanical design group* has an active research and development in the area of mechanical engineering design, dynamics and control, and vibration-based predictive maintenance. *Second energy conversion* group has active research and development in conversion energy processes, i.e., thermo-fluid engineering, power engineering, computational fluid dynamics, renewable energy/biomass, etc. *Third, materials science and engineering group* has an active research and development in field of material processes, steel processing, ceramics, composites, and advanced materials. *Fourth, mechanical production engineering* group has an active research and development in the areas of production, manufacturing engineering, quality control, CNC machines, CAD/CAM, automation systems, and robotics.

Department of mechanical engineering university-2 has two fields of research that is i) energy conversion and, ii) design, manufacturing and automation. *First, the field of energy conversion* to develop science and technology in the conversion and energy

conservation which includes the development and utilization methods, phenomena, and principles in fluid systems, thermodynamics, heat transfer and the period, the cooling system and air-governance. *Second, the field of designing, manufacturing and automation* to develop science and technology related to product development and manufacturing-oriented energy conservation, which include among others: the method and process of product design, product manufacturing methods and processes, manufacturing systems, and automation of the design process and manufacturing. Mechanical engineering research in university-2 focus on energy conservation through efficient design and manufacturing. There are some research activities, namely: i) advanced manufacturing technology and; ii) automation; iii) thermal and fire safety engineering; iv) advanced refrigeration system and technology; v) high efficiency fluid engineering; vi) advanced heat transfer technology, and; vii) naval architecture.

Department of mechanical engineering in university-3 has three laboratories to facilitate student to develop skill and ability by practicing and doing observation on how the application of engineering in workplace. *First, process and production system laboratory* has functions as service unit that supports learning activity especially the one concerning production system, production process, factory layout planning, industrial transport tools planning and controlling. *Second, simulation and computation laboratory* has function to develop skill in manufacturing system simulation, automatic production and its design, modeling and programming by computer simulation. *Third, work analysis and ergonomic laboratory* has function as tool provider for designing comfortable, safe, and productive working system. Besides being used as a place to conduct work design experiment, this lab can also be used by students for finishing their final project on design, public service, and other learning practices.

5.3. The Potential Role of PRI as External Resources of Innovation

The more progressive research in automotive engineering in PRI only occurred in the Indonesian Institute of Sciences (LIPI). The LIPI has conducted R&D on electric car since 1995, and has succeeded in creating the environmental friendly electric car the so-called Marlip. Source of innovation for Marlip electric car came from the future ideas in the field of transportation to develop the energy-efficient and environmental

friendly technology. The development of electric car has been done for several reasons namely due to high fuel price, the problem of exhaust emissions, and need for low operational and maintenance costs. Then in 2010, LIPI launched its first prototype of hybrid car.

Electric car

The Marlip electric car of LIPI has the driving system with switch back and forth mechanism (SM3). The SM3 driving system mechanism was successfully designed to reduce costs to 10 percent, compared to the solenoid driving system. The SM3 system in the Marlip electric car work manually. The mechanism is more cost efficiency and more easy maintenance. The Marlip have eight variants for special purposes in limited areas, such as airports, hospitals, and environmental friendly areas for tourism. The maximum speed is only 40 kilometers per hour, now it has been operated in several police districts in Indonesia.

AUTOMOTIVE PRODUCT INNOVATION DESIGNED BY PUBLIC RESEARCH INSTITUTION (LIPI)

Electric car "Marlip-LIPI" **Electric car "Kijang electric"** **Hybrid car "LIPI EHV"**

source : the courtesy of LIPI Bandung (2010)

SM3 technology is the embryo automotive industry with the idea of energy-efficient car and eco-friendly. The commercialization of Marlip technology needs further developmental research. The R&D investment has been funded by the government in the early stages. For the scale of mass production the private company is expected to get involved. However, since 2008 R&D investment for the Marlip car was stopped. The

focus of automotive R&D in LIPI now is more on the fuel conservation engines to reduce the dependency on oil that is increasingly limited.

Modified electric car

Based on Marlip as a foothold, the modification of electric car technology is the conversion of gasoline engines to electric motors in the Toyota Kijang car. LIPI conduct research on applied AC electric motor and has resulted in the electric car of Toyota Kijang. This innovation becomes a bridge for next LIPI automotive research to build the concept of electric hybrid car with AC electric motor.

There are some differences between these LIPI Kijang electric and Marlip electric car that had already been sold. The concept of Marlip was designed as a mode of transportation for specific areas, such as airports, hospitals, or tourist areas, while electric Kijang car is designed as the vehicle to be used in public roads.

Hybrid Car

The next LIPI innovation in automotive engineering was the success of making new breakthroughs by building hybrid car that claimed very fuel efficient. The twin-engine car using gasoline and electricity is called as "The LIPI 1st Electric Hybrid Vehicle" with the concept of hatchback. The work of gasoline engine is just to fill the electric machine, while the electric engine works to drive the rear axle.

