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Industrial Upgrading in Global Production Networks: The Case of the Chinese Automotive Industry*

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Abstract: *This article examines the development of China's automotive industry. The evidence shows that integration in global production networks has stimulated upgrading of technological capabilities among automotive firms. However, the competitiveness and intra-industry analyses show mixed results. Although intra-industry trade in automotive products has improved since 2000, the trade competitiveness of completely built up vehicles has largely remained in low value added activities. Nevertheless, firm-level evidence shows that the industry has undergone considerable upgrading, albeit in low value added activities. Trade integration and host-country institutional support have been the prime driving forces of technological upgrading in the automotive industry in China.*

***Keywords**:* automotive industry, foreign firms, production networks, technological capabilities

JEL Classification: L62, L22, L14, O31

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1. Introduction

Expanding from a small-scale production base with less than 3000 cars in 1978 to a large scale producer of over 10 million cars in 2012, the rapid growth of China's automobile manufacturing is symptomatic of the country's rapid economic transformation since reforms began in 1978. With over 100 models produced every year the automobile industry has through connecting with global value chains become an important contributor to China's GDP. However, although automobile manufacturing has recorded impressive growth in China, it is largely confined to lower value-added segments of the industry's global value chain. Although China has started to export cars using national brands, the industry largely specializes in parts, components and simple assembly activities. China has the advantage of a large consumer market and production scale (Chinese Academy of Social Science, 2013). National automobile assemblers lack the core technologies, which has led to 90 percent of the domestic market share being captured by foreign multinational firms. Foreign firms still lead in the production of the core technologies required to manufacture engines, transmissions and key components and parts.

Evidence from past work suggests that the weak international competitiveness facing indigenous car makers is caused by the lack of innovation supporting institutions, such as, well-designed industrial policy framework for supporting upgrading, and government incentives and grants to stimulate innovation, especially indigeneous innovation with independent intellectual property rights (Lu, 2006). In addition, the extensive reliance on technology imports to overcome the limited indigenous R&D capabilities has aggravated the industry's trade balance. Also, Qu (2009) concluded that policies implemented by local governments have often been divergent from the guidelines initiated set by the central government. In addition, lacking insight on the industry, central government policies have also lacked the necessary dynamism to support national assemblers. As Zhao (2013) and Huang (2012) had shown, the "market dependent technology policies have impeded indigenous firms ability to innovate and upgrade their technological capabilities. He argued that the low correlation between operating performance and innovation capacity shows that the massive production scale has not successfully transformed into stimulating firm-level innovation in national firms. Nevertheless, (2012) argued that branding by joint-venture firms in the country has successfully strengthen indigenous firms' international competitiveness.

However, this article finds existing works lacking in the way innovation is captured by evolutionary economists. As Schumpeter (1962, had argued entrepreneurs largely innovate through adaptations and incremental engineering activities.[1] Hence, it will be useful to examine if the large participation of automotive firms from China in global value chains has stimulated innovation activities by analysing the different types of innovation activities.[2] Also, past works have not analysed systematically the role of supporting institutions in China in stimulating technological upgrading in the automobile industry.[3] The state is arguably the central actor in this developmental role.[4] Thus, it is important to examine the participation of automotive firms in global production network and if they have moved upwards in the global value chain. In doing so we also analyse the role of institutions and institutional change targeted at stimulating technological innovation in automotive firms in China.

Hence, this article seeks to examine how institutional change and global production networks have impacted on the automotive industry in China. The next section traces the evolution of China's automobile industry. We subsequently evaluate the performance of the industry through the impact of trade indicators on the industry, such as, export intensities, Grubel Lloyd index and the Trade Balance (TB) index. Primary data collected from a survey of 51 automotive firms is then used to analyse the nature and level of technological capabilities and economic performance of vehicle manufacturing firms in China. The last section presents the conclusions and policy implications.

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[1] See Rasiah (2010) for a lucid account of the different types of firm-level innovative activities.

[2] Gereffi (1999) considered automobiles value chains to be driven by the producers. We use this and especially Gereffi, Humphrey and Sturgeon (2005) to examine how global value chains have impacted on Chinese automotive firms.

[3] The role of institutions, including institutional change in stimulating industrial structural change, including technological upgrading, has been articulated well by Nelson and Winter (1982), Nelson (2008) and Rasiah (2011). See Rasiah (2009), Rasiah and Amin (2010), Rasiah (2011a) and Rasiah (2011b) for a detailed account of supporting institutions that have stimulated technological upgrading in East Asian, Brazilian and South African automotive firms.

[4] The roots of the developmental role of the state can be traced to Poulantzas (1973). Subsequent works improving the arguments on the role of the state can be observed from Johnson (1982), Jessop (1988), Amsden (1989) and Evans (1995).

