TLI – Asia Pacific White Papers Series

Automotive Supply Chain: Policy Overview and Singapore's Perspectives

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A Collaboration Between

The Logistics Institute Asia Pacific

NUS National University of Singapore

Georgia Institute of Technology

To be the premier institute in Asia Pacific nurturing logistics excellence through research and education

The Logistics Institute – Asia Pacific (TLI – Asia Pacific) is a collaboration between the National University of Singapore (NUS) and the Georgia Institute of Technology (GT). Modelled after the Supply Chain and Logistics Institute (formerly The Logistics Institute) at GT, the Institute's vision is to be the premier institute in Asia Pacific nurturing logistics excellence through research and education. TLI - Asia Pacific was awarded the prestigious Asian Freight & Supply Chain Award (AFSCA) for Best Education Course Provider for five consecutive years, from 2003 to 2007.

The Institute provides postgraduate and executive education in logistics and supply chain management (SCM), notably the Dual Masters Degree in Logistics and SCM and the Executive Certificate in SCM. It also undertakes leading-edge research and development in supply chain engineering, technology and management in collaboration with industry; and hosts a regular series of THINK Tables that brings thought leaders in research and industry to discuss contemporary SCM issues, challenges and solutions in a dynamic environment.

The Institute's key research themes include:

Supply Chain Intelligence: This area seeks to focus on providing an overarching analysis of the logistics market, the trade flows, and economic barometers of the various countries in Asia as far as it pertains to effective supply chain management for various industries. Interest in this area is heavily driven by data, empirics and company cases. The Institute conducts annual on-going surveys to test the pulse of the respective markets and industries such as cold chain, 3PL, etc.

Supply Chain Optimization: This, being the traditional and existing strength of the Institute, seeks to deepen expertise in supply chain global network design and optimisation, involving the respective modes of transportation. Intensive supply network simulation on a regional/ international basis e.g. port and maritime logistics, consolidation of logistics hubs, flexibility of regional distribution centres are a primary feature of this group. Other areas of interest include system productivity at the port, the integration of manufacturing and services within the value network, dynamic pricing and revenue management for high end perishables, and the study of mergers and acquisition and its impact on the respective industries.

Supply Chain Technology: This is an emerging area for the Institute, which intends to look at the test bedding of RFID and data capture related technologies, within the context of an independent environment. Work done in this area involves both investigative led research and joint development of supply chain technology based innovation with other agencies and companies. Policy and implementation issues pertaining to new supply chain technology and the end-to-end supply chain network are undertaken on a contract research basis.

The Automotive Supply Chain:
Policy Overview and Singapore's Perspective

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Executive Summary

After the Second World War, the automotive industry was seen as both a pillar and a beneficiary of economic growth of many countries for developed and developing countries. Today, The Big Three (Ford, GM and Toyota) produce less than 60% of all automobiles and light trucks sold in the world market. Their market share has been steadily declining. The Big Three developed a consumer-oriented light truck product, the "sports utility vehicle" (SUV), which market they still dominate. However, other Japanese and German-based manufacturers have been making major inroads in this class as well. Nevertheless, the Big Three are still the largest domestic producers, in their home country. The smaller U.S. and European producers have all disappeared, and imports, especially from Asia, have surged. The smaller manufacturers have been replaced in the domestic market by "transplanted" units of Japanese, German and Korean companies, which now build in North America significant and increasing shares of their vehicles that are sold in western countries. Most of the major companies now compete globally, through cross-ownership and investment in manufacturing plants more than through trade in finished vehicles.

This white paper aims to analyze the automotive supply chain and the automotive logistics market in the Asia-Pacific (APAC) region and Singapore's current share of that market. The research provides a growth forecast of the automotive logistics market in the APAC region over the next 10 years.

To meet these goals, a thorough industry scan was carried out about the regional automotive supply chain to develop the framework. To identify the industry's best possible supply chain practices, challenges, opportunities, and critical influencing factors across the supply chain and to develop their future trends, a questionnaire based study was conducted. Based on the findings and recommendations of the pilot study, the key variables were modified and sent to the target experts in order to capture the behaviour of the automotive supply chain in the Asia Pacific-Region and the impact of Singapore's strength on this supply chain. The research also analyzed the dynamics of the regional automotive supply chain using a system dynamics model. Causal loop diagrams have been developed to identify the relationships between the variables of the automotive supply chain and automotive logistics markets. Under different system states, the policy experimentation was carried out for various degrees of delays in the model. A detailed sensitivity test was also carried out to examine the robustness of the model and to get insights on various aspects such as: the demand, the supply, the automotive logistics market and the vehicle production. A detailed sensitivity analysis showed how market changes impact on the automotive supply chain and automotive logistics markets. From the present analysis, some capability gaps associated with the automotive supply chain have been identified and strategic growth opportunities were captured for Singapore.

Introduction

The automotive industry has reached a mature state, as is evidenced by its growth and by the nature of the competition (i.e.: cost, speed, variants, a rush into a few growing regions and segments), and the industry consolidation. In parallel, technical progress continues to be dynamic. New growing regions, such as East Asia, will not change these dynamics, as new players are created in these regions, namely: in China, in India and in Malaysia. In this report, we examine how, in the long term, this industry might evolve by analyzing the automotive supply chain across the APAC region in detail.

The Automotive Supply Chain: An International Context

The 1985-1995 decade was an important period in the history of the international automobile industry. World demand for automobiles had stagnated. Declining international competitiveness had thrown the North American and European automobile manufacturers into labour turmoil. Overcapacity threatened home markets, which had already achieved predictable and mature growth rates, resulting in a glut of excess manufacturing capacity, now estimated at about 40 unneeded assembly plants worldwide. Japanese-U.S. and Japanese-European Union trade relations were increasingly strained, as Japanese automobile manufacturers penetrated western markets, while carefully protecting their home turf (Crawford and Biziouras, 2001). Recent developments, such as high industrial GDP growth (>6%) and low manufacturing compensation (< US$2.per Hr), attracted major automobile manufacturers, including the big three players mentioned earlier, to Asian markets (WBR, 2006). Figure 1 on page 5 shows that there exist migrations among automobile players (basically OEMs), first-tier suppliers and second-tier suppliers to emerging markets to reap the benefits.

Asia Pacific Automotive Supply Chain

Growth in emerging East Asia eased modestly from 7.5 % in 2004 to 6.8% in 2005 (WBR, 2006). Industry growth accelerated in Indonesia (4.8%), Singapore (9.5%), and Vietnam (17.2%) and continued at a very high rate in China (29.5%) as disclosed in the CIA Fact Book, 2006. There exists a stiff competition among Asia-Pacific countries in terms of their Industrial production Growth Rate. China, India and Japan have experienced marginal differences, in terms of: labour force, import and export among themselves. In the year 2005, the automobile market in Asia increased by 1% over the previous year (WBR, 2006). The market in Thailand and Malaysia showed a greater than 10% increase, while the market in the Philippines and Taiwan decreased by 8% and 17%, respectively. As a whole, the Asian market has continuously been recovering; however, the pace of recovery was different from country to country. The present automotive growth rate is very good for China at 14.3%, Malaysia at 13.0%, Thailand at 12.4% and Singapore at 11.0%. However, there appear to be a saturated market growth and a negative market growth rate for Japan and Vietnam respectively. On the other hand, future automobile sales in India and in China are expected to grow at faster rates and by 2010, the sales figures in these two countries, in volume of cars sold, would reach 2209 million and 4673 million units respectively. This research work was carried out to analyze the present global

automotive supply chain, specifically, the Asia-Pacific automotive supply chain and Singapore's perspective on this supply chain. A thorough investigation has been carried out in this scenario to capture the behaviour of the APAC automotive supply chain.

Automotive Supply Chain Landscape

Figure 1 on the next page shows the parts flow, the CKD kits flow, the CBUs flow, the material flow and the CKD assembly component flow among the selected Asia-Pacific countries. For the purpose of analysis and preparing the network diagrams, only the Big Three (i.e. Ford, GM and Toyota) player's automotive supply chains were considered in order to reduce the complexity.

The diagram was prepared by mapping the Ford supply chain model (prepared after studying extensively Ford supply chain) and GM's supply chain model (prepared from GMs supply chain pattern) with the Toyota landscape in the APAC region (SAP, 2003). Toyota has created a cross border system that allows minimum economies of scale of the traditional Japanese sub- contracting network to be extended to the entire Asian region. General Motors Asia Pacific has assembly facilities and sales operations in 15 countries in the Asia-Pacific region. Its manufacturing and assembly operations are in Australia, China, Indonesia, India, Korea and Thailand. In 2004, growth in the region was led by a strong performance in China and in Australia. Automobile sales totalled 887,000 units in 2004, for a regional market share of 5.2%. GMs CKD assembly and sales are located in India and in Indonesia. Ford Motor Company also has substantial impact on the APAC economy.

Ford's expectation is to integrate (multi) OEMs and service providers for a win-win situation. Ford started its India operation in 1996 at its Chennai assembly plant and now takes full control of its subsidiary. Their China and Malaysia plants carry out assembly and CBU manufacturing and services to the markets of Thailand, Indonesia, Singapore and Vietnam. Singapore places a huge role in the APAC region with its logistics and infrastructure in delivering parts and CKD kits closed to its region.

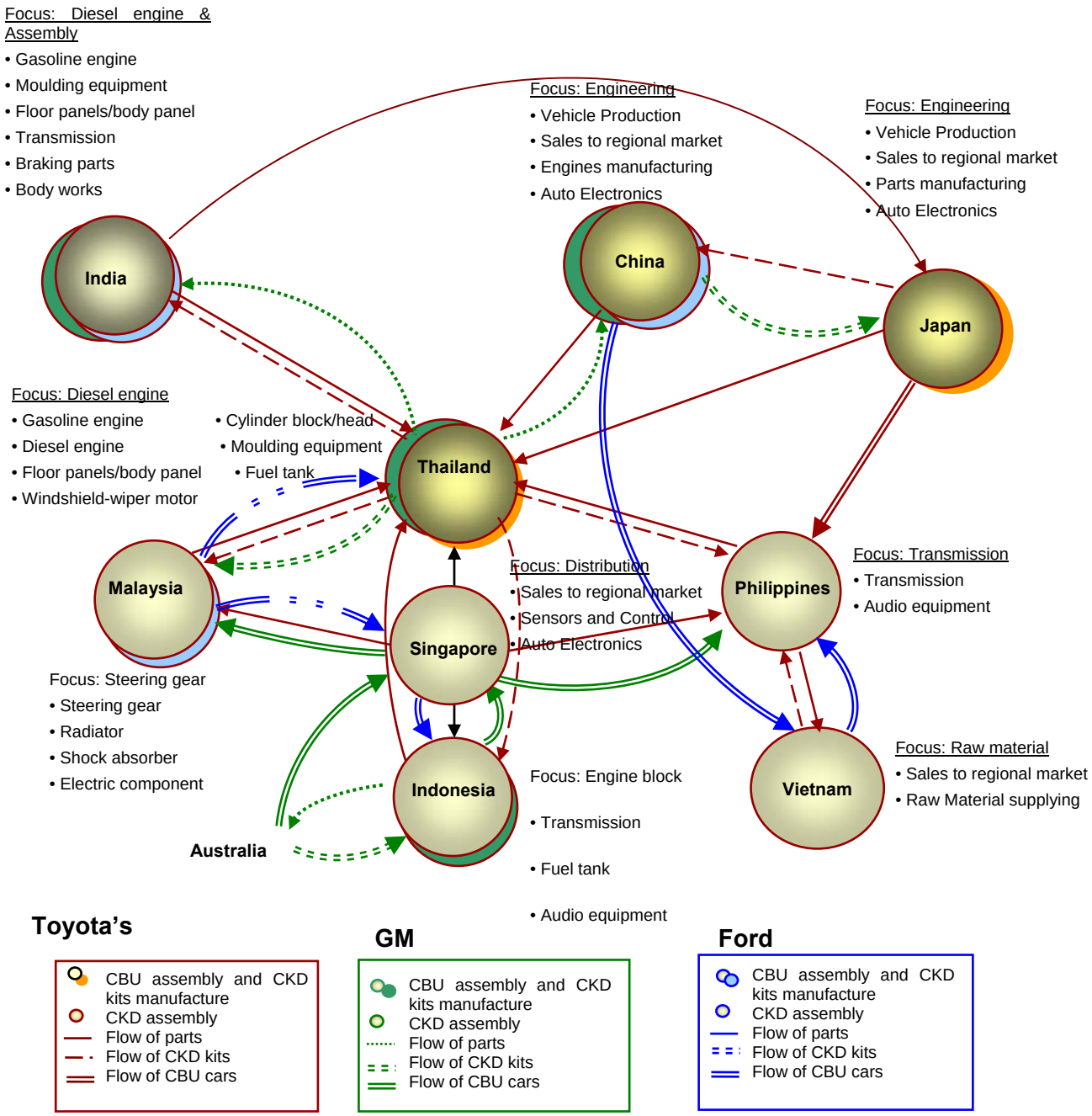

Figure 1: The Big Three player's Automotive Supply Chain in Asia Pacific Region

Research Framework

The purpose of this research is:

- To identify the industry's supply chain best practices, challenges and future trends;

- To provide the growth forecast of the automotive logistics market in the APAC region over the next 10 years;
- To identify the capability gaps of the Automotive Supply Chain and of the Automotive Logistics market in Singapore and the APAC market; and finally
- To identify the possible new growth opportunities.