LIPI Hybrid car is energy efficient vehicle. The capacity of 160cc and capable of reaching 70-80 km distance. The construction of engineering system in car is the transformation of gasoline into electricity, which is used not to run the car, but to be used as electric charge. So the car 100% driven by electricity stored in batteries supports. Thus, when the electricity in the battery is full then this automatic smart car will stop the flow of gasoline. When the electricity was not able to perform the mechanical functions of car, i.e. the car on the uphill road, then gasoline will automatically replace the role of electricity in running the car.

The first prototype of hybrid car has been tested on the streets and climbing roads. This car can be compared with foreign-made car in the capabilities and features of the

standard car. The advantages of hybrid car is that kinetic energy from the engine-driven by fuel is able to supply power directly to the battery. Hybrid car, has several advantages than that of conventional car. *Firs*t, a significant reduction in fuel usage can save fuel by 50%. *Second*, it can contribute to the reduction of carbon emissions from burning fuel. And *third*, the use of hybrid car can save on operating costs because it is cheaper than conventional car.

The role of LIPI as external resources of innovation in Indonesia automotive companies is very limited and seems to be not relevance. (See also figure 7). It is because there is no relationship between LIPI and automotive companies in field of innovation activities. The automotive companies in Indonesia are subsidiary companies of MNCs which their core activities are car assembling and marketing. The R&D activities of the MNCs are conducted generally by principals and their own regional research center in supporting their global production. In other word, it is not viable the MNCs subsidiaries will use LIPI as their external resources of innovation, i.e. in commercializing the products innovation of LIPI. Although, subsidiaries and local companies tend to be indifferent to recognize the results of PRI product innovation due to the subsidiaries companies is entirely dependency to the product innovation determined by principals. However, public research institutions like LIPI has shown the potency to be the external resources of innovation in local automotive companies in the future.

5.4. Innovation Cooperation between Industry and PRI

Engine design

Indonesian government through ministry of research and technology (KNRT) encourages innovation cooperation among PRI, industry and university by providing grants to finance R&D the so-called “rusnas program”. The program aims to mobilize and improve the HR competency on specific technology areas in PRI, industry and universities that work together in utilizing the existing facilities. For example, in the field of automotive, the rusnas program developed engine design that was managed by BPPT (Board of technology assessment and application) in cooperation with SMEs.

The engine had a single cylinder diesel engine to be utilized in production units including hand tractors and generators. This engine design program has build a network of cooperation between local industry, SMEs, engineering communities in engines and automotive products, research institutes, universities and laboratory facilities, R & D, training and business workshops..

PTN is a SMEs that already has experienced in producing diesel engines with 1 cylinder and the power of 8.5 hp. PTN in cooperation with BPPT produced a 1 cylinder engine with capacity of 500cc gasoline. PTN has been successfully designing and building the jigs and fixtures as mechanical process in engine components. In the production process PTN applied the concept of 'low volume-low cost'. As for the making of cast aluminum components for engine, BPPT in cooperation with PTL conducted experiment on casting engine components that succeeded in reducing production cost significantly.

Product development in the form of 500cc engine by using raw material from aluminum alloys and utilizing the existing facilities (i.e. casting and machinery industry, testing units for machinery and tools technology center at BPPT) to produce the engine prototype. The engine development started from size (500cc) that did not collide with a similar engine in the market. The mastery of existing engine technology could be developed into next sizes e.g. 750cc, 1000cc, 1600cc and so on. Engine was developed with the basic concept of big torque at low rpm, so that it can be developed into multi-purpose machine.

The basic concept of multi-purpose engine provided opportunities for application in non-automotive products. Given the automotive products exist in very competitive market, some types of applications such as hand tractors, rural generators, compressors, water pumps, river transport and rural vehicles become its competitive value. Engine was tested and applied in river transport / brackish water, rural vehicles, generators, and micro-car fuelled with compressed natural gas (CNG) to support the energy diversification program, which was cheaper than gasoline and support a clean environment.

The engine production will developed industrial cluster with its *core element* is the engines factory PTN. *The supporting elements*: KNRT, BPPT, universities, training

institutions, ministry of industry, ministry of education, local government and associations. *The supplier element*: foundry industry, dies & mold industry, basic components industry, industrial rubber components / plastic and electronic components industries. While the *related elements* are shipbuilding industry, automotive and car body factory. *The elements of users* are private companies, educational institutions and governments that use applications for boats, generators, water pumps, multipurpose vehicles, and agricultural tools.

Light-car prototype

Other product design developed through partnership scheme between industry and the PRI was the creation of light-car prototype the so-called Sunny 500. The design was developed by BPPT financed by rusnas program. The car was the results of innovation cooperation with industry PTITM with BPPT. The car was light because the frame was made from steel pipes while the car body was made from fiber glass materials and powered by two cylinder gasoline engine with a capacity of 500 cc, the so-called rusnas machine.

The Rusnas machine had some advantages, in addition to efficient fuel consumption, it also could use two types of fuels, gasoline or CNG. This light-car was designed specifically to meet the transportation needs in the housing complex and for rural transport, capable of driving with a speed of 60-70 km per hour. The car could drive over 100 miles per hour, but considering this car is very light weight the speed should be limited to 60-70 km per hour to remains safely and comfortably.