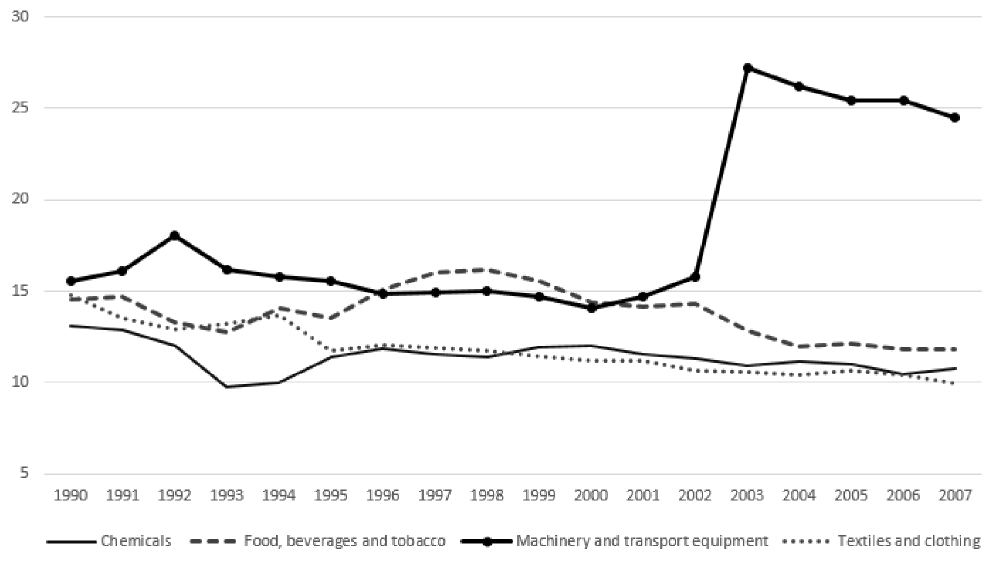
2. The Automotive Industry in China

This section discusses the origin and development of the automobile industry in China. As with reforms in general, private firms have increasingly become important in the industry in China.

2.1. Origin

The automotive industry of China grew rapidly since the 1980s to become No.1 in the world in terms of production, sales, and consumption (CAIA, 2012). Figure 1 shows the contribution of each sector in manufacturing value-added, in which the share of machinery and transport equipment manufacturing rose sharply from 15 percent in 2002 to 27 percent in 2003 before falling to 24 percent in 2007. The expansion of machinery and transport equipment has stimulated industrial structural shift from light manufacturing to heavy industries.

Figure 1: Contribution to manufacturing value-added, selected industries, China, 1990-2007 (%)

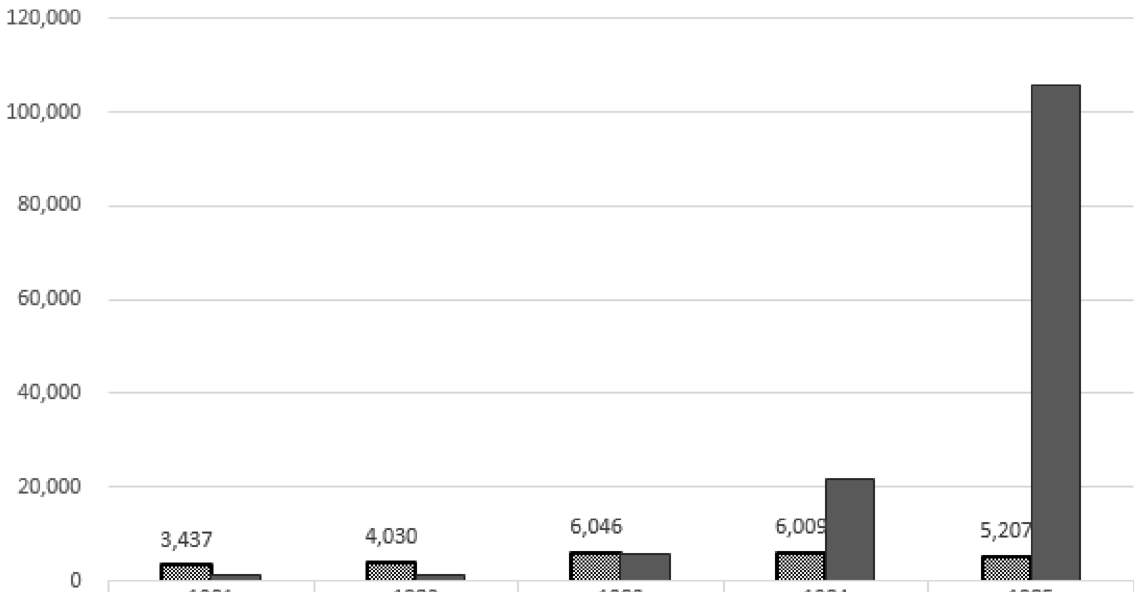


Source: World Bank (2013).

Automobile industry in China evolved from a low level of capabilities. China produced 220,000 vehicles with about 220 domestic firms in 1980. However, each firm could only produce 1000 vehicles annually.