The proposed framework for this research is illustrated in Figure 2 below. The System Dynamics modelling approach is used as the methodology to analyse the dynamics of the automotive logistics market.

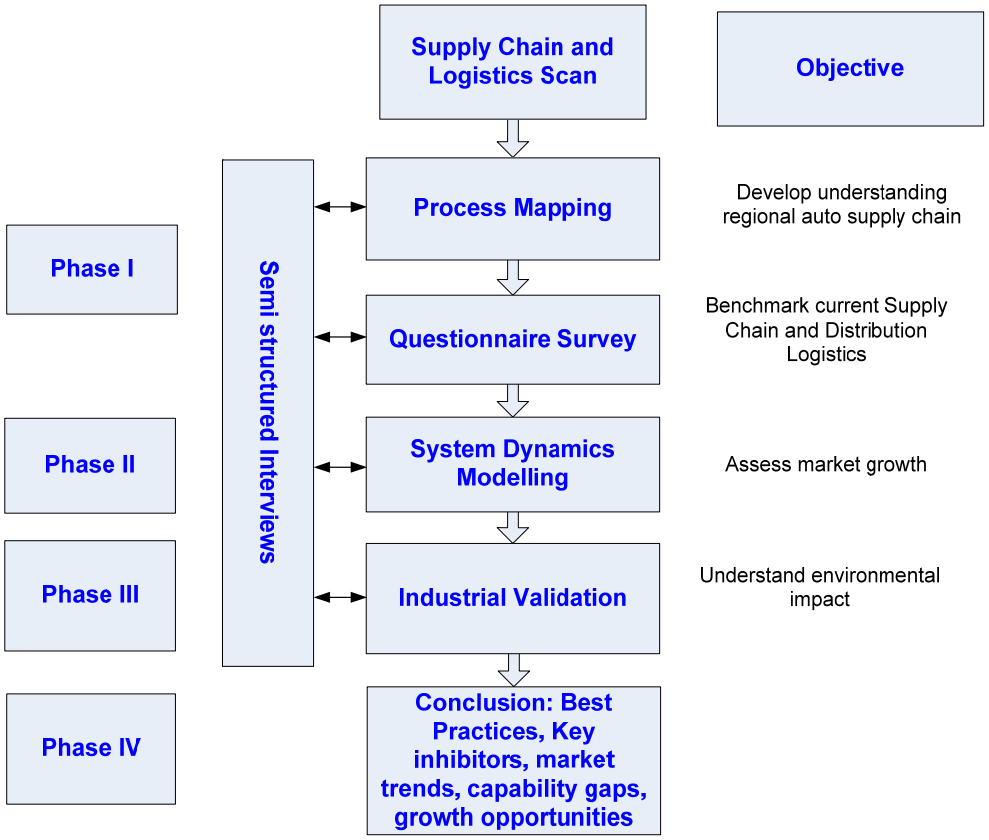

Figure 2: Automotive Supply Chain Research Framework

Identifying the Automotive Industry's Supply Chain Practices

In order to analyze the automotive supply chain practices in the selected Asia-Pacific (APAC) countries, a survey questionnaire was prepared and was sent to a group of professionals working in the logistics and automotive industry as a pilot study. From the feedback gathered, the survey questionnaire was modified and sent to target people working in the tier 1 and the tier 1.5 suppliers, OEMs, Automotive Logistics Service Providers (ALSPs) and automotive research centers in the APAC

region. The questionnaire was framed on a six-point Likert scale. Moreover, some of the questions required that the respondents choose from a number of options listed in the questionnaire. The responses received from the respondents were analyzed and statistically tested.

Observation from the Survey Questionnaire

In order to identify the generic automotive supply chain challenges, the opportunities, and the influencing factors in the APAC region, nine countries were selected on the basis of their Gross Domestic Product (GDP) in the Asian market. The selected countries were: China, India, Japan, Thailand, Singapore, Malaysia, Vietnam, the Philippines and Indonesia. From the survey questionnaire, 14 questions were answered properly with a response rate of 18.67%.

Automotive Supply Chain - Best Practices in APAC

The identified Supply Chain Best Practices, as well as the opinions of experts as regard to these best practices, which would enhance the Automotive Supply Chain of selected APAC countries, are shown in Figure 3. On the degree of the importance scale, a scale value of "1" indicates "*least important*" whereas a scale value of "6" indicates the "*most important*" followed practices. Singapore organizations would greatly benefit by acquiring some of these best practices, such as: supplier consolidations, regional trade agreements and foreign based competition. On the other hand, India would also benefit from these practices and from harnessing the power of IT and outsourcing. The important identified best practices for China are: regional trade agreements, SC outsourcing, IT implementation and supply chain collaborations and integration.

Automotive Supply Chain – Challenges and Opportunities in APAC

This research identifies some of the key automotive supply chain challenges and opportunities for the Asia-Pacific (APAC) region and for the selected countries. They are shown in Figure 4 and Figure 5 respectively. Overall, for almost all the countries, "*poor infrastructure*" was identified as the major challenge for new entrants. Besides infrastructural challenges, "*technological*" and "*cultural challenges*" were identified as having a greater influence across the APAC region. For countries like Indonesia, "*shortage of professionals*" was identified as a critical challenge. Albeit these challenges, APAC countries have enormous opportunities, such as: emerging markets, liberalization and logistical facilities.

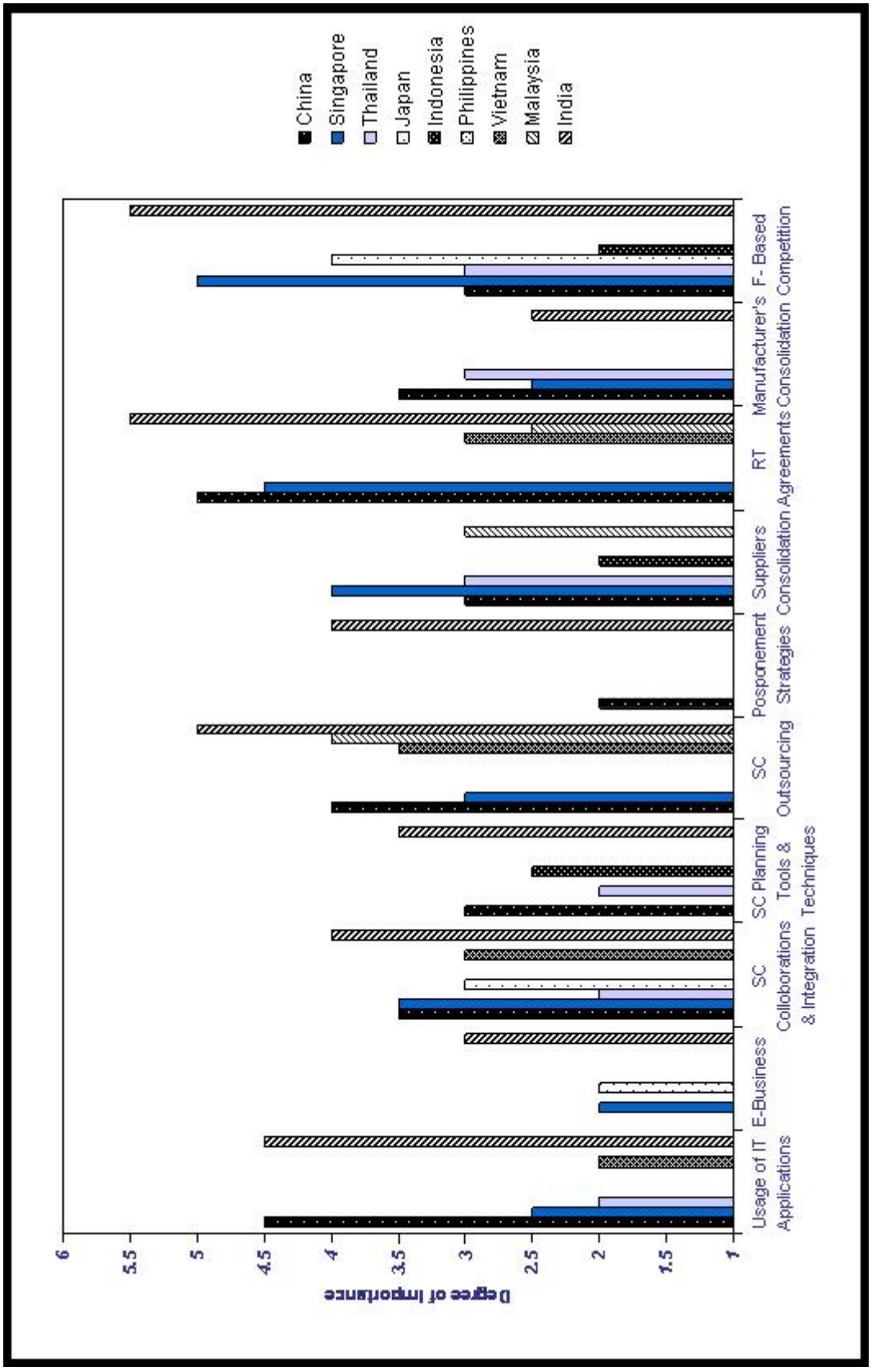

Figure 3: Supply Chain Best Practices of selected Asia Pacific (APAC) countries (1 – Least important & 6 – Most important)

