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Intra-industry Trade, Product Fragmentation and Technological Capability Development in Thai Automotive Industry*

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Abstract: *Thailand's automotive industry has evolved from a small import-substituting industry to a vibrant exporting one. It has contributed significantly and increasingly to the economy and intra-industry trade in Southeast Asia. The country also has experienced 'qualitative' change from simple production to technologically sophisticated activities. The evidence amassed illustrates that firm strategy and collaboration with other actors in the national innovation system were the most important drivers of technological upgrading in the industry. Local automotive part suppliers in particular had to become 'active' learners by collaborating with other partners beyond their own multinational buyers to compete in export markets.*

***Keywords*:** automotive, host-site institutions, intra-industry trade, Thailand, technology

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1. Introduction

Intra-regional trade among developing countries has grown rapidly in East Asia. This is due to the expansion of international production fragmentation and productive integration within vertically integrated production chains (Kimura and Ando 2005, Athukorala and Yamashita 2006). The development has been enhanced mainly because of the proliferation of free trade agreements (FTAs) and the role of transnational corporations (TNCs) through foreign direct investment (FDI) (Kawai and Wignaraja 2007). According to Hoekman and Javorcik (2006), TNCs can facilitate industrialization because they bring capital and technology into the host economies. Nonetheless, the spill-over impacts on host countries in terms of increase in indigenous technological and innovative capabilities have been different across countries. While multi-national corporations' (MNCs) strategies considerably explain these differences, national innovation systems at host-site countries are also critical (Patel and Pavitt, 1998, Rasiah, 2004; Marin and Bell, 2006, Marin and Giuliani 2007, Nawan and Intarakumnerd, 2013). Rasiah (2007), proposed the concept of 'systemic quad' underpinning industrial clusters to move from underdeveloped stages to developed ones, with a focus on basic infrastructure, high-tech infrastructure, network cohesion and global integration.

Technological capabilities of firms are resources needed to generate and manage technological change, which include skills, knowledge, and experience, as well as institutional support and linkages. Technological capabilities are also vary in depth. Basic capabilities may permit only minor and incremental change, whereas technological capabilities at the intermediate and advanced levels may require substantial changes (Lall, 1992, Bell and Pavitt, 1995, Rasiah, 2010).

Therefore, it is crucial to investigate the changing environment and investment strategies of MNCs and national firms that support the provision of basic infrastructure, high technology infrastructure, coordinate inter-firm and networks, and promote integration into global value chains.

Japanese MNCs in Southeast Asia has long played an important role in the agglomeration or industrial clusters. Lead Japanese MNCs view the 'division of labour' to locate manufacturing activities according to comparative advantage.

According to Kimura (2006) the intra-industry trade for East Asian countries, particularly in machinery parts and components, has increased since the 1990s. Hence, this study aims to investigate the status of technological upgrading in the automotive industry in Thailand. Also, it aims examine how intra-industry trade and international production fragmentation has impacted on Thailand's automotive industry.

2. Past Works on Thailand's Automotive Industry

Several past studies illustrate that Japanese MNCs have impacted profoundly on production networks and trade in East Asia. Athukorala (2008), for example, found that Japan's trade decreased over time because of the relocation of manufacturing to other countries. Rasiah (1988) and Kawai and Wignaraja (2007) reported that Japan and the Asian newly industrialized economies have relocated massively production operations in in East Asia. Japanese MNCs has been playing a crucial role in both global production sharing (Ng and Yeats 2001, Athukorala and Yamashita 2006) and the skills development in local firms in Thailand (Techakanont and Terdudomtham 2004, Yamashita 2008), which suggests that MNCs and trade are complementary, while developing countries can promote productive industrialization and trade integration.

Several studies on the automotive industry in Thailand owing to its rapid growth to become the leading production base in Southeast Asia. Techakanon (2011) discussed the experience of the development of Thailand's auto parts industry and intra-regional trade integration, which noted the rapid expansion of the industry as a consequence of production fragmentation. They also noted that the Thai government had clear policies and strategies that have been flexible and aligned towards meeting the interests of MNCs. Japanese assemblers have been crucial in pooling the productive resources among countries via regional production networks.

Intarakumnerd and Charoenporn (2010) reported that Thailand has relied heavily on FDI, which amounted US$34.2 billion over the period 1970-2006. FDI has played an important role in Thailand's industrialization since 1986. Prior to 1986, FDI in the

manufacturing industry took the form of joint ventures that focused on assembly of final goods for the domestic market using imported capital goods. A significant amount of FDI went to export industries since 1986 that specialized initially on intermediate goods, such as electronics components. As a result, Thailand's exports expanded sharply in 1986-1996 (Lauridsen, 2004).

Significant change also occurred in the structure of Thailand's manufactured exports. The share of resource-based and labour-intensive exports went down, while science-based and differentiated exports went up, especially since the 1990s. New 'high-tech' products, such as, electronics, expanded strongly. However, much of Thailand's hi-tech export was in simple labour-intensive components using imported inputs. As a result, there was no marked improvement in firm-level technological capabilities.

Hence, while the volume of FDI to Thailand increased sharply it led little to the development of domestic technological capabilities (Intarakumnerd *et al.*, 2002; Sribunruang, 1986; Kaosa-Ard, 1991). FDI attracted product and process technology management but generated little technology transfer. Machinery was imported with minimal instructions on operational procedures given by suppliers resulting in inefficiently operated and inadequately maintained equipment. The MNCs also did not actively develop subcontractors or gave technical assistance to local suppliers because of backward local supporting industries. Equally important, MNCs were unwilling to devote the resources to upgrade local suppliers (see Dahlman *et al.*, 1991; Dahlman and Brimble, 1990; Kaosa-Ard, 1991).

As a result, little transfer of technology took place in designing and engineering. Also, MNCs in Thailand invested little in R&D. In 2000, only thirty-nine MNCs (1.4 percent of the MNCs in Thailand's manufacturing sector) established R&D centres. They were mostly small and involved in adapting their products for the national market. Nonetheless, the situation has changed after 2000 as MNCs have started to invest in R&D engineering and designs in sectors, such as, automotive and hard disk drives (Intarakumnerd *et al.*, 2002).

3. Methodology

This study uses both survey and case study methods. Primary data was collected in 2012. Because of the low response rate we undertook in-depth case study interviews of four indigenous part suppliers. In addition, we uses secondary data from UN Comtrade, from 1992 to 2011, to analyse intra-industry trade.

Intra-industry trade is measured using the Grubel-Lloyd index as follows;

$$\text{G-L}_{jkt} = \frac{\sum_{i=1}^{n}(X_{ijkt} + M_{ijkt}) - \sum_{i=1}^{n}|X_{ijkt} - M_{ijkt}|}{\sum_{i=1}^{n}(X_{ijkt} + M_{ijkt})}$$

Where X_{ijkt} and M_{ijkt} are the Thailand exports and imports of product i of industry j with country k at time t.

We compute an aggregate Grubel-Lloyd index. We sums the exports and imports value of all commodities in a particular industry and calculates the Grubel-Lloyd index using this formula,

$$G - L_{jkt} = 100\left\{1 - \frac{|\sum_{i=1}^{n} X_{ikt} - \sum_{i=1}^{n} M_{ikt}|}{\sum_{i=1}^{n} X_{ikt} + \sum_{i=1}^{n} M_{ikt}}\right\}$$

In this article, we attempt to examine the trade pattern and intra-industry trade in the automotive industry in detail, in which we break down the bilateral trade flows into two types (a) inter-industry trade or one-way trade if $\frac{Min(X_{ijkt}, M_{ijkt})}{Max(X_{ijkt}, M_{ijkt})} \leq 0.1$, and (b) intra-industry trade (G-L index). We divided trade data from automotive industry into two groups, completely built up units (CBUs) and auto parts. We also analysed trade linkages between Thailand and key trade partners of Indonesia, Malaysia, the Philippines, Vietnam, Japan, China, South Korea, and Australia.

4. History, Growth and Institutional Support

4.1. Historical Backdrop and Industrial Structure

The automotive industry in Thailand started in the early 1960s under an import substitution regime. To boost investments in the domestic production, in 1969 the government imposed a minimum local content requirement of 25 percent on automotive assembly, which forced vehicle makers to source some inputs locally. However, Japanese manufacturers responded by relocating Japanese parts suppliers in Thailand.