The maximum production capacity by the largest state-owned automobile producer, i.e. China FAW Group was only 60 thousand automobiles annually with its main vehicles being trucks and Red Flag Sedans. Backward production technology has greatly constrained the industry, which the government attempted to address by launching the "market for technology" strategy in the early 1980s, while encouraging national firms to joint venture with foreign automobile companies that can bring advanced technology. The open-door policy of market orientation in the 1980s and 1990s attracted considerable technology inflows from MNCs from abroad. The expansion in foreign assembly of automobiles was particularly dramatic throughout the 1990s. Among the successful foreign brands were Shanghai Volkswagen and Guangzhou Honda. The booming demand for private cars arising from a dramatic rise in household incomes expanded sharply overall demand. As a consequence, car sales and production reached 13 million and 13.9 million vehicles respectively in 2009, making China the leading seller and producer in the world, which it has kept since with sales and production both reaching 19.3 million vehicles in 2013.

Figure 2: Output and Import, Automobile Industry, China, 1981-1985 (Units)

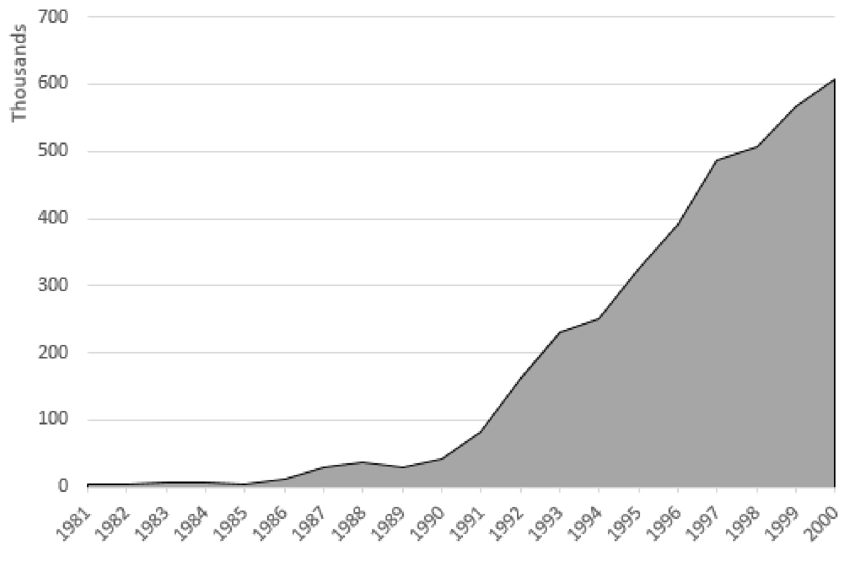


	1981	1982	1983	1984	1985
Output	3,437	4,030	6,046	6,009	5,207
Import	1,401	1,101	5,806	21,651	105,775

Source: China automobile industry yearbook (various years).

The take-off of China's automobile industry can be characterized by four stages. The first stage lasted between 1978 and 1985 when domestic demand was dominated by collective buyers of government work-units and large corporations. Although demand grew fast, it showed little sensitivity to market prices due to the low incomes of the Chinese population in 1980s. Because of limited innovation capability and low domestic production and the limited designs available in the country, vehicle imports grew over four times from 5,806 units in 1983 to 21,651 units in 1984 (Figure 2). The second stage was from 1986 to 1996 during which time foreign MNCs relocated operations through joint-venture schemes to use their cutting-edge technology to improve production capabilities. In the third stage over the period 1997-2000 joint-ventures expanded strongly following the removal of limitations imposed on foreign investment. However, despite the expansion of production scale, which attracted the introduction of more new models, the core technology was still controlled by foreign MNCs. Nevertheless, output skyrocketed to 608,500 in 2000, growing by 177 times the output in 1981 (Figure 3). The fourth stage started in 2000 during which time China's automobile industry entered a new era with significant changes to business models and innovation activities.

Figure 3: Automobile Output, China, 1981-2000 ('000 vehicles)



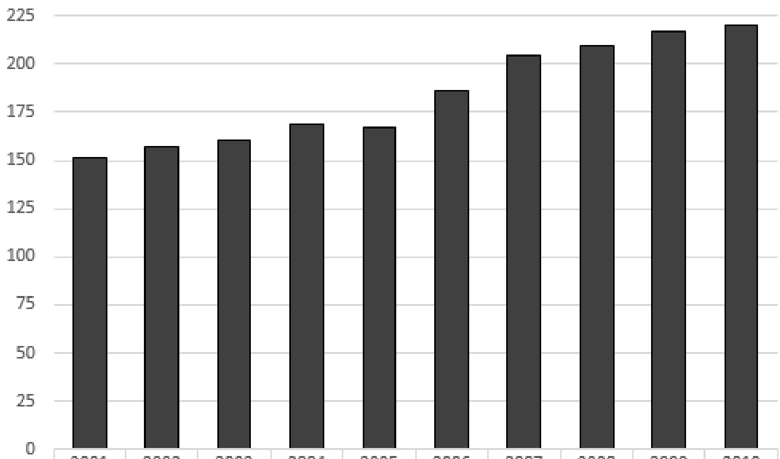
Source: China automobile industry yearbook (various years).