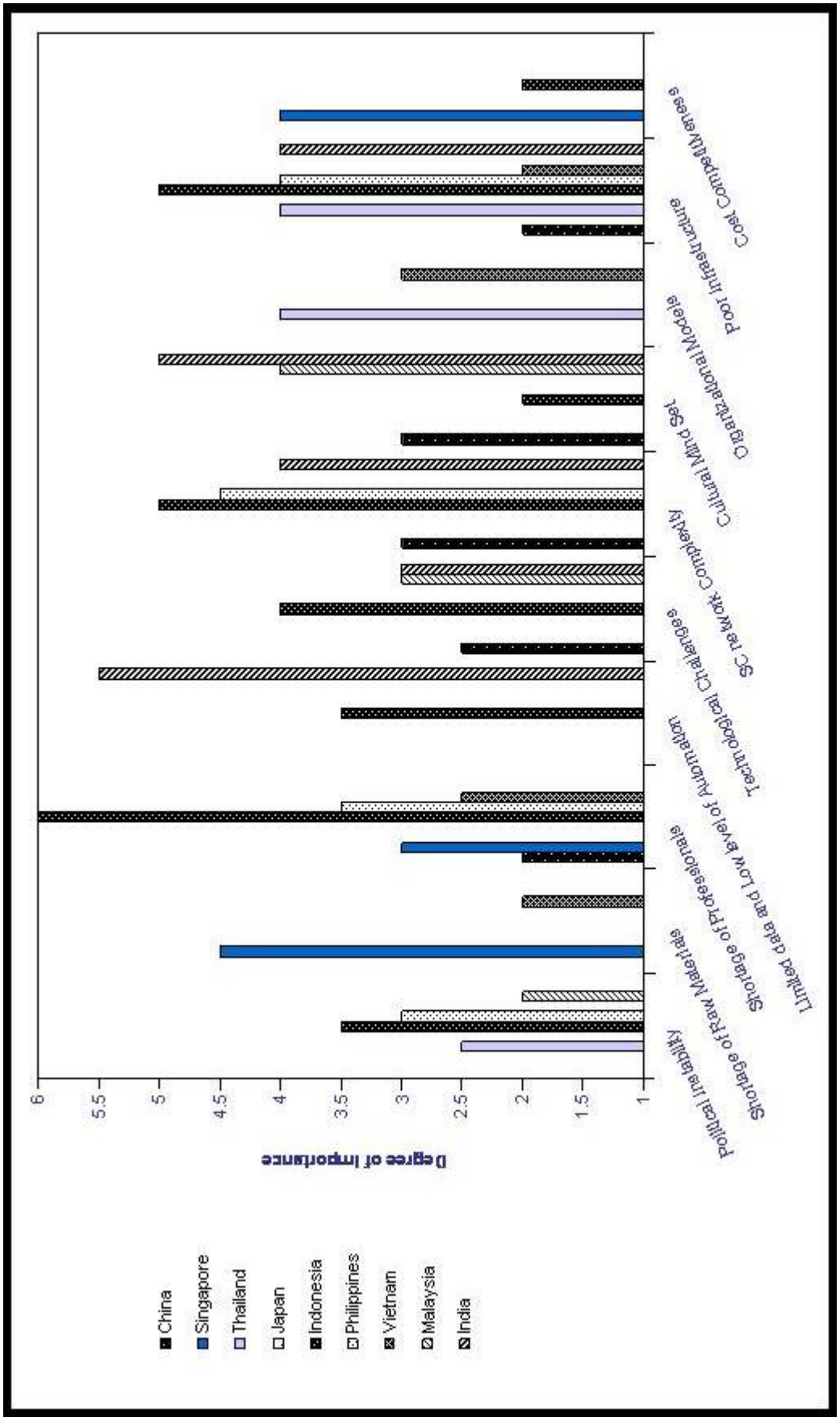

Figure 4: Automotive Supply Chain Challenges of selected Asia Pacific (APAC) countries (1 – Least important & 6 – Most important)

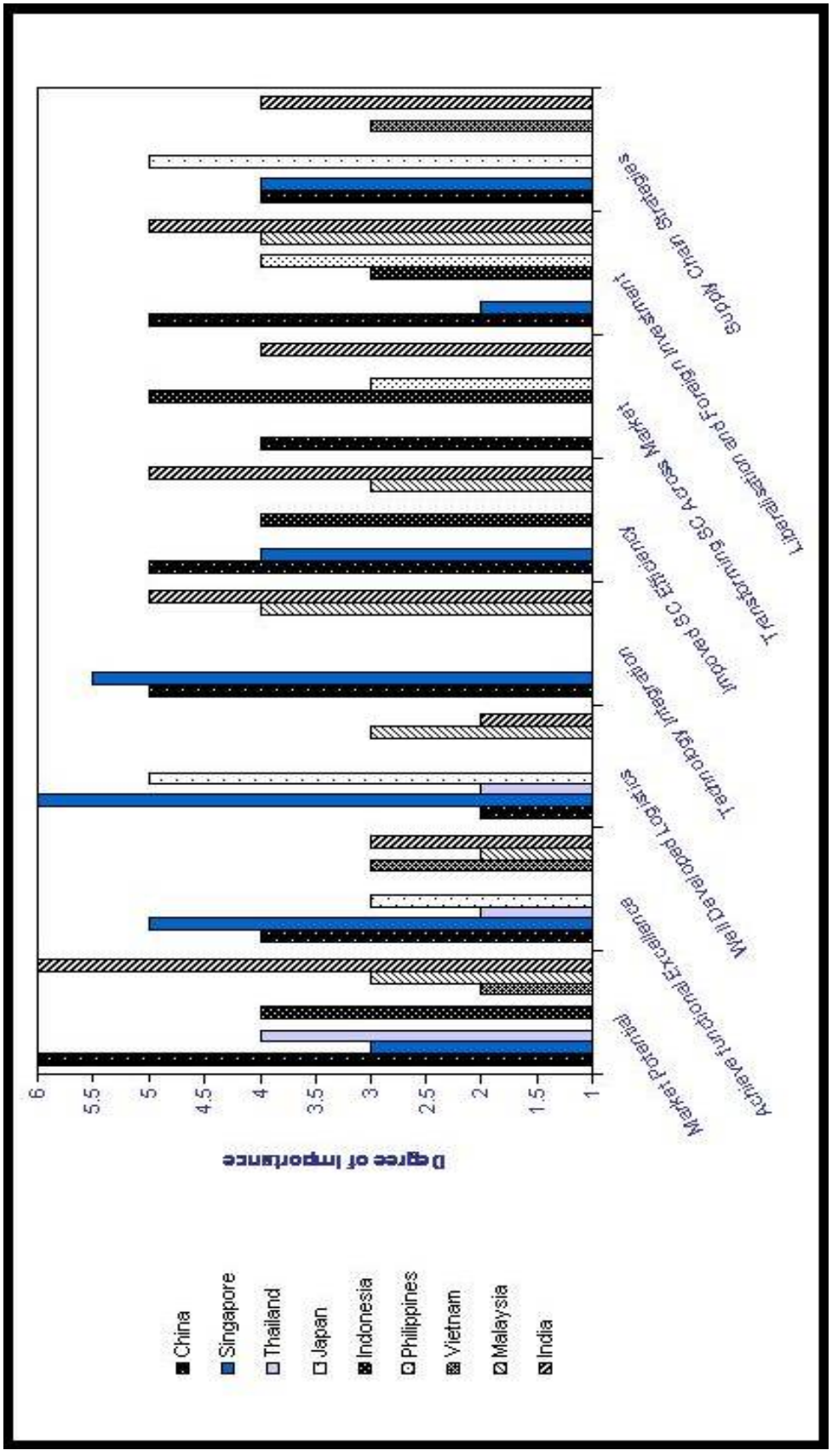

Figure 5: Automotive Supply Chain Opportunities of selected Asia Pacific (APAC) countries (1 – Least important & 6 – Most important)

Methodology to Estimate the Market Size: System Dynamic Approach

The concept of System Dynamics (SD) and its applications to industrial problems were invented by Forrester (1961) in his industrial dynamics, which he later extended and called system dynamics. Forrester (1985) described the term level as the accumulations within the system. He further explained the difference between the levels and rates. He explained decision functions as the statements of policy that determine how the available information about levels leads to the decisions. Sterman (1989) approached the system dynamics in supply chains from a behavioural science point of view and investigated how human misperceptions affect the dynamics of the system. He used a perspective simulation of a beer distribution system, which later became known as the "MIT Beer distribution game". Sushil (1993) described the system dynamics modeling process as iterative, passing through a number of sequences: conceptualization, formulation, testing, re-conceptualization and refinement. Towill (1992) conducted a study to identify the system dynamics background, methodology and applications. As a consequence of these applications in industrial dynamics in supply chain redesign, Berry et al. (1995) generated an electronic supply chain with improved design robustness and operating effectiveness.

Towill (1995) accounted in part for the great worldwide campaign to reduce all industrial and commercial lead-times. Towill (1996) discussed the industrial dynamics modelling of supply chains. Industrial dynamics is concerned with problem solving in systems which bring together machines, people and organizations. Forridge (1997) reported that Forrester's (1958) work on systems dynamics and concept of multi-phasing of the information flow developed by other researchers were officially merged into a set of best practices of communication and material flow in the supply chain.

Market Analysis in a Dynamic State

Despite the many benefits of operational planning tools, Operational Research (OR) tools are intended to optimize individual subsystems and cannot reliably anticipate the performance of the overall system, even when these tools are used in such a way that one tool's results feed into another tool's assumptions. Thus, operational tool sets are unable to accurately assess how vulnerable the automotive logistics performance would be to unexpected changes in resource demand or availability, say, in terms of the likely magnitude and duration of impact on service reliability. Perhaps even more importantly, the existing tools could only partially predict the potential synergies and system-wide benefits that might be derived from enhancing particular resource levels or modifying operating policies. When the whole is greater than the sum of the parts, traditional OR tools are generally inadequate for the task of strategic analysis (Forrester 1968, Homer 1999). Hence in this research, the System Dynamic (SD) tool is used to analyze the automotive supply chain market.

The theory of system dynamics was developed during the fifties and sixties by Jay W. Forrester as a policy design tool for the management of complex problems (Forrester, 1961). The theory draws upon the control, the organization, and the decision theories. Mathematically, system dynamics is a set of

non-linear differential equations that are solved numerically. The basic building blocks are stocks and flows within a structure of information feedback loops. System Dynamics has been used to analyze dynamic patterns in a range of different industry sectors (Sterman, 2000). Proper use of SD models for market forecasting can provide more reliable forecasts of short to mid-term trends than statistical models, and thus lead to better decisions. In many systems, structural momentum dominates over noise in the short term. SD provides a means of understanding the causes of industry behaviours and thereby changes in industry structure as part of an early warning or ongoing learning system.

Developing a Causal Loop Diagram

System Dynamics focuses on the structure and behaviour of systems composed of interacting feedback loops. A Causal Loop Diagram (CLD) is a system dynamics tool, which encourages the modeller to conceptualize the real world systems in term of feedback loops. In a CLD, the arrow indicates the direction of influence, the sign (plus or minus) indicates the type of influence. If a change in one variable generates a change in the direction of the second variable relative to its prior value, then the relationship between the two variables is positive. If a change in one variable produces a change in the opposite direction of the second variable, then the relationship is negative (Forrester, 1961 and Goodman, 1974). The loop polarity can be determined by adding up the number of negative signs around the path. If the numbers of negative signs are even, then the loop is positive otherwise the loop is considered negative. Figure 6 shows the causal loop diagram of the automotive logistics market. The model is classified into four groups, namely: the inbound logistics market, the manufacturing logistics market, the outbound logistics market and the after-sales market. Increasing demand of Inbound Automotive Logistics Service Providers (IALSPs) has a positive effect on the demand of automotive component manufacturing; the increasing automotive component demand in turn increases the demand of CKD kits and this in turn increases the finished vehicle demand. Thus the entire structure forms a positive loop.

The increasing finished vehicle demand increases the profitability of automotive firms and this in turn increases the finished vehicle market share. Any increase in the finished vehicle market share has an overall effect on the desired capacity and this influences the Completely Built up Units (CBUs). The increased supply of CBUs has a positive effect on the Outbound Automotive Logistics Service Providers (OALSPs) and this demand in turn increases the demand of finished vehicles. Thus, all the elements pertained to this loop also form a positive loop. The increase in finished vehicles and the CBU market share tend to enhance a positive trade value. The increase in vehicle trade has a positive effect on the GDP growth and this, in turn, improves foreign investments, investments on infrastructure, new technologies and logistical issues. Improvement in infrastructural issues tends to increase the automotive logistics market and this in turn improves the vehicle parts production. Hence, all the components pertaining to this loop form a positive loop in its model. The present CLD can be extended by formulating a Flow Diagram (FD) which shows the variables and their growth rate as well as their influence rate in the following section.