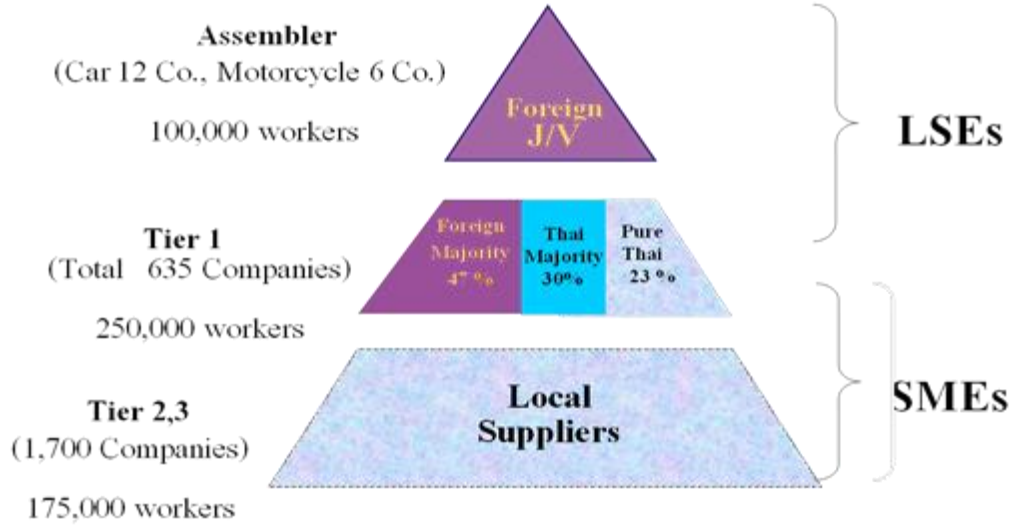
With the aim of reducing current account deficits, the Thai government limited the number of automotive models and increased the local content requirement to 50 percent for passenger cars, which was further raised to 54 percent for passenger cars and 60-72 percent for pick-up trucks in the early 1980s. This policy gave rise attracted new investments into automotive parts and facilitated technology transfer in the industry. FDI inflows from the 1980s took a new dimension when the Yen appreciation triggered the relocation of Japanese parts producers to Thailand costs in the 1980s.

Liberalization pressures from the General Agreement on Trade and Tariffs (GATT) led the Thailand government allowed capacity expansion and repealed prohibitions on imports of vehicles. Lower domestic automotive prices, combined with economic expansion, spurred a rise in sales in 1991-1996, which was also characterized by the first exports of vehicles produced in Thailand.

Following the 1997-98 financial crisis, Thailand's Board of Investment (BOI) removed the restrictions on foreign equity, which previously required majority ownership by Thai nationals. Many investors, mostly Japanese, took advantage of this new policy, and hence, from November, 1997 to September, 2000, mean foreign equity in the164 automotive firms increased to exceed 50 percent of total equity (Charoenporn, 2001). Since the 2000s, MNCs' in the automotive industry have also begun to invest in R&D in Thailand, though, their activities mainly focus on modification of existing designs products to fit national demand and to exploit local advantages, such as, natural raw materials.

The structure of products in the industry can be classified into three groups, which include 12 vehicle assemblers, around 635 tier-1 suppliers, and around 1,700 tier-2 and tier-3 suppliers (see Figure 1). Most assemblers are MNC subsidiaries who are dominated by Japanese MNCs, and Daimler Chrysler, General Motors and Ford. Sufficient pool of engineers and technicians, and extensive supplier network has made Thailand the strongest automotive production base in Southeast Asia.

Figure 1: Structure of Automotive Manufacturers, Thailand, 2013



Source: Thai Automotive Institute (TAI), updated in July 2010

First-tier suppliers have been increasingly dominated by foreign MNCs and joint ventures as Japanese automotive production networks increasingly integrated operations. Functions assigned to individual parts became more complex as functional and structural coordination with other parts increased (Takeishi and Fujimoto, 2001). Since Thai suppliers did not have capability to produce high precision parts they fell down to become second-tier suppliers. Indigenous Thai suppliers mainly produced 'non-functional' parts in 2013, such as, body parts, accessories, while foreign suppliers concentrated on 'functional' parts that demand high manufacturing and design capabilities to produce engines, electrical transmission, and suspension parts (Table 1)

Table 1: Number of OEM Parts Suppliers, Automotive Industry, Thailand, 2010

Parts	Thai	Thai Majority	Foreign Majority	Total
Engine Parts	20	8	35	63
Electrical Parts	15	10	27	52
Drive/ Transmission	17	6	29	52
Suspension/ Brake	13	1	21	35
Body Parts	57	17	47	119
Accessories	18	2	19	39
Others	214	24	111	349
Total	**354**	**68**	**287**	**709**

Source: Thai Automotive Institute

The results of a study by the College of Management, Mahidol University (2006) show in general that, component suppliers in Thailand could be classified into two categories based on the level of technological capabilities. Suppliers to suspension and brake, interior and exterior designs had the capabilities to compete in export markets. Suppliers to engine, electronics and drive transmission components enjoyed low capabilities because of proprietary knowledge held by MNCs. Nonetheless, since the mid-1990s, MNCs adopted global sourcing strategies so that sourcing is open to any supplier that could produce the sub-system components at given quality and price without providing them design blueprints. Therefore, first-tier suppliers had to acquire designing and system integrating capabilities. As, a result, some national OEM suppliers started developed their own designs and brands to participate as first-tier suppliers (see Intarakumnerd and Virasa, 2004).

5. Economic Contribution

The automotive industry has contributed significantly to Thailand's economy. The industry employed about 310,000 persons in 2011(see Tables 2 and 3).

Table 2: Manufacturing Value Added in constant 2002 prices, Thailand, 2001-2011

	2001	2002	2003	2004	2005	2006	2007	2008r	2009r	2010r	2011p
Food products and beverages	307,403	332,304	373,311	373,161	383,886	420,498	437,951	448,174	437,261	454,944	478,372
Tobacco products	33,493	34,595	35,814	38,919	36,790	32,089	34,400	34,085	31,122	34,723	36,202
Textiles	115,730	117,793	119,183	127,175	126,299	125,941	121,265	119,095	111,292	122,423	102,155
Wearing apparel	96,518	102,055	107,053	112,423	118,450	122,250	118,251	118,227	108,475	113,399	95,902
Leather products and footwear	39,120	37,055	37,811	35,013	36,537	35,907	39,444	37,520	35,290	35,068	35,348
Wood and wood products	18,031	19,519	20,035	22,292	21,539	21,353	23,447	22,332	21,560	25,426	27,830
Paper and paper products	36,039	38,490	39,844	39,498	42,274	45,234	46,926	44,262	44,409	46,855	45,169
Printing and publishing	18,118	19,180	19,905	21,353	22,929	21,925	21,890	22,742	21,010	21,787	21,568
Refined petroleum products	117,425	118,905	116,505	110,256	109,350	110,496	116,744	110,162	119,151	122,170	106,429
Chemicals and chemical products	98,297	105,403	111,759	121,358	131,363	131,440	141,349	131,989	155,017	169,009	160,391
Rubber and plastic products	78,346	90,297	103,920	111,571	112,735	112,839	120,363	121,186	113,742	130,631	128,649
Other non-metallic mineral products	71,965	80,382	88,554	100,841	108,285	109,020	104,871	100,617	95,719	104,777	105,019
Basic metals	35,516	44,247	47,447	52,186	52,019	53,970	55,431	50,083	44,963	48,219	43,977
Fabricated metal products	56,314	60,709	65,439	73,622	69,065	72,921	76,390	73,452	61,287	69,151	70,627
Machinery and equipment	64,114	66,731	73,884	89,428	102,520	110,682	136,932	151,341	134,296	162,006	163,320
Office, accounting and computing machinery	35,331	46,381	72,692	91,078	113,457	152,759	211,698	256,461	260,956	298,039	220,347
Electrical machinery and apparatus	36,686	38,173	46,089	49,956	52,271	57,345	64,263	68,612	69,865	78,925	78,313
Radio, television and communication equipment and apparatus	59,199	72,056	79,946	86,599	85,212	90,897	91,326	89,953	86,891	100,424	92,285
Medical, precision and optical instruments, watches and clocks	21,055	22,100	21,276	24,858	27,880	33,133	36,505	41,971	42,724	49,546	42,367
Motor vehicles	69,500	83,009	110,721	133,759	143,978	153,846	164,487	188,625	143,145	204,530	185,683
Other transport equipment	29,707	41,154	53,185	66,315	73,758	69,978	62,082	73,702	55,114	73,334	83,907
Funiture; manufacturing n.e.c.	81,823	85,915	80,272	81,523	75,912	78,853	92,813	89,975	95,769	99,593	96,783
Recycling	347	373	453	479	657	874	996	1,082	1,286	1,370	1,408
Total value added	**1,522,485**	**1,656,826**	**1,825,098**	**1,961,198**	**2,043,792**	**2,158,456**	**2,314,548**	**2,369,826**	**2,290,053**	**2,550,477**	**2,427,172**