2.2. Upgrading since 2000

Since the turn of the millennium, upgrading in automobile manufacturing among domestic firms grew at an unprecedented rate. The number of indigenous brands increased from 14 in 2000 to 180 in 2010(CATR&CAIA, 2011). Also, of 221 new models introduced in 2010, 120 were developed by Chinese vehicle manufacturers with strongly involvement by national private firms. sector is actively engaged: 20 new automobile products were invented by The Chang'an Corporation, Great Wall Corporation, BYD Corporatin and Jeely Corporation launched 20, 13, 8 and 5 new modes respectively in 2010 (CATR&CAIA, 2011).

In addition, the rapid expansion since 2000 has raised the industry's contribution to the national economy. The automobile industry produced total output of 4.3 trillion and value added of 997.2 billion in 2010. (CATR&CAIA, 2011)The industry also employed approximately 2.2 million people in 2010 (Figure 4).

Figure 4: Automobile Employment, China, 2001-2010



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Employment	151	157	160	169	167	186	204	209	217	220

Note: y-axis in10 thousand persons.
Source: China Automobile industry Association & Ministry of Commerce (2013).

Table 1 shows the employment elasticity of transportation equipment manufacturing over the period 1980-2008.[5] It can be seen that the employment elasticity of the industry in this period was positive in all years except for 1981, 1984, 1986, 1989 and 1996-2001. The introduction of reforms on SOEs owned enterprises explains both the fall in employment and in the negative employment elasticities recorded by the industry over the period 1996-2001. It has been positive since 2001, which suggests that the turning point when value added is driven be a shift from labour to capital inputs have not arrived yet in the industry. The reforms introduced in the SOEs not only resulted in massive layoffs, it also led to the introduction of modern management practise, which drove productivity up significantly.

Table 1: Employment Elasticity, Transportation Equipment, 1998-2008, China

Year	Value added*	Real Annual Growth	Employment (by 10,000)	Annual employment growth	Employment Elasticity
1980	81	NA	250	NA	NA
1981	79	-2.47%	266	6.40%	-2.59
1982	80	1.27%	283	6.39%	5.05
1983	81	1.25%	285	0.71%	0.57
1984	125	54.32%	282	-1.05%	-0.02
1985	163	30.40%	287	1.77%	0.06
1986	160	-1.84%	298	3.83%	-2.08
1987	173	8.13%	305	2.35%	0.29
1988	213	23.12%	311	1.97%	0.09
1989	207	-2.82%	317	1.93%	-0.68
1990	218	5.31%	322	1.58%	0.30
1991	260	19.27%	333	3.42%	0.18
1992	333	28.08%	349	4.80%	0.17
1993	508	52.55%	426	22.06%	0.42
1994	539	6.10%	462	8.45%	1.38
1995	553	2.60%	490	6.06%	2.33
1996	615	11.21%	473	-3.47%	-0.31
1997	671	9.11%	445	-5.92%	-0.65
1998	776	15.65%	418	-6.07%	-0.39
1999	847	9.15%	407	-2.63%	-0.29
2000	935	10.39%	395	-2.95%	-0.28
2001	1,165	24.60%	384	-2.78%	-0.11
2002	1,577	35.36%	387	0.78%	0.02

[5] Employment elasticity refers to the growth of employment generated from a 1 percent growth in value added (in constant prices).

2003	2,108	33.67%	409	5.68%	0.17
2004	2,452	16.32%	433	5.87%	0.36
2005	2,778	13.30%	469	8.31%	0.63
2006	3,540	27.43%	501	6.82%	0.25
2007	4,947	39.75%	550	9.78%	0.25
2008	6,300	27.35%	641	16.55%	0.60

Note: *in 100 million US$ using 1990 constant prices.
Source: Calculated by authors based on data supplied by Chen (2011).

The profitability of the entire automobile industry saw a steady improvement from 4.7 percent in 2001 to 8.7 percent in 2010 (Table 2). The breakdown by size shows large firms enjoying higher sales and cost margins and return of equity (ROE) than the small and medium enterprises (SMEs) in 2012 (Table 3). Indeed, the dominance of the large enterprises suggests that the Chinese automobile industry has become monopolistic since 2000 in which the concentration ratio of the three biggest players of FAW, SAIC, DongFeng Group reached about 50 percent in 2002. The largest 10 enterprises accounted for 84 percent of total sales in 2006 and 87 percent of total production in 2011 (Shi Jianhua, 2012). The giant industrial players expanded through reorganization, and mergers and acquisitions. Market power in the industry can be considered to be higher still because of strategic tacit cooperation in production technology, R&D and marketing activities, which also explains why large firms achieved better performance than the SMEs. The highest sales margin (20.0 percent) and ROE (17.9 percent) was recorded by foreign owned company and joint-venture firms respectively in 2012 (Table 3), indicating that indigenous firms are still lagged behind foreign and joint-venture firms in the industry Foreign and joint-venture firms also enjoyed the highest net sales profits despite recording the highest cost margins in 2012.