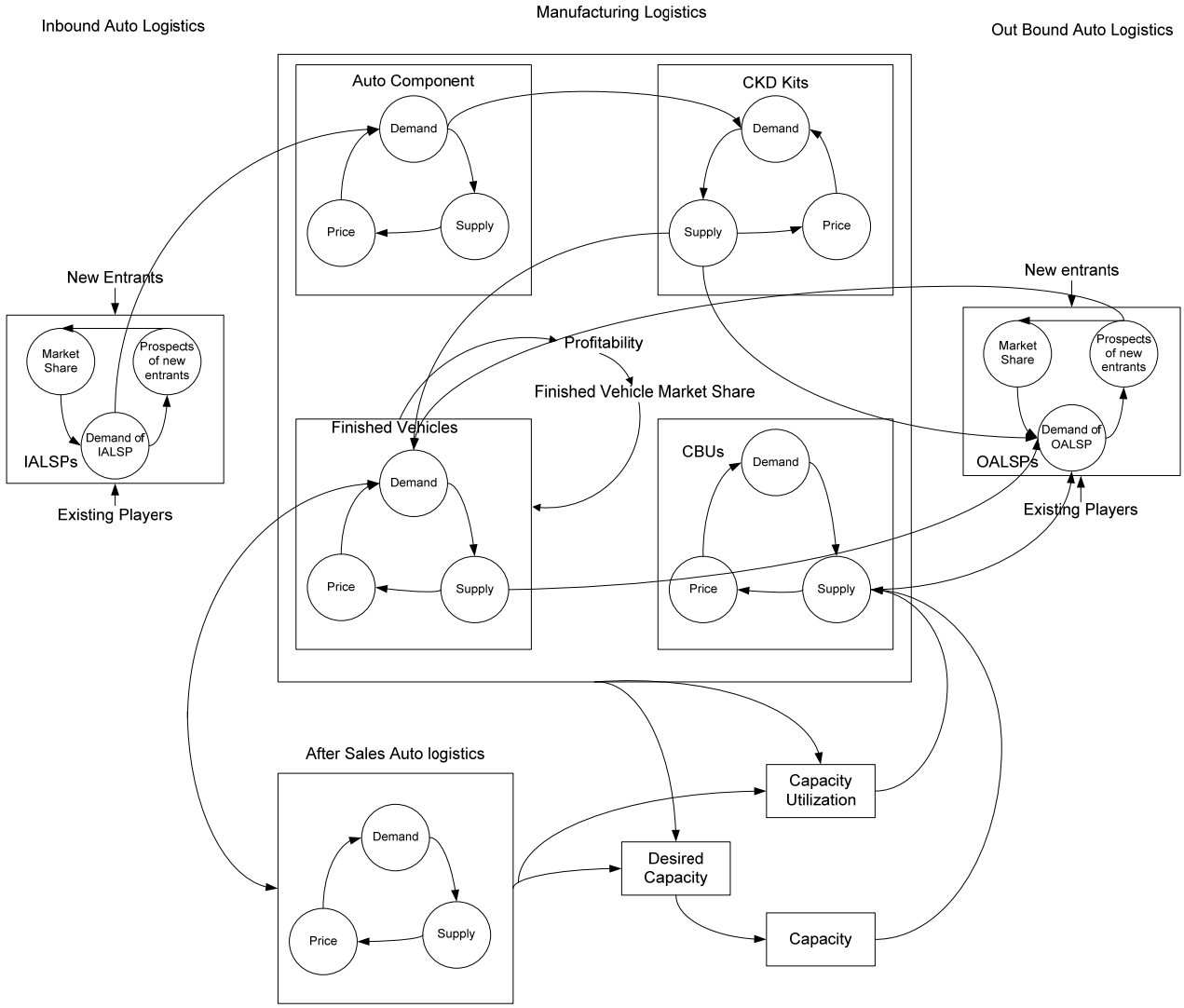

Figure 6: Causal Loop Diagram of Automotive Logistics Market Growth model

Developing Flow Diagram

The causal loop of the model has been converted into a Flow Diagram (FD) with the help of the Powersim Constructor V 2.51 software. Level variables, rate variables, decision variables and decision points are interconnected. The system dynamics dynamo equations have been generated for the model to represent the dynamics of the systems encapsulating the rate of change with each iteration. The resulting flow diagrams for the variables associated with the automotive supply chain and logistics model are shown in Figures 7 to 9.

The dynamo equations are represented as follows: "A" denotes auxiliary equations and "K" denotes system state at a time K. For example, the first equation in the following set implies the growth of the Singapore automotive components and vehicle market in its dynamic state. Growth of this market is influenced by a fractional import rate, a market life and a manufacturing cycle time. The equations are written in terms of the generalized time steps J, K, L, using the arbitrary convention that K represents

the "point of time" at which the equations are being evaluated. The level equations show how to obtain the levels at time K, based on: (i) levels at a previous time J; and (ii) rates over the interval JK. Here, N denotes the initial value of the variables.

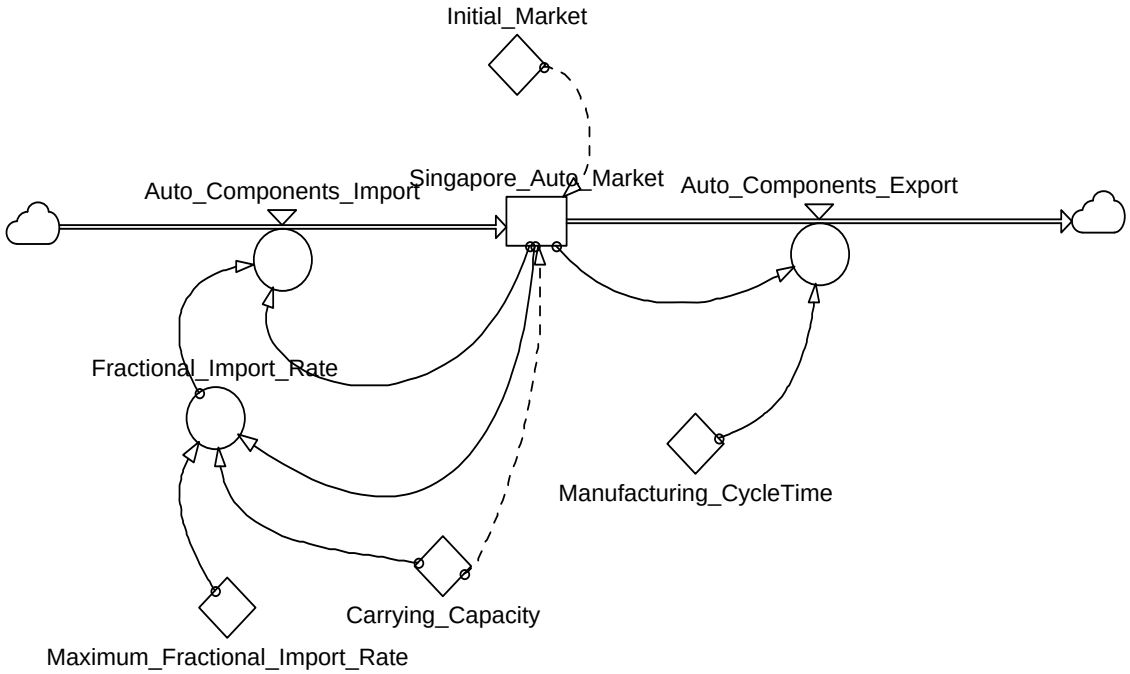

Figure 7: Singapore Automotive Component import export model

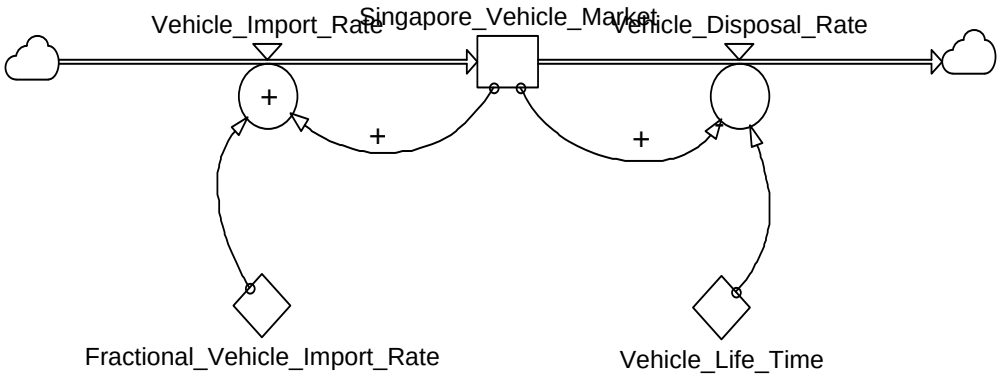

Figure 8: Singapore Vehicle Growth model

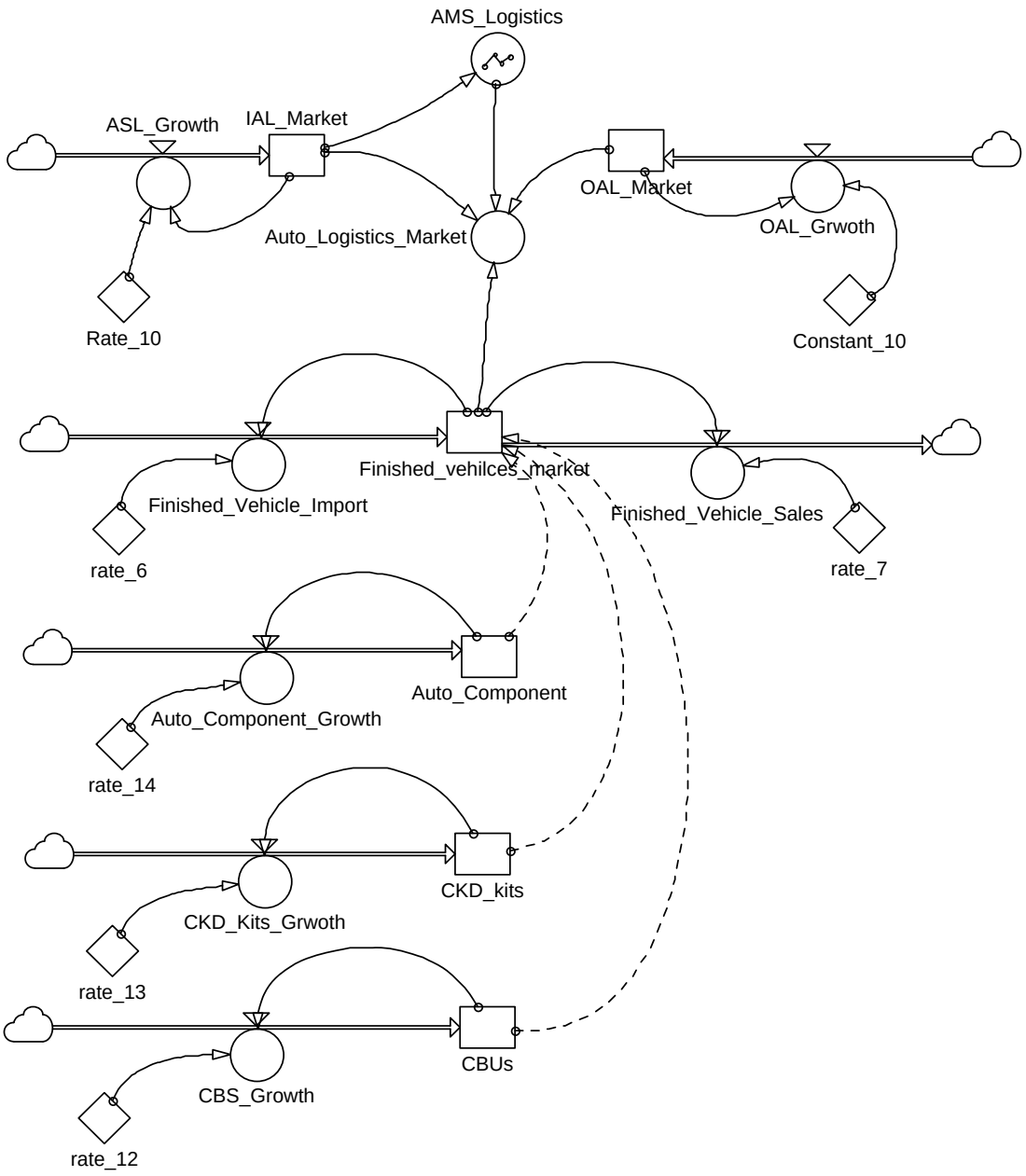

Figure 9: Automotive Logistics Player Growth analysis

Dynamic Equations

The dynamic equations for the automotive supply chain market are represented as:

N Singapore_Auto_Market.J = Initial_Market.J*Carrying_Capacity.J

L Singapore_Auto_Market.K = Singapore_Auto_Market.J + (Auto_Components_Import.JK - Auto_Components_Export.JK).DT

A Auto_Components_Export.K= Singapore_Auto_Market.K/Manufacturing_CycleTime.K

A Auto_Components_Import = Fractional_Import_Rate*Singapore_Auto_Market

Model Validation

The validation of any system dynamics model is necessary to establish sufficient confidence in the model according to some chosen criteria relevant for the organization or system under study. There is a significant variety in the concepts, underlying validation in the literature. According to Forrester, (1961) the purpose of the model is to aid in designing better management systems and the significance of the model depends on how well it serves its purpose. Forrester emphasized the role of development of system dynamics as a methodology for systems description and qualitative analysis with validated output and its significance. Hence, the model developed should be validated using statistical tests for mean (t-test) and variances (F-test). For this reason, the mean and variance of the model and actual values for all the variables are calculated and tested against statistical tests (see Table 1). Multi-regression analysis is being conducted among the 11 independent variables and dependent variable (Automotive logistics market variable-unknown variable) and the correlation between them shows these values are strongly correlated and have an impact on the automotive logistics market at 5% significance level (see Table 2).

Table 1: Statistical significance values at 5% level

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	5302.24	3046.04	1.74	0.16	-3154.92	13759.40
Australia	3.37	3.34	1.01	0.37	-5.90	12.65
China	-0.01	0.24	-0.02	0.98	-0.66	0.65
India	-0.54	0.84	-0.64	0.56	-2.87	1.79
Indonesia	-3.79	3.19	-1.19	0.30	-12.64	5.06
Japan	-1.52	0.62	-2.43	0.07	-3.25	0.22
Korea	-0.41	0.42	-0.97	0.39	-1.59	0.77
Malaysia	4.91	1.83	2.69	0.05	-0.16	9.98
Philippines	8.57	11.50	0.75	0.50	-23.35	40.48
Singapore	-1.90	4.52	-0.42	0.70	-14.45	10.66
Thailand	2.43	4.19	0.58	0.59	-9.21	14.08
Vietnam	4.06	10.60	0.38	0.72	-25.38	33.49

Table 2: Multi regression analysis of vehicle sales data sets

	Australia	*China*	*India*	*Indon-esia*	*Japan*	*Korea*	*Malaysia*	*Philipp-ines*	*Singa-pore*	*Thailand*	*Vietnam*
Australia	1.000										
China	0.891	1.000									
India	0.883	0.995	1.000								
Indonesia	0.578	0.701	0.703	1.000							
Japan	0.617	0.821	0.802	0.868	1.000						
Korea	-0.344	0.025	0.043	0.290	0.298	1.000					
Malaysia	0.658	0.843	0.837	0.782	0.886	0.344	1.000				
Philippines	-0.065	0.191	0.176	0.482	0.481	0.403	0.145	1.000			
Singapore	0.863	0.964	0.955	0.698	0.830	0.032	0.913	0.057	1.000		
Thailand	0.738	0.931	0.923	0.832	0.949	0.253	0.878	0.402	0.902	1.000	
Vietnam	0.602	0.693	0.677	0.560	0.708	0.186	0.817	-0.192	0.799	0.742	1.000

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

Against its 16 sample sizes, the multiple R value is calculated as 0.9302848 and the squared multiple correlation (R^2) is calculated as 0.8654299. This implies that the independent values are 86.54% correlated with the dependent variable (Automotive logistics variable).

Estimating Automotive Logistics Market

In this section, we estimate the automotive logistics demand of the APAC region from the statistically tested data sets being fed in the Automotive Supply Chain Dynamics model. Since the collected data sets of CKD kits and after-sales products are inconsistent, having small sample size, we skipped these data sets and their impact on the automotive logistics market prediction. In order to calculate the overall automobile sales of the selected economies, the individual sales pertained to those economies have been forecasted and are shown in Figures 10 to 13.

The model takes history of data sets about the automotive vehicle markets, spare parts market, after sales market and simulates in a continuous time scale with subject to delay and noise conditions and forecasts the next five years of each and every segment. The auto logistics market is estimated considering only the road freight shippers in order to the complexity of the approach. The over all auto logistics market has been determined aggregating the auto logistics demand induced in each segment

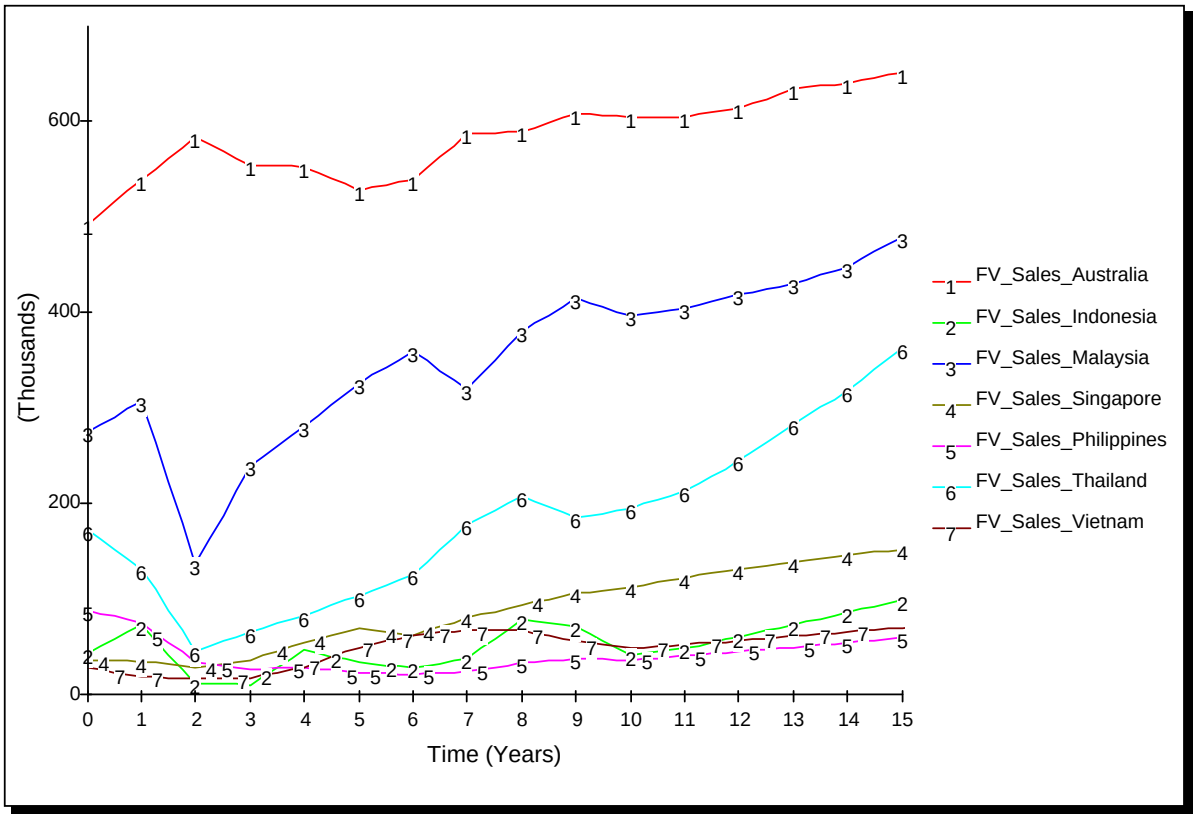

Figure 10: Finished Vehicle (Passenger Cars) sales in the selected APAC countries (Excluding major Automotive Economies) Passenger cars include small cars, medium cars, large cars, luxury cars and sports car segments (Base year: 1996)

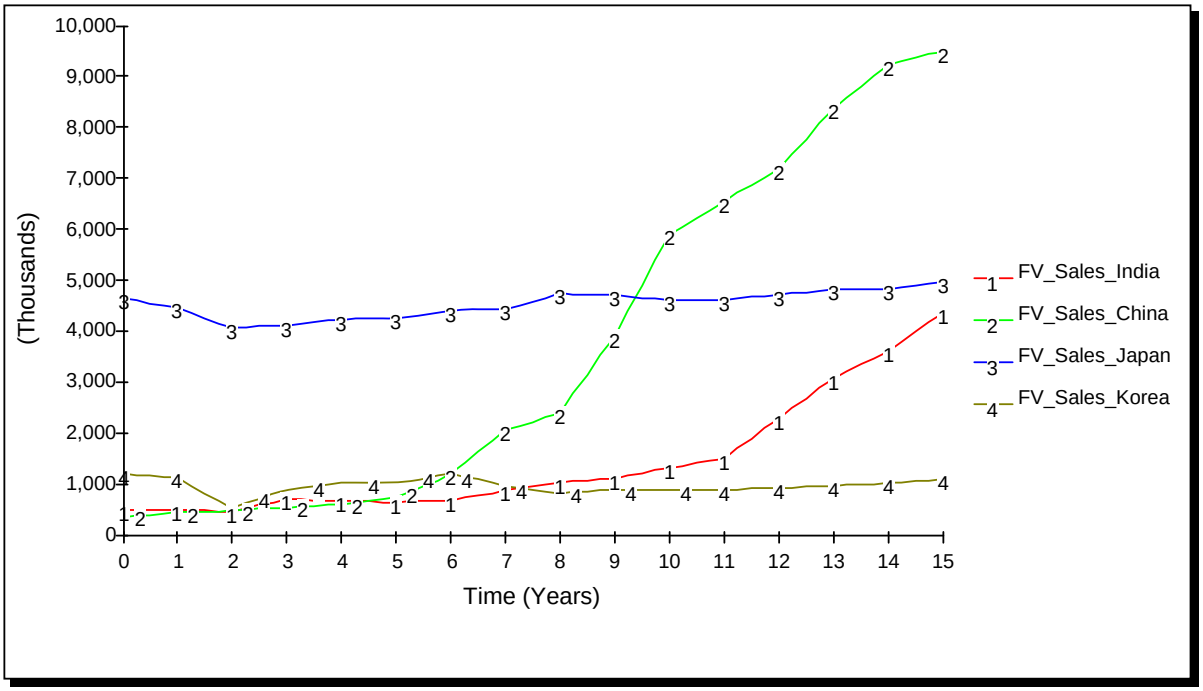

Figure 11: Finished Vehicle (Passenger Cars) sales of major Automotive Economies in the APAC region. (Base year 1996)