Source: National Economics and Social Development Board (NESDB)

Table 3: Employment, Automotive Industry, Thailand, 2001-2011

Industry	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Autmobile assembly	29,571	38,144	34,966	29,083	44,876	41,866	39,727	38,307	34,947	50,207	49,920
Body parts	3,996	8,154	21,972	10,749	20,295	13,193	14,399	8,774	7,224	14,153	14,794
Autopart and component	62,251	67,175	75,336	86,885	109,037	139,689	176,600	184,314	157,956	158,668	231,761
Motorcycle assembly	14,437	15,808	22,634	33,677	20,772	26,405	25,446	26,820	20,098	19,329	18,327

Source: NESDB.

MNCs' decision to expand production in Southeast Asia is subject to demand conditions, level of development and availability of supporting industries. With several initiatives, such as, the development of key groupings ASEAN+3 and ASEAN+6 to integrate East Asian countries over the past two decades, international production networks can be linked and the evidence has been observed by an increase in the degree of intra-industry trade in parts and components through both intra-firm and inter-firm trade (Kimura and Ando 2005). Rapid integration into the regional production networks of China as a major final assembler, based on intermediate inputs (parts and components), has made the region more dynamic and vertically integrated (Athukorala 2008).

We calculate G-L index of trade between Thailand's automotive industry and selected trade partners in ASEAN, namely, Indonesia, Malaysia, the Philippines, and Vietnam. Thailand transformed from being a net importer to a net exporter since 2000 (Table 4). A surge in production and export of especially CBUs and automotive components occurred as Thailand became assemblers strategic export base (Figures 2 and 3). Thailand's intra-industry trade, both exports and imports, grew dramatically since 2000. Exports grew by 22 times between 1996 2011while imports grew by only two times making Thailand net exporter since early 2000s. On exports Thailand has integrated more with ASEAN, ASEAN+3 and ASEAN+6, especially Australia, Indonesia and Malaysia. On imports, Thailand integrated more with ASEAN, in particular, Indonesia, and ASEAN+3, especially China and South Korea. However, trade patterns and structure also vary with models. For instance, Australia is the main export market for one-ton pickup trucks, while Japan is a key source of parts for domestic production.

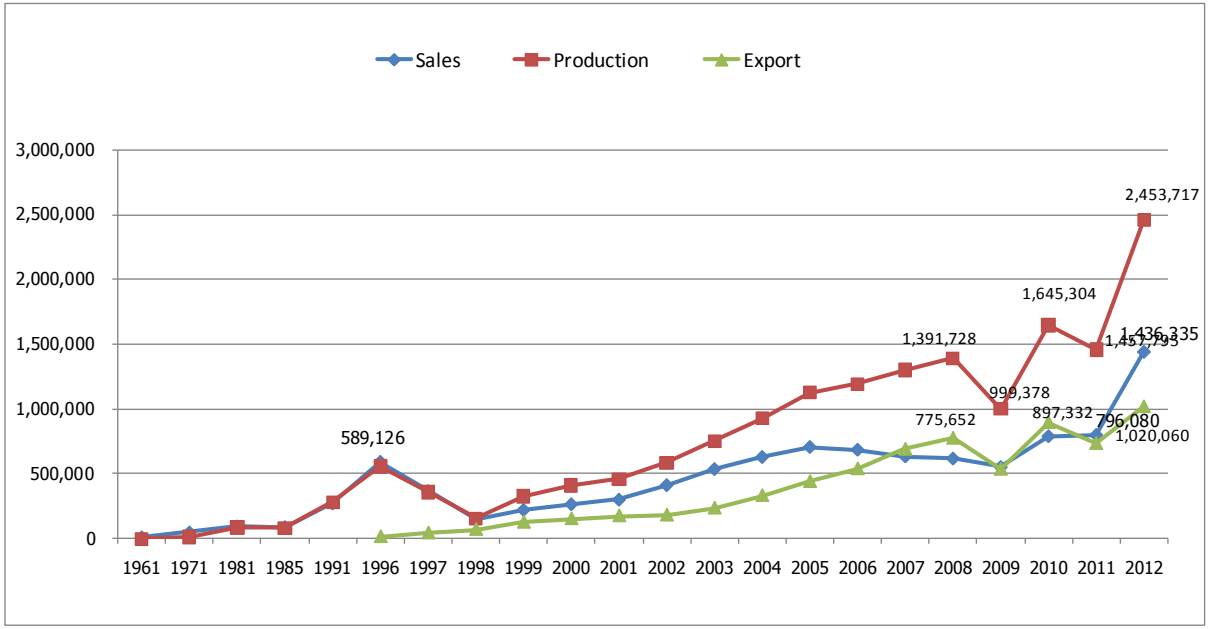
Thailand's automotive sector has become a component of the global production networks (GPN) of many car manufacturers as Automobile production in Thailand surpassed one million units in 2005, 1.6 million units in 2010 and 2.4 million units in 2012 with exports accounting for one million units (Figure 2. This success can be attributed to strategic investment by Japanese carmakers and the investment promotion and eco-car programme of BOI.

Table 4: Thailand's Automotive Trade by Country, 1992-2011 (%)

	Exports				Imports			
Country/region	1992	1996	2002	2011	1992	1996	2002	2011
ASEAN	5.42	20.14	14.73	24.42	0.54	1.73	10.05	11.88
Indonesia	0.70	2.20	5.06	10.67	0.06	0.13	2.82	5.89
Malaysia	2.30	3.85	4.63	6.32	0.16	0.48	2.19	1.86
Philippines	1.14	4.34	2.52	3.84	0.32	1.12	5.00	3.33
Vietnam	1.28	9.75	2.52	3.59	0.00	0.00	0.05	0.80
ASEAN+3	18.31	29.29	28.25	34.29	78.99	79.64	76.83	81.25
Japan	11.85	8.03	12.08	8.25	76.54	75.65	64.02	58.98
China	0.37	0.50	0.92	1.24	0.37	0.51	1.65	7.02
Rep. of Korea	0.67	0.62	0.52	0.38	1.54	1.76	1.10	3.36
ASEAN+6	21.09	32.39	38.55	47.85	79.24	80.26	77.23	83.86
India	0.03	0.09	1.11	2.75	0.08	0.10	0.15	2.31
Australia	2.74	3.02	9.19	10.82	0.17	0.51	0.25	0.31
World	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
$ millions	468.00	1,239.04	4,305.95	27,413.44	3,170.63	6,131.11	3,554.11	13,452.74