Table 2: Profitability, Automobile industry, China, 2001-2010

Year	Net Sales	Gross Profit	Gross Margin (%)
2001	43389889	2047249	4.72
2002	60821956	3738365	6.15
2003	82048162	5567835	6.79
2004	93061416	5755083	6.18
2005	102411213	4304382	4.20
2006	137469137	7381948	5.37
2007	170655239	10270378	6.02
2008	187278178	9735809	5.20
2009	235295633	16876505	7.17
2010	299640274	25985985	8.67

Source: China automobile industry yearbook (various years)

Table 3: Profitability by Ownership and Size, Automobile Industry, China, 2012

Category	Number of firms	Sales margin	ROE	Net profit on sales	Cost margin
Ownership					
State owned	219	16.82	14.20	9.42	7.92
Collective	137	12.14	11.66	10.35	4.64
Stock cooperative	74	16.06	15.49	12.07	5.62
Joint venture	300	19.41	**17.87**	**13.60**	**12.92**
Private	5105	13.69	13.11	11.27	6.45
Foreign	2476	**19.96**	16.71	**13.60**	10.74
Size					
Large	**474**	**18.07**	**15.67**	**12.03**	**10.13**
Medium	1923	15.52	14.52	12.35	7.65
Small	8172	14.18	13.63	11.52	6.08

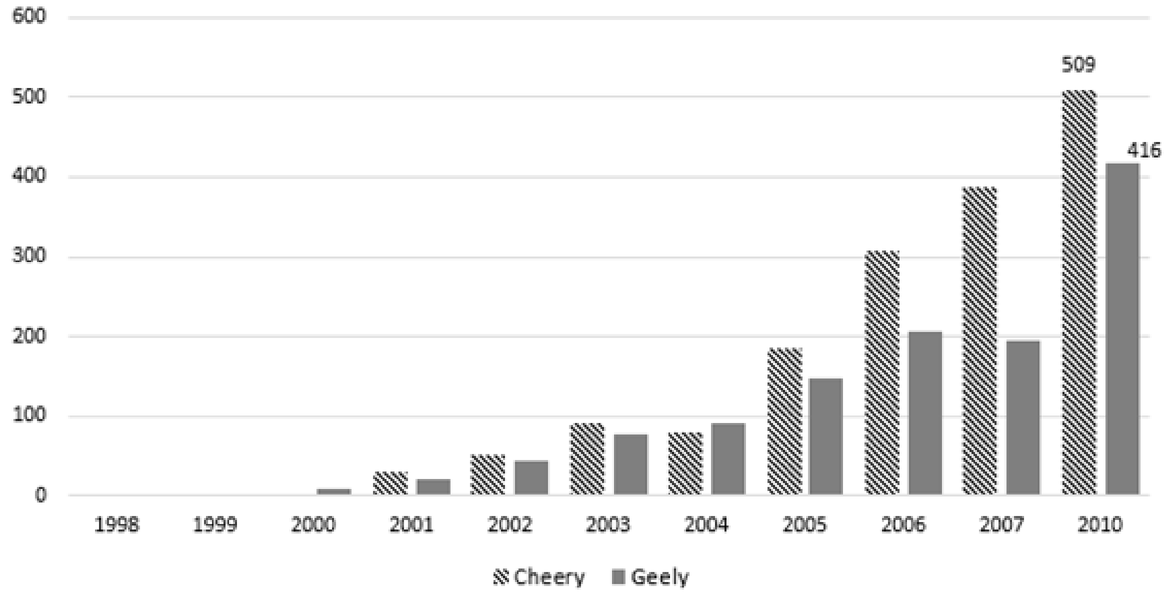
Source: China Statistics Bureau (2011).

2.3. Rise of Private National Firms

Despite the superior technological and market access enjoyed by foreign firms, national automobile enterprises using their own brands evolved strongly since 2000. Private national assemblers had 4 out of the top 10 automobile producers in 2006, selling 300, 267, 210 and 204 thousand vehicles each annually. While the general findings of Lu (2006), Qu (2009) and Zhao (2013) may hold, national enterprises' innovation capabilities have improved since 2000 following the introduction of a policy framework to support technological upgrading in both foreign and national firms (Yin Luanyu, 2010). As a result, sales of China's national firms using their own brands reached 2.9 million in 2010, which accounted for 31 percent of the total market share.

In addition to creating an environment-friendly market for private sector to participate, efforts have also been made by government of China to further accelerate the industry's development through industry reconstruction and reorganization since 2002. The industrial reforms included the introduction of private ownership in vehicle making, which in the past was strictly controlled by state-owned companies. Together with joint ventures, many private companies have entered the automobile industry. Many of them diversified from other industries, such as, home appliances, cell phones and batteries, chemicals and cigarettes. The automobile industry has the attracted a diversity of competitors so that foreign, joint-ventures, SOEs and national private firms compete. Geely Automobile and Cheery Automobile are some of the private vehicle manufacturers that have become big with strong participation in production and marketing activities. The output of these two major private car manufactures expanded rapidly from 2 million and 10 million respectively in 2000 to 509 million and 416 million vehicles respectively in 2010 (Figure 5).