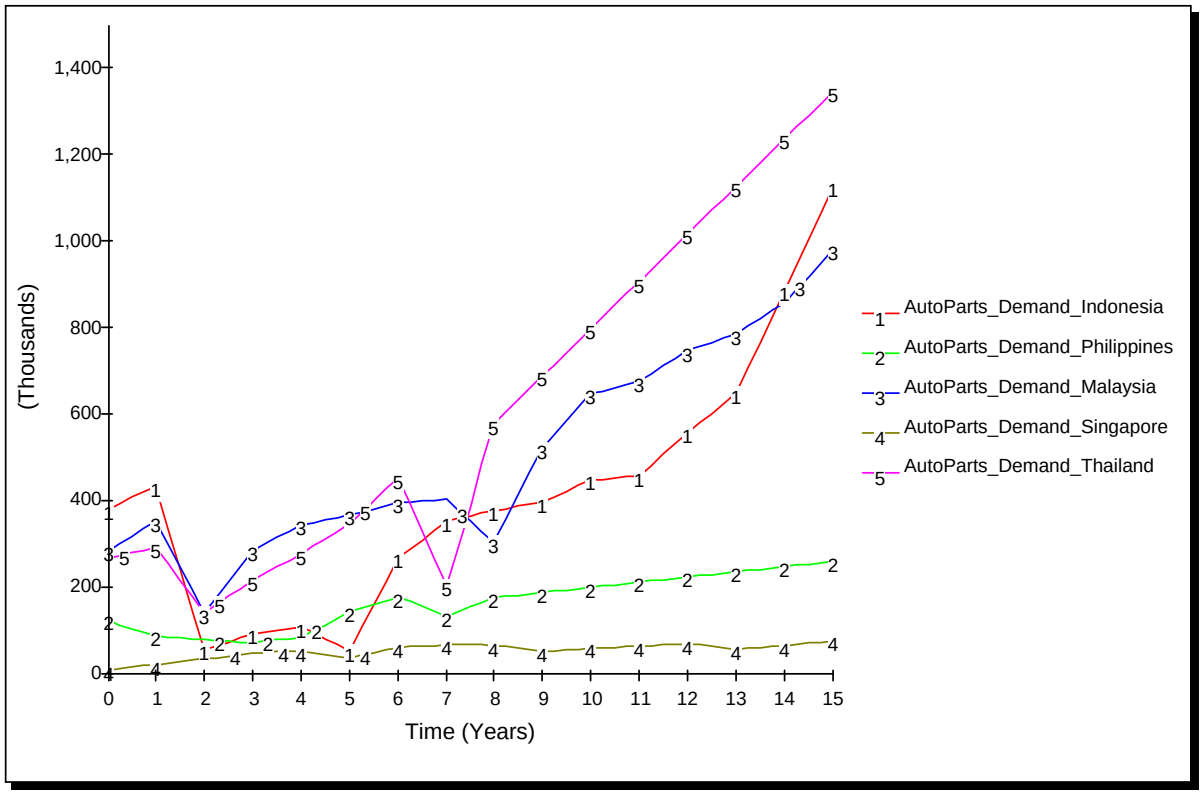

Figure 12: Automotive part demands in selected countries (Excluding major Automotive Economies) Base year: 1996 (Automotive parts mentioned here consist of tier 1 and tier 1.5 components). Data: SICCI Data Book, 2004

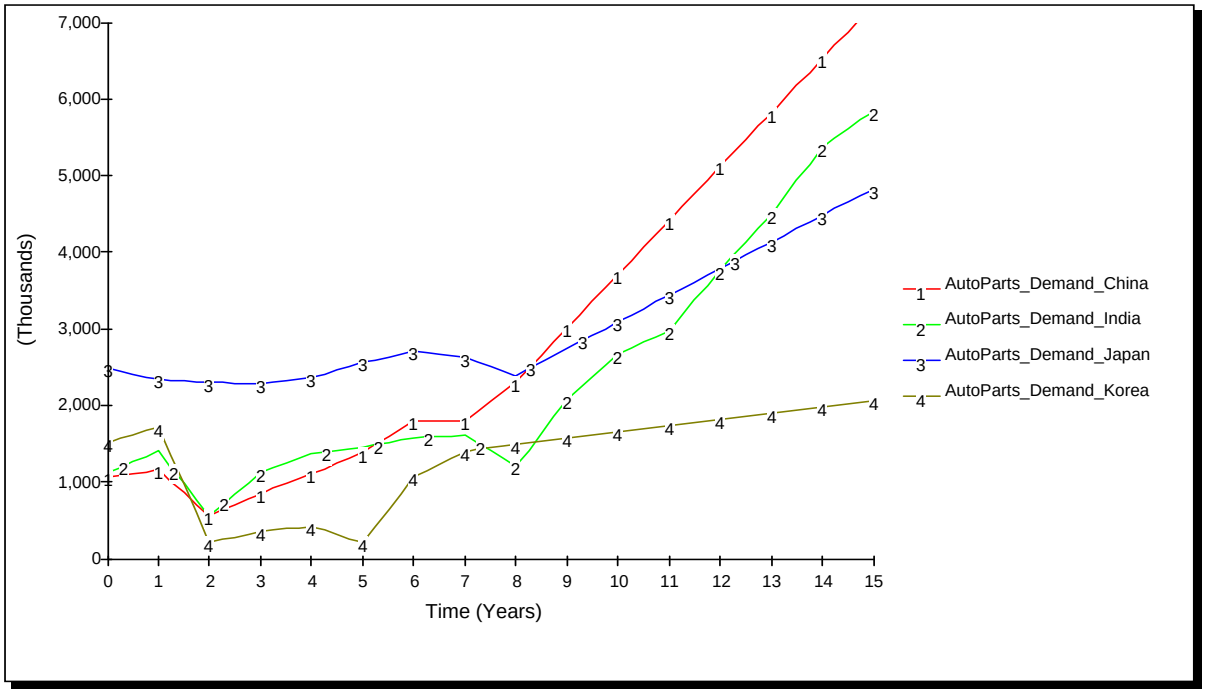

Figure 13: Automotive part demands in selected major automotive economies
Base year: 1996 (Automotive parts mentioned here consist of tier 1 and tier 1.5 components). Data: SICCI Data Book, 2004

The total automotive logistics market of the APAC region is estimated from the demand of passenger car sales and that of the automotive spare parts market of the selected countries (Figure 14). The accessed data were closed data sets, accessed through a proper channel and used for research purposes.

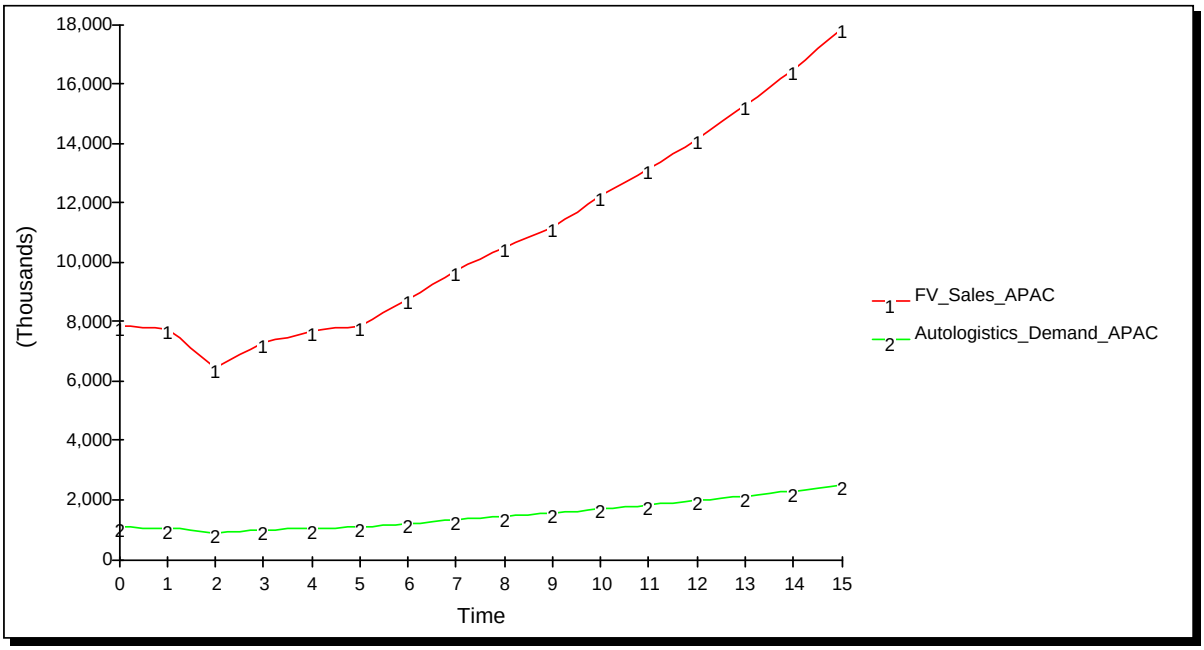

Figure 14: Total finished vehicle (Passenger Cars) sales and predicted automotive logistics demand in the APAC region

Estimating Automotive Logistics Revenue in APAC

According to the study conducted by Frost and Sullivan (2006), the outsourced logistics market in South-East Asia has grown by 9.9% to US$14.8 billion in 2006 from its revenue of US$13.5 billion in 2005. Moreover, from our analysis, we have calculated the value of the automotive logistics revenue from the logistics outsourcing and the logistics cost figures for the data of the past 8 years as shown in Figure 15. The outsourced logistics market in 2006 was about 37.5% of the total logistics market, which included the spending on logistics managed in-house by the companies. In 2007, the outsourced logistics market is expected to experience a growth of 10.2%, reaching a revenue figure of US$16.4billion. In 2008, the figure is expected to cross the US$ 22 billion mark.

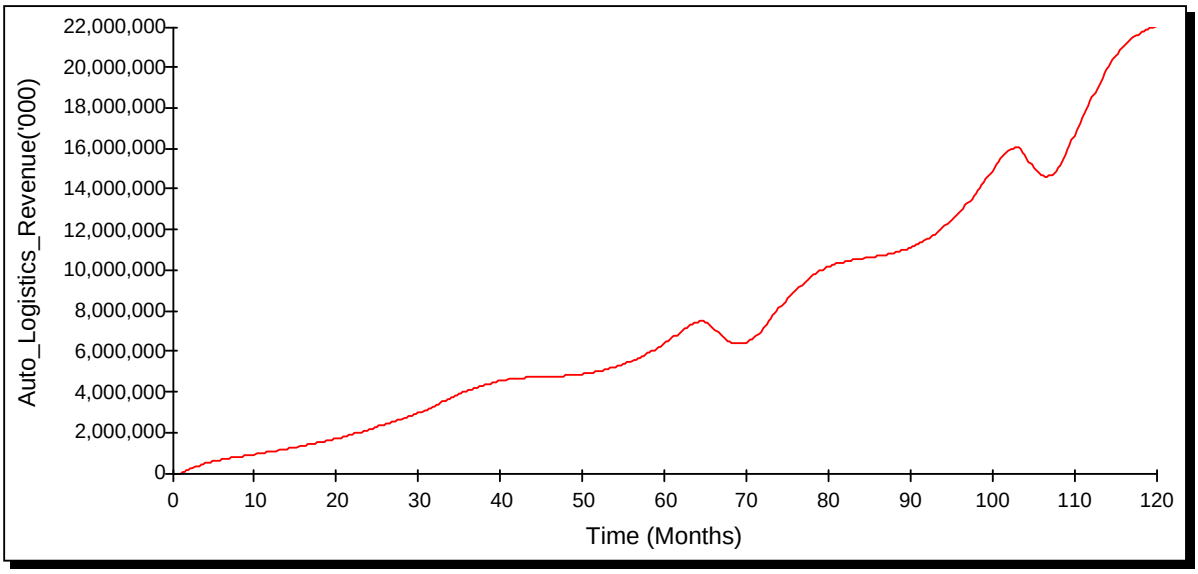

Figure 15: Automotive logistics Revenue estimation of APAC region (base year 1998)

Logistics companies in four South-East Asian countries, namely: Malaysia, Singapore, Indonesia and Thailand are competing in four sectors, which are: retail, Fast Moving Consumer Goods (FMCG), automotive and IT/electronics. Among these sectors, the automotive logistics market is fully outsourced and maintained by third party ALSPs. In Malaysia, DHL was honored as the best logistics service provider in retail and FMCG sectors, while in Singapore, DHL was also honored as the best logistics provider in retail and in the automotive sectors.