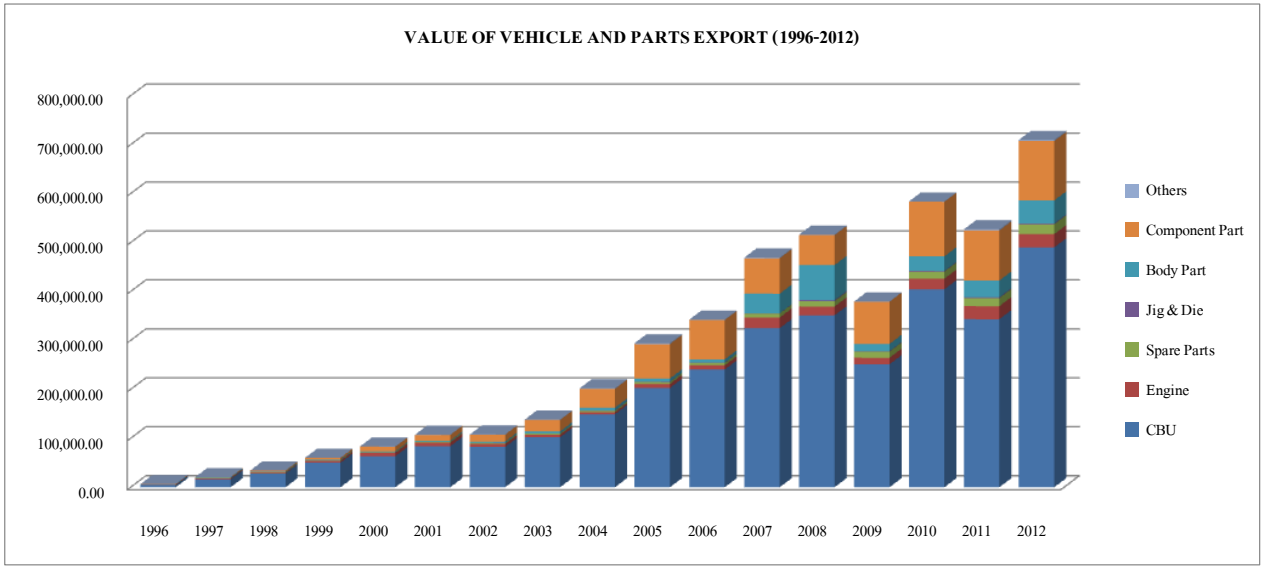
Source: Authors' own calculations based on UN Comtrade database, 2014

Figure 2: Production, Sale, and Export, Automotive Industry, Thailand, 1961-2012 (Million Units)



Source: Federation of Thai Industry.

Figure 3: Composition of export, Automotive Industry, Thailand, 1996-2012



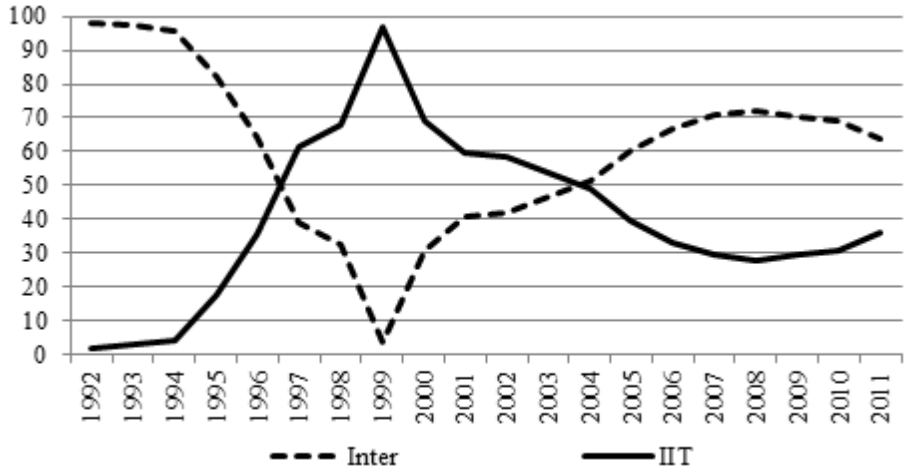
Source: Federation of Thai Industry

To examine the evolution of trade patterns between Thailand and selected trade partners, we need to disentangle bilateral trade flows into two groups: (a) inter-industry trade (one-way trade), (b) intra-industry trade (IIT). The degree of intra-industry trade (IIT) between Thailand and its trade partners has been increasing. Figure 4 illustrates that Thailand enjoys a positive intra-industry trade in auto parts trade, while in (CBUs), intra-industry trade was mainly one-way trade before 1997 but has since the recovery period of 1997-2000 has surged. According to Poapongsakorn and Techakanont (2008) and Techakanont and Charoenporn (2011), carmakers in Thailand were forced to utilize their enormous excess capacity when demand fell in 1997-2000.

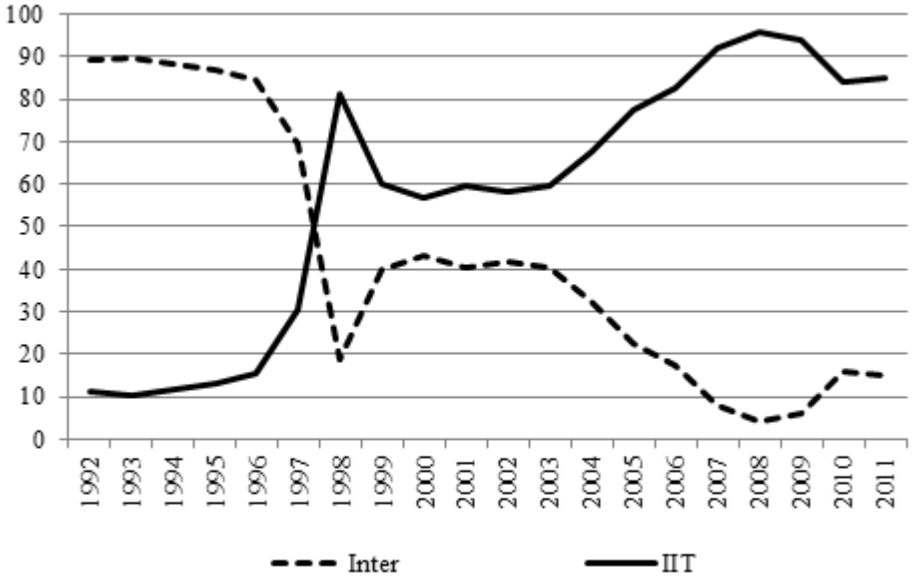
The degree of intra-industry trade in auto parts increased significantly in 1996-2011. As with the CBUs, the transition in inter- and intra-industry trade occurred during the period 1997-2000. Production fragmentation became a clear phenomenon after global car manufacturers chose Thailand as their export base for one-ton pickup trucks since 2000 and for eco-cars since 2007, which attracted massive numbers of suppliers as automobile assembly requires proximate parts suppliers. Japanese suppliers in Thailand not only supply the domestic market, but also export within the production networks. Therefore, the G-L index for auto parts reached almost 90 percent in 2001, indicating that Thailand's automotive industry is strongly integrated with other countries.

Figure 4: Inter- and Intra-industry Trade, Automotive Industry, Thailand, 2000-2011 (%)

a. Automobile products



b. Auto-parts



Note: Thailand's automotive industry trade with Australia, China, India, Indonesia, Japan, Korea, Malaysia, Philippines and Vietnam.
Source: Authors' calculations

Table 5 presents the inter- and intra-industry trade with nine trade partners. Different patterns among the trading partners and products can be identified in 1992, 1996, 2002 and 2011. Thailand tends to have a higher degree of IIT in CBUs with Japan and Indonesia. IIT with Malaysia and the Philippines show a decline, while that of China has increased in 2002-2011. IIT increased significantly for almost all trade partners in 1992-2011, especially China, India and Vietnam.[3]

[3] Based on our calculation, the degree of intra-industry trade in auto parts, between Thailand and selected trade partners, were relatively high, more than 90 percent in recent years, and being at 85 percent in 2011.

Table 5: Inter- and Inter-industry trade, Automotive Industry, Thailand, 1992- 2011

	1992		1996		2002		2011	
Countries	Inter	IIT	Inter	IIT	Inter	IIT	Inter	IIT
a. Automobile products								
Australia	95.88	4.12	0.89	99.11	99.96	0.04	99.82	0.18
China	42.04	57.96	83.29	16.71	91.54	8.46	12.98	87.02
India	100.00	0.00	67.60	32.40	98.59	1.41	91.95	8.05
Indonesia	100.00	0.00	86.36	13.64	70.29	29.71	72.18	27.82
Japan	99.85	0.15	98.42	1.58	33.76	66.24	10.49	89.51
Korea	100.00	0.00	98.02	1.98	94.27	5.73	84.80	15.20
Malaysia	66.19	33.81	33.34	66.66	99.90	0.10	80.67	19.33
Philippines	100.00	0.00	99.95	0.05	48.38	51.62	80.71	19.29
Vietnam	100.00	0.00	100.00	0.00	99.46	0.54	85.02	14.98
Total	98.10	1.90	64.42	35.58	41.71	58.29	63.91	36.09
b. Auto-Parts								
Australia	50.53	49.47	30.32	69.68	76.23	23.77	87.85	12.15
China	95.87	4.13	94.67	5.33	37.82	62.18	54.10	45.90
India	89.21	10.79	77.64	22.36	79.65	20.35	49.24	50.76
Indonesia	7.64	92.36	54.81	45.19	27.10	72.90	46.58	53.42
Japan	93.19	6.81	95.07	4.93	65.78	34.22	60.56	39.44
Korea	67.01	32.99	52.73	47.27	0.19	99.81	55.22	44.78
Malaysia	37.87	62.13	20.36	79.64	36.67	63.33	72.19	27.81
Philippines	33.39	66.61	27.14	72.86	30.77	69.23	4.74	95.26
Vietnam	99.84	0.16	99.85	0.15	95.04	4.96	78.43	21.57
Total	88.95	11.05	84.46	15.54	41.81	58.19	15.00	85.00

Source: Authors' calculations based on UN Comtrade database.