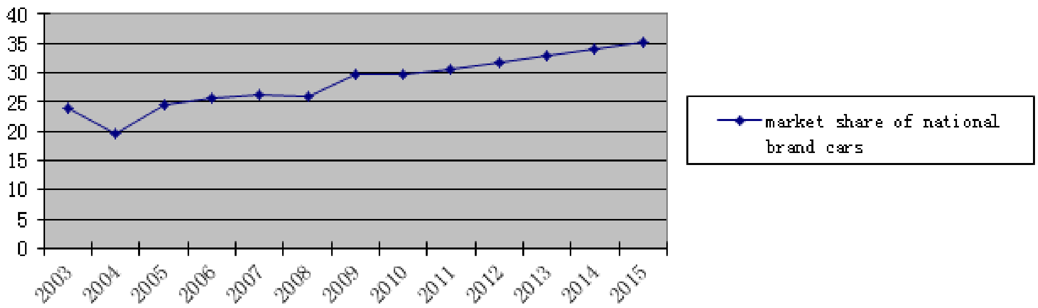
Figure 5: Automobile Output, Cheery and Jeely, China, 1998-2010 (‘000 vehicles)



Note: 1998-2000 data from Lu (2006); 2001-2007 data from Fourin China auto weekly (2008); 2010 data from China Automobile Industry Yearbook 2011.
Source: Lu (2006); Fourin (2008); China (2011).

However, despite the promise shown by Chinese national brands, Chinese private car makers face a number of challenges. Although the market share of national brands show a projected rise from 25 percent in 2003 to 35 percent in 2014 (Figure 6), the growth rate of Chinese branded vehicles has slowed down. The sale of Chinese branded passenger cars totalled 6.1 million cars in 2011 with market share dropping to 3.4 percent compared to the previous year. Their competitiveness based on pricing is slowing diminishing as a growing number of joint-venture firms have extended to compete in the low-end market. The lack of R&D capability is one of the weaknesses that has plagued private national firms. While the R&D expenditure in sales of the top three automobile makers in China ranged between 0.7 percent and 2.8 percent it is not high enough to rival international competitors, such as Toyota and Volkswagen as theirs exceeded 4 percent in 2010 (Table 4).

Figure 6: Projected Market share of Vehicles using National Brands, 2003-2015



Note: Data after 2009 were forecasted.
Source: China Automobile Industry Development Report 2010.

Table 4: R&D indicators, Selected Automobile Groups, China, 2006-2010

Firms	**R&D personnel***		**R&D investment***		**Sales revenue***		**R&D intensity %**	
	2006	2010	2006	2010	2006	2010	2006	2010
Domestic:								
FAW	2254	4632	250093	452623	14916914	29401552	1.68	**1.54**
SAIC	5350	17047	99739	649784	14168729	50338908	0.70	**1.29**
DongFeng	5351	8388	491318	359182	17503082	34878599	2.81	**1.03**
BYD	NA	NA	NA	NA	NA	NA	2.0	**2.9**
Jeely	NA	NA	NA	NA	NA	NA	8	**8**
Foreign:								
Toyota	NA	NA	NA	6236000	NA	NA	NA	**4-5%**
Volkswagen	NA	NA	NA	5346000	NA	NA	NA	**>5**
General Motors	NA	NA	NA	3905000	NA	NA	NA	**>5**

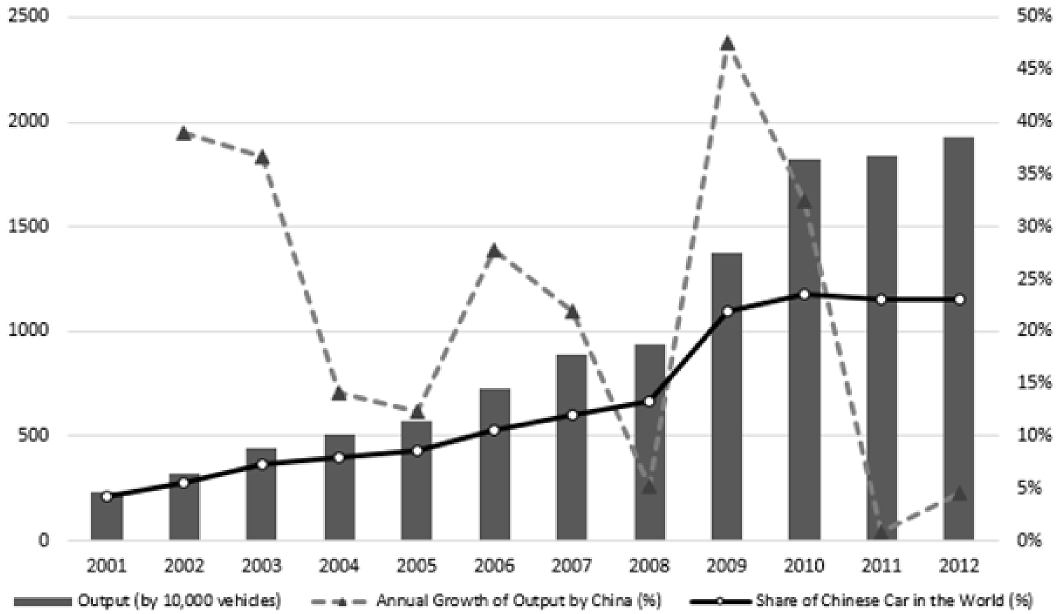
Note: * in 10,000 yuan.
Source: Chinese Automobile industrial Association (2013)