PRI assistance to industry in engine testing

In 2001-2003, a local company PTK performed reverse engineering process in motorcycle. A certain type of motorcycle with its patent and industrial design was outdated. PTK improved it by styling the design and by optimizing the platform (frame and engine) with minimal platform changes, then applied the technologies by using the existing automotive component in market. The results of PTK's innovation, the company has commercialized various types of motorcycles with several brands such as

Taurus (2005), Taurus Ultima (2006), Taurus Grand with 110 CC engine (2006) and Taurus Supermoto with 120 CC engine (2007). Furthermore, PTK developed three prototype 135 cc engines by fuelled 50% bio-ethanol, LPG hybrid engines and fuel injection engines. In developing these engines, especially to test the strength of engine, PTK has been supported by technical assistance from PRI namely BTMP-BPPT.

PTK is currently able to produce and market the motorcycle of 3 thousand units per-month (its capacity of 10 thousand units per month). Based on its innovation success, PTK received numerous awards, such as Motor Plus Award for local design (2005), Golden Awards in Indonesian good design selection (2006) and Upakarti for technological innovation (2006). In this process, PTK has registered 24 patents and industrial designs in countries such as Indonesia, Malaysia, Thailand, Vietnam, China, Taiwan and India.

6. Conclusion and Policy Implications

6.1. Conclusion

The study revealed that the resource of innovation in Indonesian automotive industry diverged from individual and organization actors, both from internal and external resources. The innovation resource mostly comes from internal organization of the company.

i) sources of knowledge in *product innovation* came from: *first*, external organization those are company's competitor that stimulates the creation of new product in sharp market competition and company's principal that transfers the product technology to its subsidiaries. *Second*, internal organization namely individual initiative inside company, such as the idea of top executive or experienced entrepreneurs to create new product.

ii) Source of knowledge in *process innovation* came from internal organization that is advancement of automotive engineering research done the principals, then they transfer the technologies to its subsidiary to increase company competitiveness in globally advanced technology race.

iii) Source of knowledge in *organizational innovation* came from internal organization such as the principals initiatives to create the alliance companies in fulfilling the company's needs to increase competitiveness and productivity through efficiency in market competition.

iv) Source of knowledge in *management innovation* come from internal organization such as the principal transfer of skill and expertise to its subsidiary for solving the problem that exists the production and organization

Furthermore the study results conclude that, *first,* main *external resource of innovatio*n in Indonesian automotive industry mainly came from company's competitor. *Second,* the role of university and PRI as external resources of innovation in Indonesia were very small (if not unavailable). *Third,* the dominant role of university was as the provider of educated people, mostly automotive engineers with bachelor degree. *Fourth,* innovative PRI has shown the potency to be the external resources of innovation for local automotive companies in the future. *Fifth,* innovation cooperation between industry and PRI was linked by R&D matching grant provided by the government. *Sixth,* The PRI's support to innovative industry occurred in the form of technical assistance.

Finally, the study confirmed the claim of terWal, *et al.* (2007) that the dynamic capabilities (including absorptive capacity, network stability, and capacity enhancement) of firms have an important function in influencing the company growth and evolution in the long run. *First,* absorptive capacity of company to absorb, understand and exploit external knowledge creates the differences in the patterns of company evolution. *Second,* the positioning and stability of company network determine the company's ability in exploiting external knowledge sources. *Third,* the company's dynamic capacity enhancement to serve new markets determines the company's dynamic growth in the long run.

6.2. Policy Implications

The role of university and PRI as external sources of innovation for Indonesian automotive industry needs to be strengthened in future. Some policy implications to

encourage university and PRI to help the development of local automotive industry in Indonesia are as follows:

i) University should improve the graduates' quality in automotive engineering by continuously linking engineers supplied by university with the quality of engineers demanded by the MNCs in Indonesian automotive industry.

ii) University should perform the industrial application of research output in automotive engineering to help the local automotive companies.

iii) Innovative PRI that has shown the potency to be the external resources of innovation for local automotive companies should be promoted to realize its potency by encouraging the related state own enterprises (SOEs) to support the commercialization of PRI's innovation.

iv) Innovation cooperation between local automotive industry and PRI should be strengthened by increasing the allocation of matching grant for R&D in automotive engineering provided by the government.

v) The PRI's support to locally innovative industry should be expanded from technical assistance in product testing to technology assistance in product innovation, by sharing qualified research scientist and engineers (RS&E) of PRI to help and develop local industry.

Innovation through R&D activity inside local automotive industry is expected occurred parallel with the increase of efficiency, productivity and competitiveness of Indonesian automotive products. This implies that government should continue:

i) to upgrade local component competitiveness of non-OEM by applying product standardization;

ii) to increase OEM component export through export incentives by cutting high cost economy;

iii) to encouraging MNCs investment in raw materials by using domestic resources (i.e. aluminum alloy factory) by providing investment incentive in basic industry, and;

iv) to improve infrastructure for domestic transportation by encouraging public-private partnership to invest in transportation infrastructure,

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