While Thailand's auto-parts show higher intra-industry trade integration, vehicles show higher inter-industry trade integration. Also, some manufacturers have begun R&D activities in Thailand. Toyota turned Thailand as a global production hub when it announced the Innovative International Multi-purpose Vehicle (IMV) Project in 2002 (Osono *et al.,* 2008) to produce four out of the five *newly designed models* export models. In 2013 the production capacity of Thailand's Toyota was expanded to exceed 800,000 units annually. Toyota also selected Thailand as its regional headquarters for engineering, technical support to Toyota operations in ASEAN and Asia. Other car manufacturers that use Thailand as their export base include Nissan, Mitsubishi and Honda.

6. Host-site Institution Support

Thailand's automotive industry has also benefited from host-site institutions. Previous research already noted on how Thailand's automotive industry benefited from liberalization efforts as the Thai government earmarked FDI as the catalyst to strengthen the growth of local supporting industries. Also, economic and political stability, good basic infrastructure, and a pool of skilled labour were crucial in attracting FDI (Techakanont and Charoenporn 2011). Regional development policies were imperative for the agglomeration of automotive firms in the central and eastern part of Thailand. The process was shaped by the regional-based investment incentive scheme and the development of infrastructure. Foreign vehicle makers became important players as they brought technology, intensified competition, and induced national firms to upgrade technological capability. Nonetheless, industrial policies to strengthen up local suppliers, such as, local content regulations also helped as it created the initial base of local parts suppliers (Doner, 1992).

In addition, the Thailand Automotive Institute (TAI), a semi government agency, played intermediary roles in facilitating cooperation between MNCs and local parts suppliers. The most important programme organized by TAI is the Automotive Human Resource Development Program (AHRDP), which aimed at upgrading the capability of local parts manufacturers. Its mission is centred on enhancing Thai

automotive workforce competency through a large-scale "train the trainer" programme, and establishing a skills certification framework. Four leading Japanese companies provided training experts and course materials, namely, Toyota (Toyota Production System), Honda (moulds and dies technology), Nissan (skills improvement), and Denso (manufacturing skills and mind management). The training covered theoretical knowledge, hand-on skills, and attitude. Thai university professors were also invited to teach theoretical courses, which has created a pool of talented trainers and improved awareness of the importance of human resource development (Intarakumnerd and Chaoroenporn, 2013).

While the presence of MNCs offers the opportunity to tap into the knowledge locally, its appropriation depends on absorptive capacity linkages among players (Breschi and Malerba 2007). For the Thai automotive industry, universities and public research institutes have also played supporting roles in helping the automotive industry in Thailand. Since the 1990s and early 2000s, Chulalongkorn University, King Mongkut's Institute of Technology Ladkrabang, King Mongkut's University of Technology Thonburi, King Mongkut's University of Technology North Bangkok, and Thai-Nichi Institute of Technology have targeted *automotive engineering programmes* to produce qualified manpower for the increasingly technologically sophisticated industry. They provided such courses with significant collaboration with leading private firms. For example, Toyota contributed to Chulalongkorn University's automotive engineering programme by donating modern equipment and sending their managers to be guest lecturers. As for research institutes, the National Science and Technology Development Agency (NSTDA) provided training and consulting services in finite element analysis to Toyota and its second and third tier local auto parts suppliers. NSTDA also carried out research on the intelligent traffic systems, which aims to increase driving safety and efficiency (Intarakumnerd *et al.*, 2012).

However, the role of host-site institutes in supporting the industry is still insufficient, especially in *high-tech infrastructure*, as well as, *network cohesion* (Rasiah, 2007). Nevertheless, some institutes have started to play a positive role since the 2000s to provide more sector-specific human resource development and research collaboration with firms in the industry.

7. Findings from Field Study

7.1. General Characteristics

Table 6 presents the general characteristics of the 32 sampled firms composed of 2 assemblers, 21 first-tier suppliers and 4 second-tier suppliers. We classify firms according to ownership. Thai firms having Thai ownership exceeding 80 percent, joint venture (JV) firms with Thai equity between 21 and 80 percent, and foreign firms with foreign ownership exceeding 80 percent. Large firms with over 200 employees and registered capital of US$25 million or more dominated the sample. The main products of the sampled firms include passenger vehicles, engine parts, transmission, air condition, body parts, exhaust pipes, fuel tanks, door mirrors, safety glasses, seats and plastic parts.

Table 6: General Characteristics of Sampled Firms, 2012

Basic Information		Ownership		
		T	JV	F
Nature of business	Assembler	0	0	2
	1st	7	7	12
	2nd	3	1	0
Establishment Year	<1990	3	1	3
	1990 -2000	2	4	9
	>2000	5	3	2
Employment size	M (less than 200)	3	1	0
	L (201-1,000)	2	2	9
	XL (more than 1,000)	5	5	5
Capital (million USD)	<5	4	2	1
	5-25	6	6	7
	26-50	0	0	2
	>50	0	0	4
Export 2011	0	4	3	2
	0.1-10%	1	2	1
	>10%	0	0	2
	N.A	5	3	9
Local inputs sourced	<25%	2	0	0
	25-50%	3	0	2
	51-75%	0	2	2
	>75%	3	5	6
	N.A	2	1	4

Source: Authors survey (2012)