3. Integration in Global Value Chains

The discussion on the development of China's automobile industry cannot be complete without an account of global value chains. We capture the impact at the aggregate level by looking at trade indices.

The integration of Chinese automobile industry to global value chains since 2001 has significantly increased automotive trade from China. Although output has increased unevenly since, the share of vehicles manufactured in China in the world climbed from 4.2 percent in 2001 to 23 percent in 2012 (Figure 7). Exports in output rose from 3.4 percent in 2001 to 9.9 percent in 2007 before falling to 5.1 percent in 2011 (Table 5). The falling shares, inter alia, can be attributed to falling external demand caused by the 2008-09 global financial crisis.

Figure 7: Output, Growth and Share of Chinese Vehicles in the world, 2001-2012



Source: China Automobile industry Association & Ministry of Commerce (2013)

Table 5: Export Intensity of Output, Automobile industry, China, 2001-2010

Year	Gross output *	Sales *	Export *	Export Intensity
2001	44,331,852	43,389,889	1,484,929	3.42%
2002	62,246,394	60,821,956	2,326,679	3.83%
2003	83,571,570	82,048,162	2,810,941	3.43%
2004	94,631,639	93,061,416	4,205,613	4.52%
2005	102,233,353	102,411,213	5,234,947	5.11%
2006	139,375,342	137,469,137	12,347,671	8.98%
2007	172,420,240	170,655,239	16,954,620	9.94%
2008	187,805,358	187,278,178	18,101,295	9.67%
2009	234,377,996	235,295,633	12,813,438	5.45%
2010	302,486,165	299,640,274	15,309,818	5.11%

Note: * in 10 thousand yuan.
Source: China automobile industry yearbook 2011.

The internationalization of the automotive industry took on a new dimension following China's accession to World Trade Organization (WTO) in 2001. Accession to the WTO expanded both outward and inward FDI. Taking automobile components and parts for example, the export demonstrated an average annual growth of over 30 percent since the new century. Firstly, Chinese vehicle makers adjusted their business strategies to relocate the entire value chain of production abroad rather than simply selling finished vehicles in international markets. Hence, China's national branded vehicles have since 2001 expanded production abroad. China's national firms have also expanded their presence abroad through mergers and acquisitions, which includes the acquisition of the famed automobile firms of SsangYong (formerly South Korean), Rover (formerly British) and Volvo (formerly Swedish) by SAIC, Nanjing Auto, Geely respectively. Secondly, FDI inflows to the automotive industry has also risen sharply since. The large domestic market and institutional support from the government has stimulated the growth of R&D labs and centres in the industry, albeit they still lag behind such developments in the world's leading automobile firms.

China's automobile exports mainly go to the emerging markets of Egypt, Iran, Brazil and Chile, while imports mainly come the advanced countries of Germany, Japan, Belgium, USA, and the United Kingdom (Table 6). Although exports of vehicles to Germany has increased, imports have grown far more over the period of 2006-2011. Meanwhile, while the private national firms of Cheery, Jeely, Great Wall and FAW exported over 60 percent of vehicles from China, they are primarily in the low value added segment as they still lack the core technologies to compete in the higher value added segments, which explains why they are primarily targeted at developing economies.

Table 6: Top Import Origin and Export Destination by countries, 2006-2011 (%)

No.	Country	2006	2007	2008	2009	2010	2011
Import							
1	Germany	53	46	42	50	61	59
2	Japan	17	21	29	25	18	11
3	South Korea	6.8	5.0	2.8	3.0	1.4	3.5
4	USA	5.7	12.9	7.5	4.7	3.6	4.8
5	France	3.7	1.7	1.4	2.4	1.6	4.0
Export							
1	Russia	21	22	19	6	13	13
2	Egypt	3	3	6	11	8	4
3	Chile	2	3	4	3	3	8
4	Ukraine	4	19	19	5	3	6
5	Germany	0	5	7	15	6	3

Source: Chinese Automobile Association (2013)

3.1. Intra-industry Analysis

Using time-series import and export data, this section analyses the intra-industry trade and competitive trends of China's automotive industry.

Intra-industry trade is normally estimated using the Grubel–Lloyd (G-L) (1972) index can be measured as follows:

$$\text{G-L}_i = \frac{(X_i + M_i) - |X_i - M_i|}{X_i + M_i} = 1 - \frac{|X_i - M_i|}{X_i + M_i},$$

Where X_i and M_i refer to exports and imports of good i respectively.