The market for the automotive logistics services in APAC is highly competitive, with slow growth and generally below industry average margins. The logistics industry associated with the automotive sector in APAC is worth many billions of dollars and is of prime importance to all the major logistics players, as well as of strategic significance to vehicle and component manufacturers. There are many strong players already in the market and the prospect of new entrants is high. These new entrants are likely to expand by acquisition. Vehicle manufacturers, as well as an increasing number of component suppliers, are generally well-informed and pursue aggressive purchasing strategies which reduce the margins of their logistics suppliers. The automotive sector has not developed global supply chains in

the way that has emerged in other sectors over the past decade. On the contrary, supply chains are regionally based within currency areas. Therefore, the demand for global transport services is lower in the automotive sector than in a number of other sectors.

We estimate the size of the Asia-Pacific (APAC) market as being in excess of US$17 billion split among the Inbound market, the Finished vehicle market and that of the Aftermarket. The compound annual growth rate in these markets, between 2003 and 2008, is estimated to be: for the Inbound market: 0.6%, for the Finished Vehicle market: 2.52% and for the Aftermarket: 1.79%. This is quite comparable with the European market. The size of the European market, which is in excess of €17 billion split between the Inbound, Finished vehicle and Aftermarket. The compound annual growth rate in these markets, between 2003 and 2008, is estimated to be: for the Inbound market: 0.8%, for the Finished Vehicle market: 2.12% and for the Aftermarket: 1.58%. The following section of this report depicts the region-wise forecasts of the auto logistics market in the APAC region.

Estimating Automotive Logistics Market in Singapore

In 2003, the Logistics industry in Singapore contributed to about S$6.7 billion (or 4%) of the GDP and employed around 71,400 people or 8% of the overall services workforce. Foreign Airlines offices and Airport Services Companies were the largest employers of logistics workers. Around 62% of the 5,380 logistics firms were large establishments (i.e. which employ more than 100 workers) and they accounted for around 86% of the workforce in the logistics industry. Key business challenges included attracting new customers, retaining existing customers and dealing with increased competition locally.

The situation is a bit different for the Singapore automotive logistics industry. Although the industry contributes to a considerable percentage of the logistics industry, its growth rate is expected to be more than 10% annually. In the emerging neighbouring markets, Singapore was rated as the best Automotive Logistics Service provider in two consecutive years among the ALSPs. In recent years, Singapore's logistics market is opening up to the outside world. Automotive Logistics enterprises are reorganizing and integrating in the competitive environment. It is more and more obvious that state-owned, private-owned and foreign-funded enterprises are surviving and thriving in these competitive markets. Integrated with traffic and transportation, storage and delivery, the automotive logistics industry realizes low costs and high benefits in enterprises and society. Therefore, the automotive logistics industry, together with IT- enabled supply chains, is looked upon as the important content of the Automotive supply chain. It is forecasted that during the next three-year period, Singapore's Automotive logistics industry will keep an annual growth of 13%. With the increasing demand of logistics, the logistics services for enterprises will change from the low-value fundamental services to high-value added services. Logistics infrastructure, integrated logistics, traffic and transportation, and delivery services provide huge investment opportunities. However, the related risks must be put into account, and one should be cautious when choosing investment projects.

Identifying Capability Gaps and Growth Opportunities for Singapore

Singapore's Growth Opportunities in the Automotive Logistics Market

In general, automobile manufacturers tend to outsource more 3PL services, direct a larger percentage of their logistics expenditures to outsourcing, and rely on 3PL providers more for transportation management technology in comparison with other industries. Transportation, shipment consolidation, cross-docking, and Lead Logistics Providers (LLP) services were noticeably higher than other industries with an 11 % average increase across all services. Automobile manufacturers outsource 60% of their logistics expenditures, 5 percentage points higher than the overall industry average. The most commonly outsourced logistics activities are transportation (99%), customs clearance (73%), warehousing (65%), shipment consolidation (60%), and freight forwarding (55%). Moreover, automobile manufacturers rely on their 3PL provider's transportation planning and execution technology 16% more of the time than those of other sectors. The most common technology-based services for the automotive respondents are transportation execution (79%), visibility (64%), warehouse management (61%), web portal communications (60%), and transportation planning (53%). Figures 16 and 17 highlight the top three current and future automotive logistics initiatives. In several areas, 3PL providers have opportunities to develop and improve service offerings and customer satisfaction programs, addressing both existing and untapped demands in the automotive sector. Failure to accommodate such automotive requirements may cause automobile manufacturers and suppliers to look elsewhere or to build logistics capabilities themselves.

Current and Future Automotive Logistics Initiatives

	Current		Future	
Service Parts Management	Dedicated delivery service to dealers from parts distribution centers	60%	Retail channel distribution	63%
	Dealer-managed inventory replenishment	42%	Packaging design, outsourcing, and ownership	50%
	Parts distribution center outsourcing programs	41%	Dealer-managed inventory replenishment	49%
Returnable Container Programs	Increase use for inbound-to-manufacturing	46%	Radio frequency identification initiatives	75%
	Outsource tracking and management	27%	Outsourcing returnable container design	61%
	Outsource ownership of assets	24%	Increase use for inbound-to-manufacturing	36%
Order-to-Delivery Cycle Times	Build-to-order	61%	Demand management and analysis	63%
	Dynamic available-to-promise	54%	Locate-to-order	47%
	Vehicle identification number tracking	48%	Postponement or late configuration	44%

Figure 16: Top Three Current and Future Automotive Logistics initiatives adopted
Source: 3PL Study Report, 2006

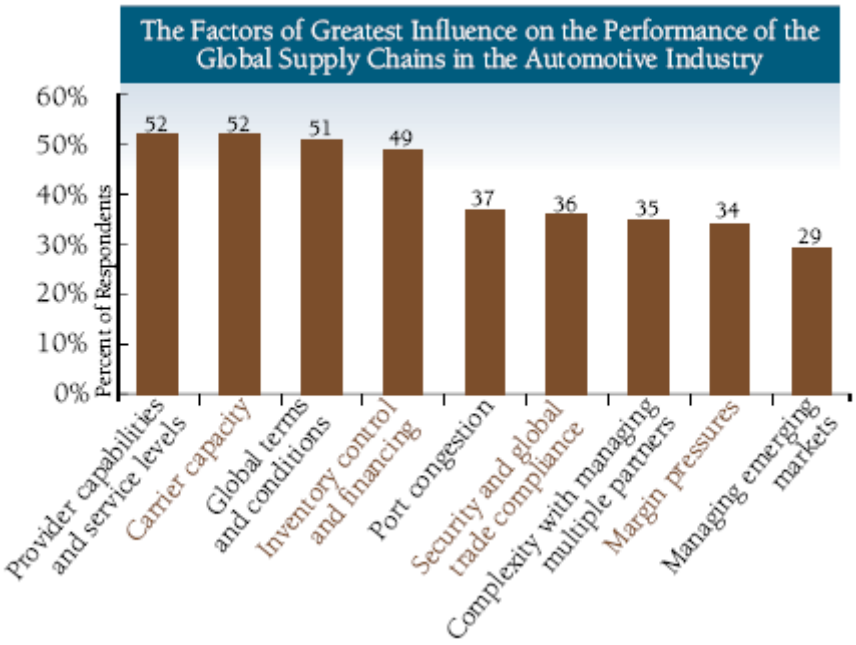

Figure 17: Greatest Influencing Factors in the Automotive Logistics Industry
Source: 3PL Study Report, 2006

Outsourced Logistics Services					
Logistics Activity	All Regions	North America	Western Europe	Asia-Pacific	Latin America
Transportation	90%	83%	95%	95%	90%
Warehousing	74	74	76	77	57
Customs Clearance and Brokerage	70	71	59	83	65
Forwarding	54	55	54	66	15
Shipment Consolidation	47	44	50	53	35
Reverse Logistics (Defective, Repair, Return)	35	28	44	36	30
Cross-Docking	34	36	40	30	18
Transportation Management	34	27	36	48	18
Freight Bill Auditing/Payment	33	55	22	18	17
Product Labeling, Packaging, Assembly, Kit	33	26	45	33	20
Fleet Management	19	13	20	21	30
Supply Chain Consultancy by 3PL Provider	18	21	16	16	10
Order Entry, Processing, and Fulfillment	14	14	10	14	19
LLP/4PL Services	11	12	13	6	15
Customer Service	10	8	9	13	10

Figure 18: Outsourced Logistics Services to different horizontals of the Automobile Industry
Source: 3PL Study Report, 2006

The research highlights future scope existing in 3Pl/4PL outsourcing decision for LLPs in the automotive logistics segment. Because LLPs can control the supply chain risk, increase visibility from suppliers to customers by integrating them in one umbrella. They can provide tactical outsourcing to suppliers present in the automotive spare parts and CKD or CBU customers by leveraging their

strength. By maintaining a collaborative partnership LSPs can share risks and benefits mutually towards a win-win scenario.

Growth Opportunities in delivering High-Tech Automotive Components

Singapore automotive logistics players can be competitive when compared to other regional automotive logistics players in some of the identified possible areas like dispatching/transporting high-tech components, such as: electronic components, sensors, display equipments, safety equipments etc., as shown in Figure 19. These components are smaller in size and frequently require a higher margin. Singapore air cargo firms and their competitiveness in delivering goods to worldwide markets have added an advantage to these segments to provide logistical services in the APAC region. We have also predicted from the first phase of this research that, in the future, the electronic components of a car will represent 70% of it cost value due to the fact that these electronic components will be found everywhere in a car and will control most of its functions. Singapore already has considerable electronic players operating in the domain. There exist wider logistical opportunities which should be reaped at the right time.