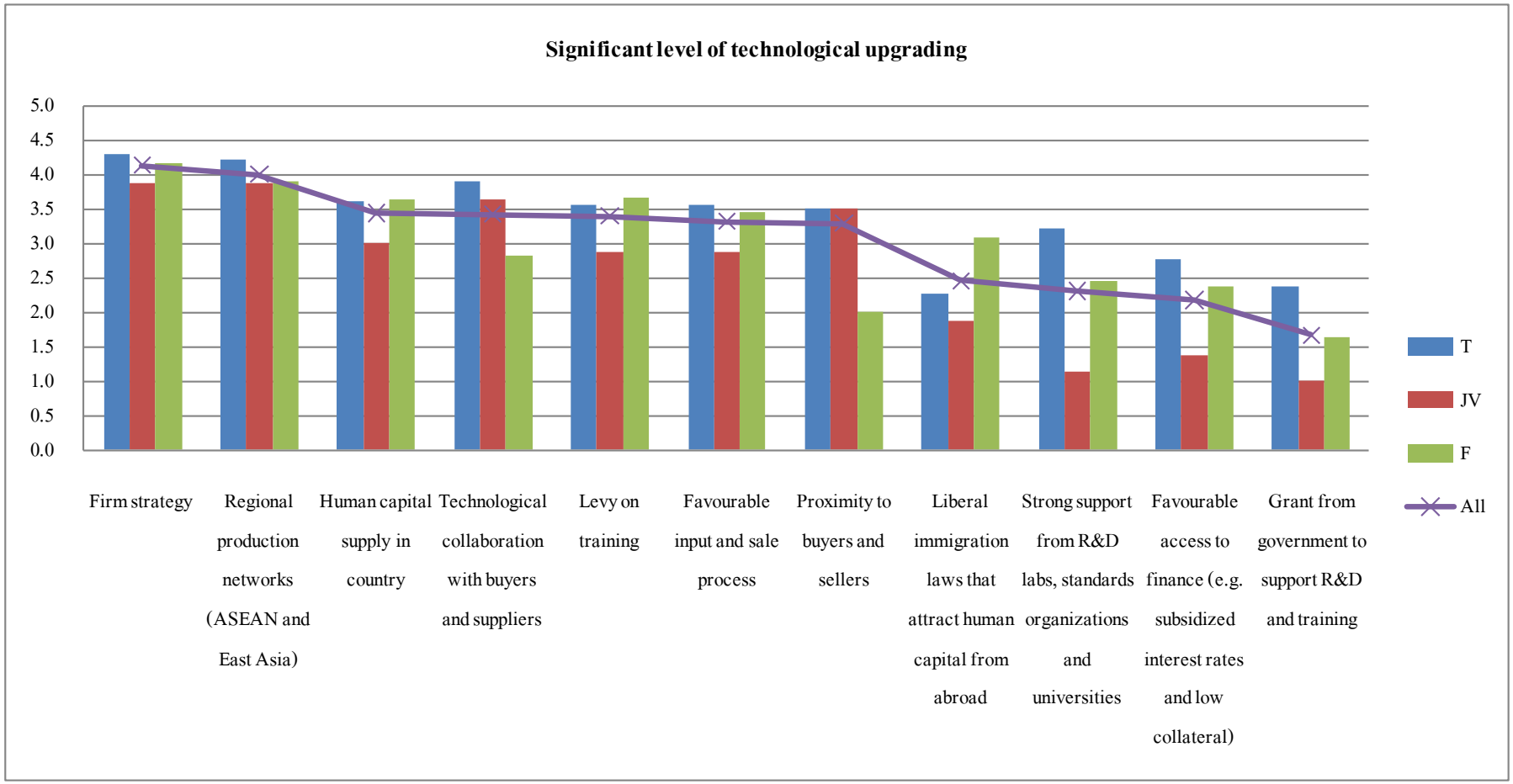
7.2. Technological Capability Upgrading

Over half of the firms reported participation in innovation activities largely in incremental innovation, especially adapting process layout and machinery with a few in product innovation and mostly new to the firm. This is because many carmakers launch new models in Thailand. Parts designed and developed for the global market are then adapted for them. Nonetheless, a few firms reported innovations new to the world, especially by foreign firms. Two carmakers and first-tier suppliers reported launching new models and parts in Thailand, which confirms the changing institutional framework in Thailand that has increasingly supported R&D since the 2000s.

Most innovation took place in machinery and equipment, production process layout, and inventory and quality control system adaptations. Some large suppliers have started to develop technological capabilities beyond minor adaptations, though, not in product innovation. The case studies confirm that integration into the production networks of automakers offers them the opportunity to upgrade. Firms that have successfully upgraded include the Summit and Somboon Groups. However, to move further up the technological ladder they need to have better strategies to build their capabilities by leveraging on other sources of knowledge.

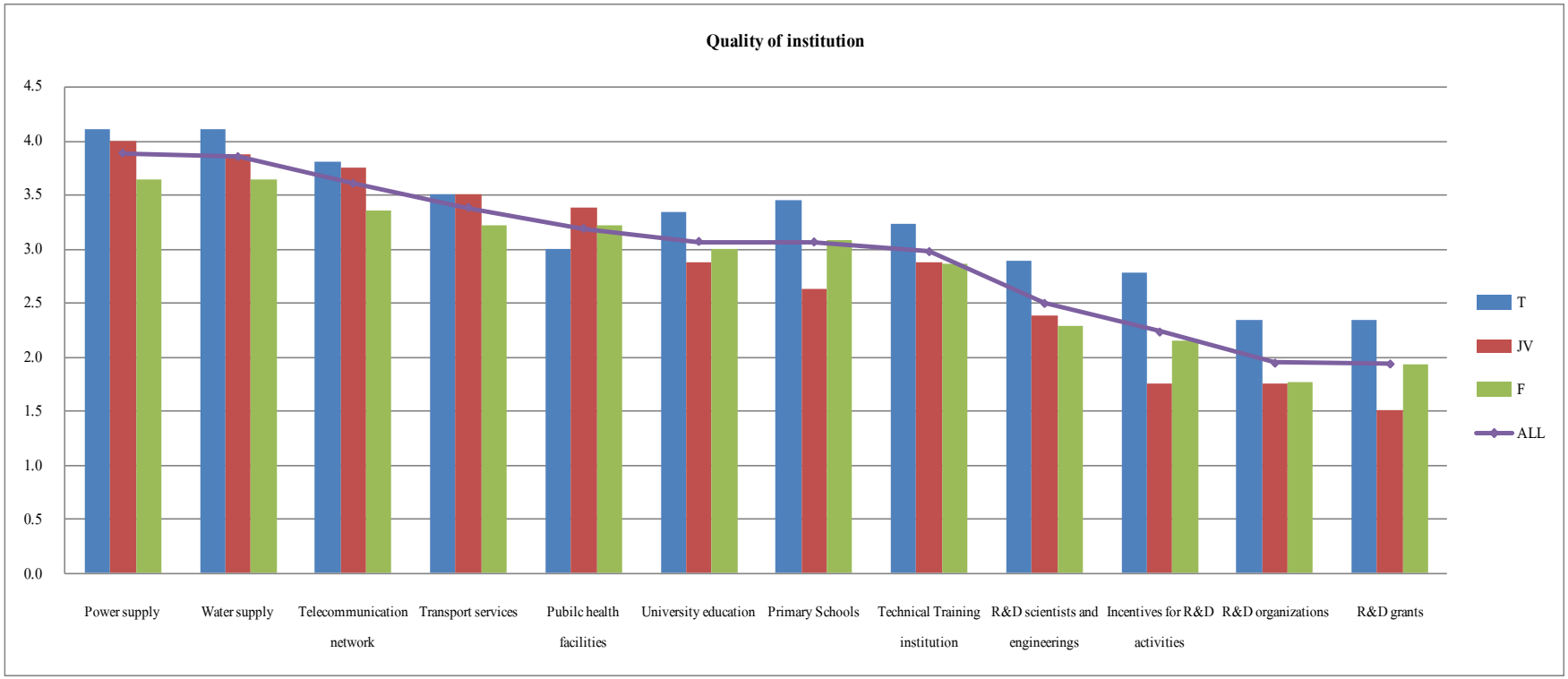
While being part of regional production networks is important, the most important factor for technological capability upgrading is firms' own strategies to evolve their absorptive capacity. The sampled firms regard technical linkage with buyers as an important channel of upgrading, which is consistent with previous findings (Techakanont and Charoenporn, 2011), as they can benefit from technical linkages and interactive learning with customers. Firms in the Central and Eastern Seaboard area reported that collaboration with key actors in the sectoral innovation system, namely, buyers, suppliers as important irrespective of ownership. Foreign firms considered the role of public labs, standard organizations and universities as important compared to national firms in accessing external sources of knowledge (Figure 5).

Figure 5: Significance Level of Factors Contributing to Technological Upgrading



Source: Authors' owned survey.

Figure 6: Quality of Government Assistance and Institutions



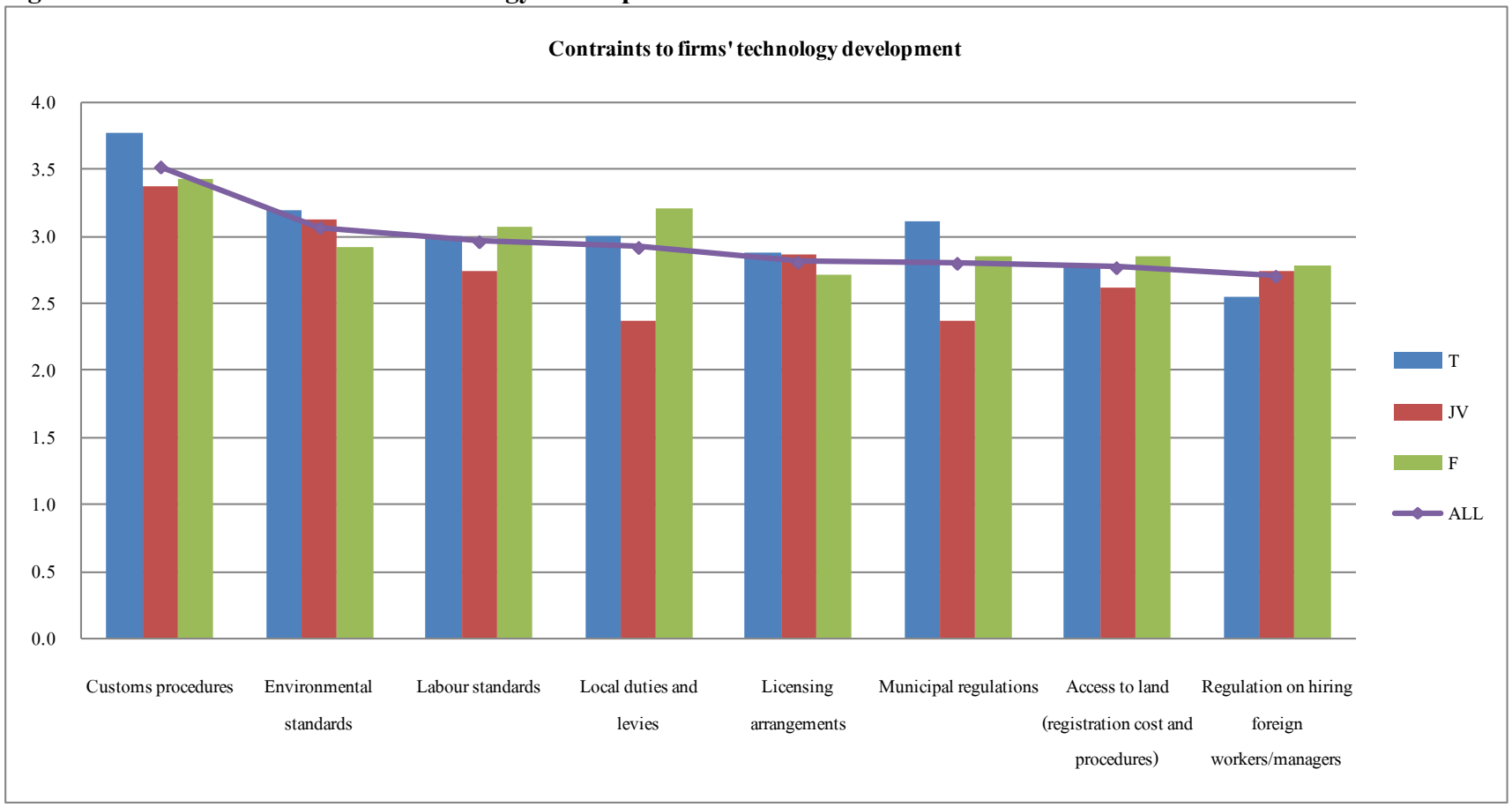
Source: Authors' owned survey.

National firms reported government support, including incentives, as more significant than foreign and joint venture firms, which is because they are small and technologically weak. Nonetheless, the quality of government assistance was rated highly only in the provision of water, power and telecommunication services as the ratings for 'high-tech' infrastructure support was low. Government services were rated lowly by joint ventures and foreign firms (see Figure 6).

Regarding constraint to technology development, most firms viewed that custom procedure being the most important constraint. Foreign firms had high concern on environmental standard and local duties and levies. Thai firms were worried about regulation at the municipal level (see Figure 7). This is because many local firms have their factories located in different location whose municipal governments have different perception and ways of implementing safety and environmental regulations as well as collection of local taxes.

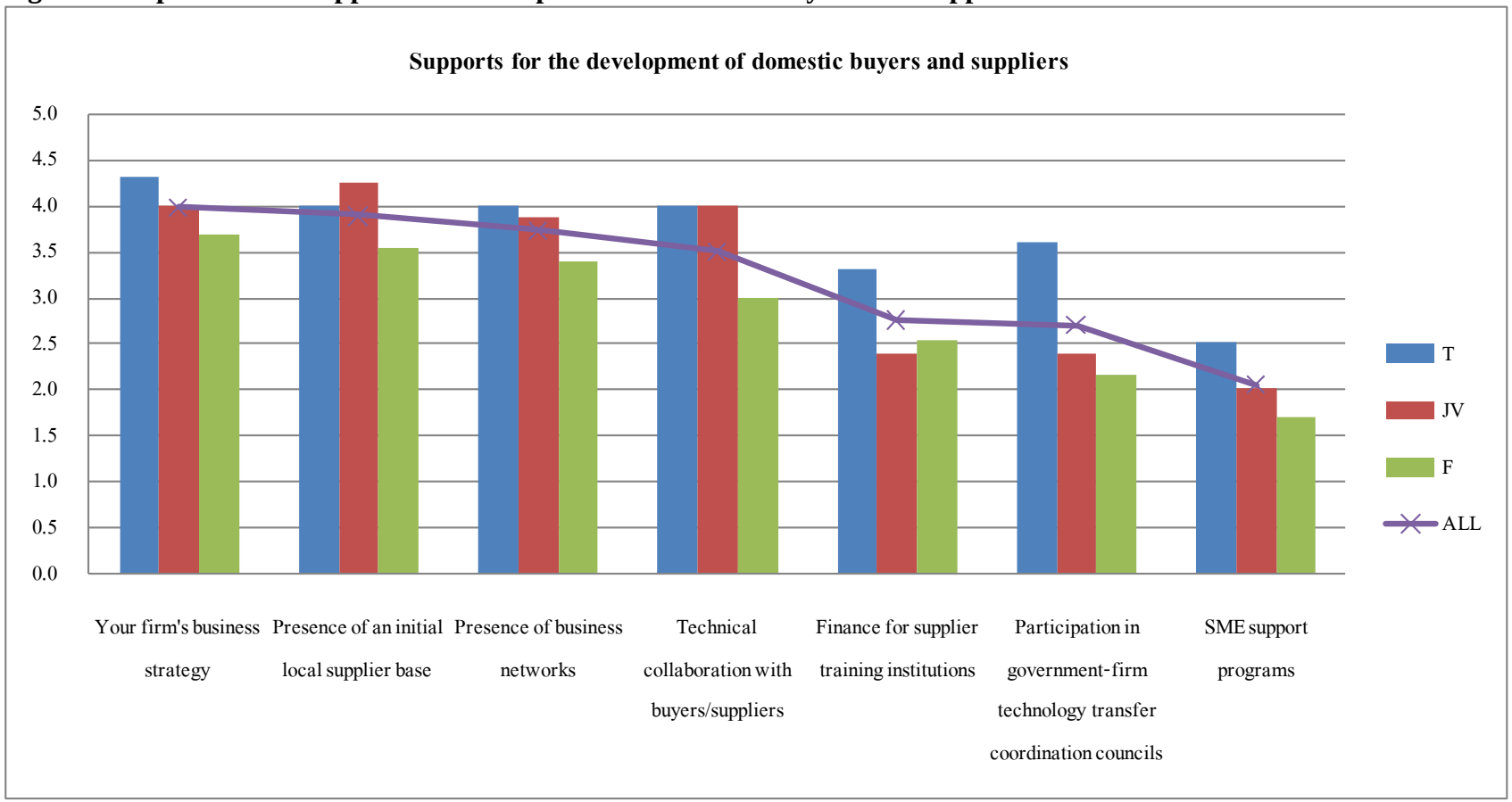
The significance of local supplier base indicates the importance of 'geographical clusters' (Figure 8). Proximity between the firms and local suppliers has helped facilitate interactive learning between them, which is especially strong in Thai and joint-venture firms. However, foreign firms relied more on suppliers outside the country.

Figure 7: Constraints on Firms' Technology Development



Source: Authors' owned survey

Figure 8: Importance of Support for Development of Domestic Buyers and Suppliers



Source: Authors' owned survey

8. Case Studies

To supplement the survey four case studies of technological upgrading are examined here. All of them are national firms.

8.1. Summit Group

Summit Group is one of the largest auto parts producers in Thailand, which consists of more than 30 companies. Its subsidiary, Summit Auto Seat Industry (SAS), established in 1972 with 100 percent Thai equity is the most competitive local first-tier supplier and competes successfully with MNCs. To keep up with technological changes globally, the company invests in new technologies. Most investment decisions are made internally by the management following a two-step process. The first step is to study new technologies after which the company would discuss them with customers and, if possible, would propose the use of specific technologies. Once customers agree, the company would then decide to invest. For example, the company recently invested in a new hydro-forming system after discussing with customers and visiting some of the leading factories abroad.

In addition, SAS works with lower-tier suppliers to improve the quality of their products and parts. SAS has also developed linkages with the local university, King Mongkut University of Technology to organize training courses for the company's staff. In some cases, the linkages expanded to include a strategic relationship to develop new products. As a result, SAS has developed design capability, rapid prototyping, and simulation analysis. It has upgraded itself from an ordinary parts producer to a sub-system integrator i.e., designing and integrating parts and components into a sub-system to sell to automakers.