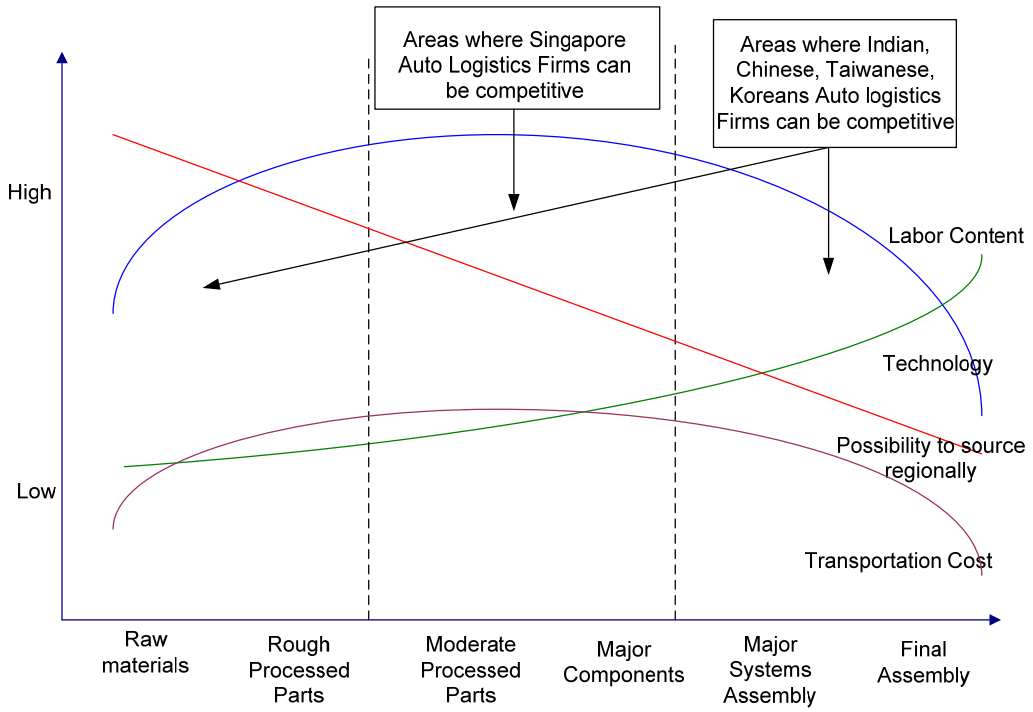

Figure 19: Possible growth opportunities areas where Singapore Automotive Logistics Companies can be competitive

Growth Opportunities in Delivering High and Low Value added Components

According to recent statistics, Figure 20 shows that Singapore has been ranked as having the fifth best air cargo service facilities in the world, in terms of: services, operations and container handling. Singapore has also been ranked as having the second best ship port in the world on the same terms.

Singapore can make use of these efficient logistics service facilities for high-value added components at one side and low-value per cube/pound at other side across the APAC region. Figure 21 shows that Singapore air and marine logistical service providers can be competitive either by direct servicing or by outsourcing. Emerging ASEAN's and APAC's automotive markets could be served by these efficient logistics services.

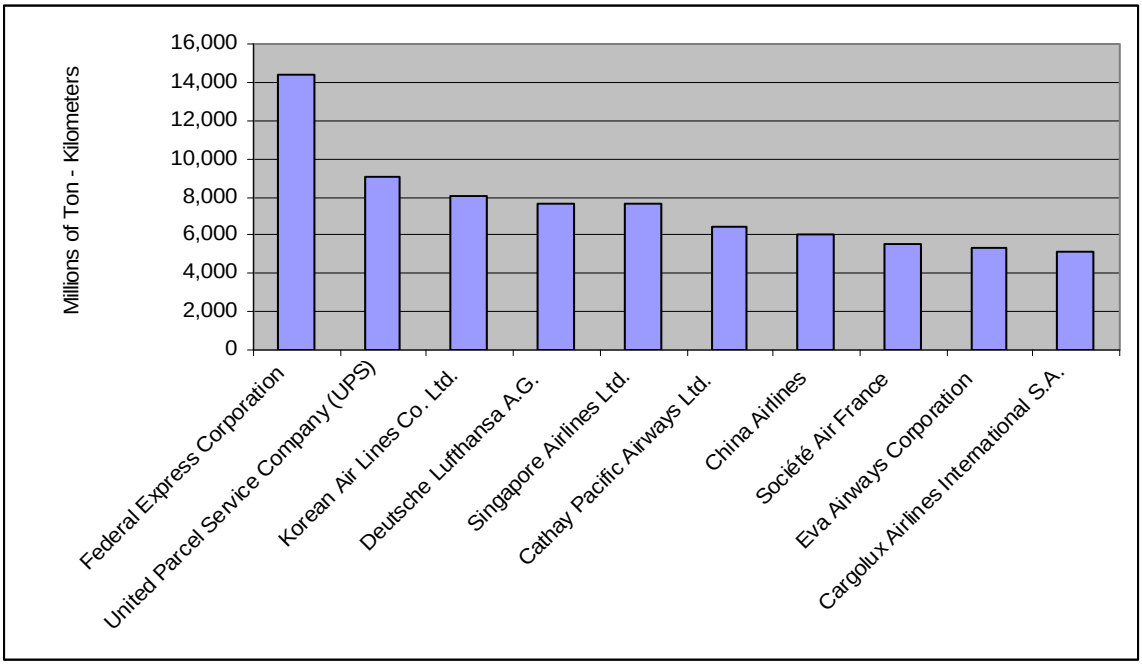

Figure 20: Comparison of Global Air Cargo Carriers
Source: International Air Transport Association (2006)

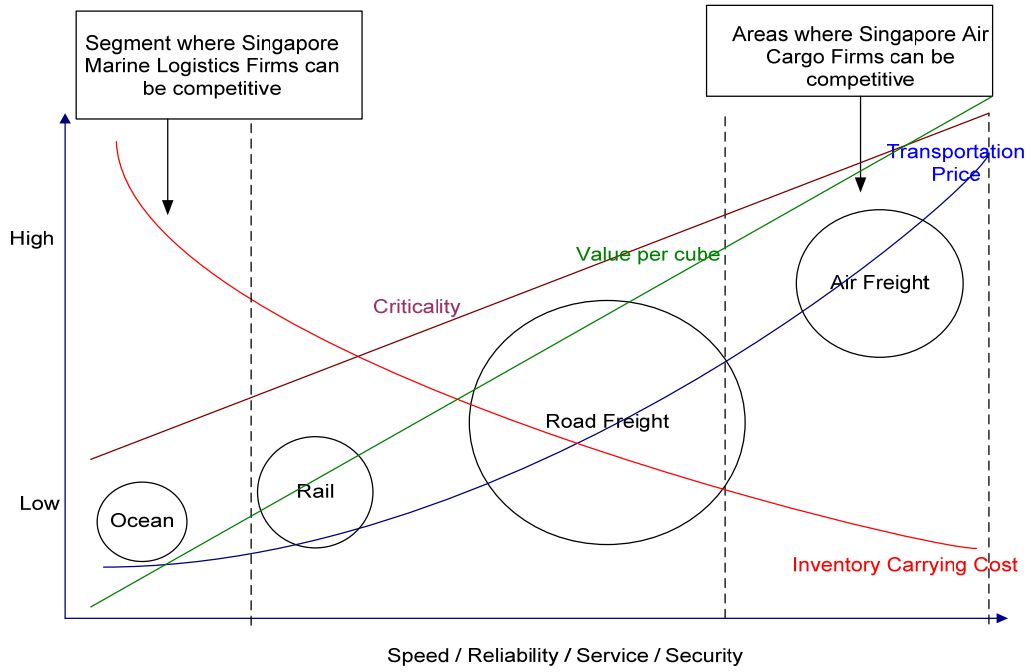

Figure 21: Segments where Singapore air and marine logistical service providers can be competitive either by direct servicing or by outsourcing

Providing Logistics Services in After Sales Market

The global aftermarket is a huge sector, worth over € 600 billion in 2005 and forecast shows continued growth over the coming years (Datamonitor, 2007). However, the pattern of expansion will be uneven, with strong growth in the developing markets of Asia, Eastern Europe and the Middle East / Africa countering more modest growth in the developed markets. To be successful, market players will have to work with five key underlying trends, namely: the uneven levels of car park growth by geographic region, the trend towards better quality original equipments and replacement parts, the rising commodity prices, the trend towards remanufactured products and the continued merger and acquisition activities. Deloitte Research (2007) surveyed nearly 80 of the world's largest manufacturing companies about their after-sale service business, and published the results early this year. Deloitte found that across these automotive companies, services revenues represent an average of more than 25 percent of the total business. In many of these firms, the service business contributes 50 percent or more of the total revenues (Figure 22). According to Deloitte's research, the median company benchmarked secures only 40 percent of the after-sales service market and 75 percent of the after-sales spare parts market for its own installed base of products "captive" customers.

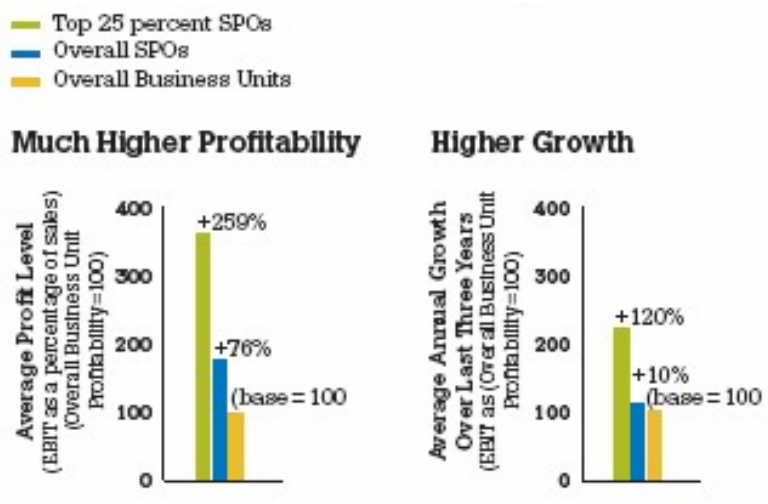

Figure 22: Profits and Growth: Impact of service and parts operations on the automotive business performance *Source: Deloitte Research, 2007*

Conclusions

As the manufacturing landscape is changing rapidly, requiring new mindsets and skill sets, the Economic Development Board of Singapore (EDB) continues to deepen Singapore's manufacturing culture and skill sets. Initiatives adopted include the establishment of new policies with companies as well as with research institutes, universities and polytechnics to expand the industry's R&D in the automotive sector. The government has also budgeted S$5 billion to identify and develop new research areas and to provide Singapore a quantum leap in its national R&D endeavors (EDB, 2006). Singapore's automobile manufacturing and automotive logistics landscape will, in the future, be bigger

and broader. Existing alongside the rig builders and computer manufacturers will be companies involved in wearable electronics, automotive electronics, nanotechnology, aircraft systems and bio-fuels, opening up exciting opportunities, which extend beyond production to the entire automotive value chain.

This research analyzed the dynamics of the regional automotive supply chain using a system dynamics model. Causal loop diagrams have been developed to identify the relationships between the variables of the automotive supply chain and the automotive logistics markets. Under different system states, a policy experimentation was carried out for the various degrees of delays in the model. A detailed sensitivity test was also carried out to examine the robustness of the model and to get insights on various aspects, such as: the demand, the supply, the automotive logistics market and the automobile production. A detailed sensitivity analysis showed how market changes impact on the automotive supply chain and automotive logistics market. From the present analysis, some capability gaps associated with the automotive supply chain have been identified and strategic growth opportunities were captured for Singapore. The research recommends:

1. There are huge opportunities in the automotive logistics market and automotive in the after-sales market in the neighbouring regions of Singapore. Being a regional hub in logistics services, Singapore can capture strategic opportunities to improve its GDP

2. Automobile sales in the ASEAN and the APAC markets are poised to grow in the next 10 years and this gives a wide scope for the automotive logistics market

3. The demand for highly efficient automotive logistics players and a logistics hub are always required; Singapore can play a vital role in this capability gap.

4. Opportunities for automotive logistics service providers exist in delivering high-value added and low-value added automotive components to nearby countries in the APAC region.

5. Opportunities also exist in the outbound automotive logistics segment where Singapore can outsource its port facilities to transit the automotive equipments for efficient shipments across the Asia-Pacific region.

Singapore automotive logistics service providers (ALSP) should efficiently utilize these opportunities in order to reap maximum benefit and win in this competitive scenario. It shows the strategic direction where LLPs can look and can share risks and benefits with suppliers and customers towards a win-win scenario.

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Appendix I - Major Automotive Players Interviewed for the Study

1. Toyota Motors
2. Ford
3. Volkswagen Group (VW Group)
4. General Motors
5. BMW
6. Daimler Chrysler
7. Honda
8. Denso
9. Delphi
10. Cat Logistics
11. TNT Logistics
12. Visteon
13. Subaru Motors
14. ZF

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