The Summit group produces seats and stamping parts. It established the Summit Auto Body assembly in 1986 with product engineering capability, which industry officials reported as a must to supply automakers since 2012. Automation of the production process rose from 25 percent in 1995 to 75 percent in 2012. The firm was able to participate in the product development stage of new pickup trucks of several brands, which were launched in Thailand since 2009. The product development activities have been extended to cover brake systems, clutch parts, oil tubes and door

sashes. While it employed 26 R&D engineers in 2012 for some orders the company sent guest engineers to participate in the 'product development' stage at buyers R&D centres.

8.2. Somboon Group

One of the biggest first-tier and second–tier automotive parts suppliers in Thailand, the Somboon Group (SG) was established in 1975 and aims to be to be a leader in automotive parts manufacturing in Southeast Asia, providing end-to-end services. SG consists of 4 companies, namely, Somboon Advance Technology Plc, Bangkok Spring Industrial Co., Ltd., Somboon Malleable Iron Industrial Co., Ltd. and International Casting Products Co., Ltd. Its major customers include Auto Alliance, Dana, GM, Hino, Honda, Isuzu, Kubota, Mitsubishi Motors, Nissan, Toyota, and Yongkee.

SG is active in leveraging external sources of knowledge. It has technical relationships with international organizations. SG conducted training using one professor from Osaka University in 2009. The firm also used a consulting service from an international organization undertaken mainly through of email communication, and sending products abroad for testing. In addition, under recommendation of its Japanese buyer, SG paid Japanese first-tier suppliers in Japan for their technical advice, such as in developing new processes. However, the knowledge transfer method of this type is mainly tacit knowledge through on-the-job training and seeking advice. This long-term relationship was established quicken knowledge transfer.

In 2009 sought to internalize the development of technology by investing about 400 million baht in a testing lab for springs, stabilizer bars and brake parts, and spring design and production to participate in new product development. With 40 full time staff members involved in R&D section SG has targeted raising its technological capabilities begun to become a first-tier supplier.

Successful technological development led to SG obtaining a design patent on disk brakes in 2007, which was developed through technological cooperation with King Mongkut University of Technology and Thailand's National Metal and Materials Technology Centre (MTEC). While SG managed to upgrade to develop its

own product engineering and development capability, it lost its link with the Japanese buyer as the closed nature of Japanese production networks ended it once its technical agreement with its Japanese service provided was terminated. To offset the lost demand, SG is planning to set up an office in Japan to develop close relationships with its buyers. This case study shows how national firms struggle in the process of technological level up in functional parts. However, several national firms still acquire technology by hiring Japanese experts to fill in the gap in high value added activities, such as in R&D and testing.

8.3. Daisin

The company was established in 1979 to manufacture aluminum casting parts for the automotive industry as a foreign joint venture with Nissin Koygo Co., Ltd with 67 percent Thai equity. The case of Daisin demonstrates the necessity of 'active' investment for indigenous technology capability development and the significance of working closely with suppliers and carmakers (Honda Motor Thailand) in order to access support for its capability development.

The company hired a retired Japanese engineer who helped it to improve its production capability and in negotiating with Nissin to lower significantly its royalty fees. Later, the company also acquired external knowledge through its partnership with Nissin by hiring other Japanese technical consultants to help in developing its own designing capability Initially, Nissin was quite reluctant to help. Eventually, the company worked closely with buyers to produce new a design for hand brakes and a new lighting system, which led to Honda and Toyota inviting Daisin's engineers to Japan as their guest engineers to jointly develop a new brake. Daisin now has become an original design manufacturer (ODM) for several automakers. The company has successfully used its design capability to diversify into other markets, such as, long-tail boats, small rice mills and wood-cutting machines, which has offered lucrative business as the profit margins are higher than the knocked down prices possible in Japanese global production networks.

8.4. Sammitr Motor Manufacturing.

Sammitr Motor Manufacturing (SMM) began as a limited company in 1967 to produce body parts, moulds and fixtures for automakers. SMM's production line was later extended to include other related industries like agriculture machines. Its main business consists of trailers (70 percent of total sales), OEM parts (15 percent) and spare parts (15 percent).

To maintain leadership and a competitive edge, the company has assigned an R&D unit since 1997 to develop, upgrade and present new products which can better meet and exceed customer needs. Not only has the company strived to develop in-house personnel with knowledge and expertise in automobile engineering and alternative energy, it has also joined hands with local and foreign leading research institutes like China Chong Qing Automobile Research Institute (CCARI), and Thailand's National Metal and Materials Technology Center (MTEC) to advance this further.

The SSM reported R&D results that are mostly tacit knowledge embedded in the ability to improve production processes and develop new products. The company also has joint R&D projects with automakers to develop new parts, which help in securing purchasing orders. Its successful projects include the production of light-weight trailers, special-purpose trucks, NGV trucks, NGV conversion kits and Multi-Purpose Trucks using 100 percent biodiesel engines. SMM invested in China to access raw materials and cheap labour to produce metal parts for trailers and trucks, such as chassis and body, which are then imported for assembly in Thailand. Like Daisin, SMM exploited its designed capabilities acquired while working with MNCs to diversify into more profitable markets, including in designing and manufacturing a small batch of tailor-made trucks for an Australian mining company.

Overall, the case studies elucidated interesting observations. Through integration in regional production networks through OEM arrangements national firms have acquired basic production knowledge and access to competitive global automotive markets. In the initial stage, the most important knowledge transfer channel came in the form of technical assistance from either automakers or foreign suppliers. Nonetheless, competition and global sourcing strategies of global carmakers forced them into the role of sub-system integrators. Summit and Daisin have been

successful as they managed to develop their own design and system integrating capabilities. However, many others failed. Interestingly, successful companies like Daisin developed such capabilities through their own efforts and collaboration with local universities and retired foreign engineers outside standard production networks of MNCs, which highlights the importance of having 'independent' strategies to leverage external knowledge sources beyond simply relying on learning within existing global production networks of MNCs.

9. Conclusion

Thailand's automotive industry has come a long way from just a small import-substituting industry to a large and vibrant exporting one contributing significantly to the country's GDP and employment. It has been well integrated into global production networks, especially those of Japanese car makers. As the industry's products have become more fragmented, intra-industry trade between Thailand and other countries in East Asia has risen markedly, especially in automotive parts. This is a consequence of Japanese production networks, which has evolved through Japan's FDI to China and Southeast Asia. In the process of industrial development, firms in Thailand regardless of ownership in the automotive industry have deepened their technological capabilities. Due to changes in strategies of foreign car manufacturers and some host-site advantages like availability of skilled engineers and technicians and local supplier networks, the industry has experienced 'qualitative' changes from just a production base to participate in the technologically sophisticated activities of advanced engineering, testing and product design for the Southeast and East Asian, and global markets.

Although further strengthening is essential, institutional support from 'high-tech infrastructure' and 'network cohesion' in supporting industrial and technological upgrading of automotive firms has emerged recently. Universities and research institutes have started to sector-specific teaching and research programmes and close collaboration with the industry. The sector-specific government promotion agency of Thailand Automotive Institute) has been increasingly played a strong intermediary

role to establish and strengthen linkages between foreign firms, local suppliers, universities and other government agencies.

The survey also produced interesting findings, which confirm and elucidate previous studies. While, firms' own strategy is the most important factor for technological upgrading, collaborating with other actors in the national innovation system, especially local buyers and suppliers are also significant, while proximity did matter for interactive learning, especially among national automotive firms which rely less on suppliers and buyers from abroad compared to foreign firms and joint ventures. While the Thai automotive industry has increasingly integrated into global and regional networks, paradoxically, geographical clusters at home have become more important, which the government should observe and target efforts to strengthen national automotive clusters. Compared to joint ventures and foreign firms, national firms have higher expectations for stronger support from government in general and from local universities, laboratories and standard organizations in particular. Hence, the government should pay more attention to improve strategic support for technological development in national firms beyond just providing basic infrastructure to strengthen high-tech infrastructure and network cohesion.

As the case studies demonstrate, national first-tier parts makers have to enhance their design and system integration capabilities. Failure to do so will mean slipping down to lower tiers with much less profit margins. Remarkably those who succeeded formed their strategy 'independently' outside regional production network of MNCs and relied on their own efforts or collaboration with other partners outside existing production networks, which shows the limits to of regional production networks in upgrading technological capabilities. Hence, in contrast to the arguments of the global production sharing exponents, national firms have to seek external support to evolve their technological capabilities to reach the technology frontier.

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