The G-L index of engines increased rapidly from 0.2 in 1996 to 0.8 in 2012 (Figure 8). However, apart from the years 1997 (0.6) and 2008 (0.8), the G-L index of completely built up units (CBU) has been lower than 0.5 over the period 1996-2012. The low G-L index indicates that imports of CBUs exceed exports. China has done well in auto parts as it has continuously 0.5, though, largely in the low value added segments. Nevertheless, significant improvements have taken place for the industry as a whole as its G-L index has risen in trend terms from 0.3 in 1996 to 0.9 in 2012.

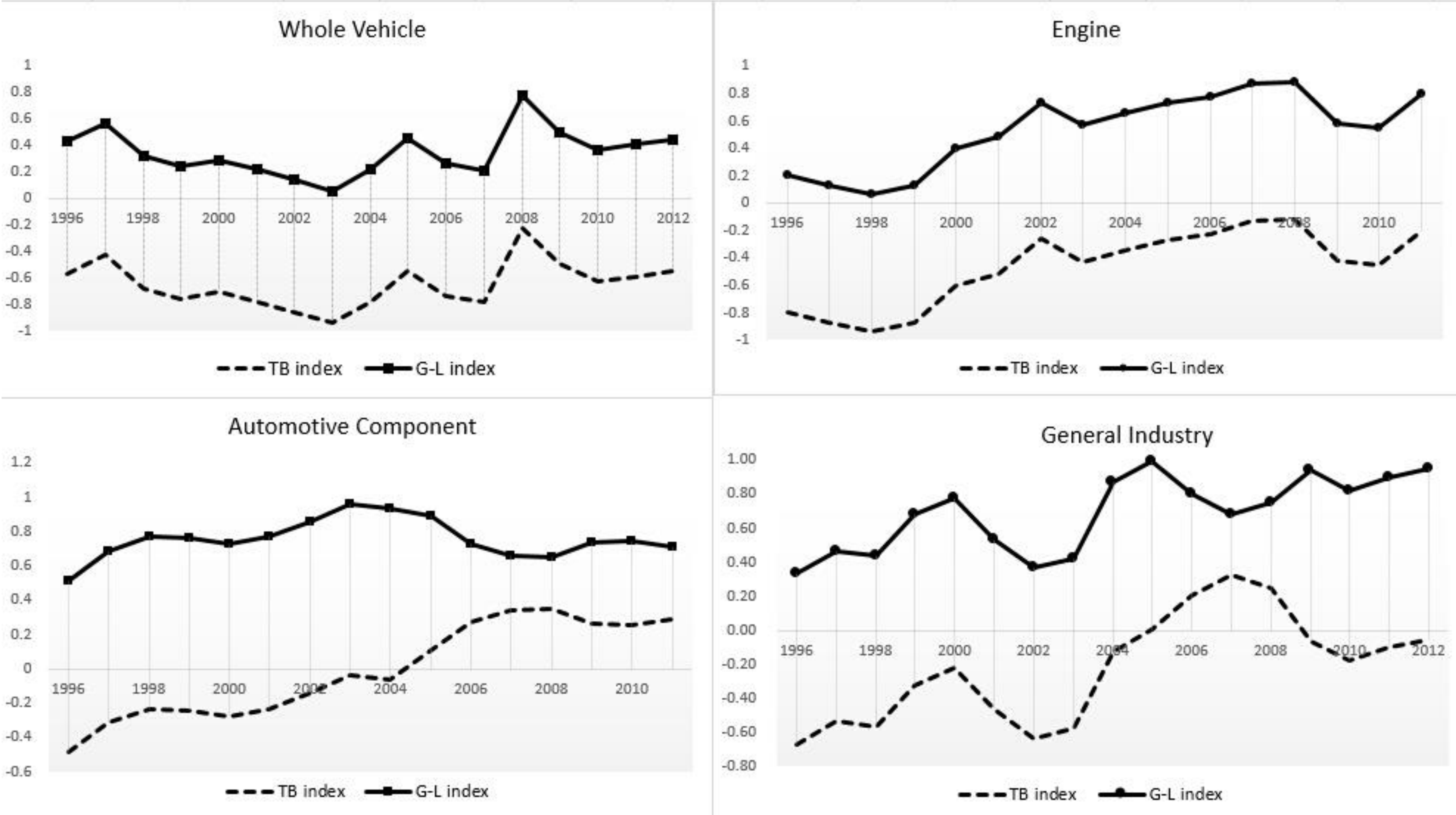
We now estimate the Trade Balance (TB) index to examine the competitiveness of the automotive industry in China. The TB index shows the relative advantage or disadvantage of a certain country in a certain class of goods or services. The TB is can be estimated as follows:

$$TB= (X_i-M_i)/(X_i+M_i)$$

Where X_i and M_i refer to the import of good i. TB indices range from 0 to 1.

In general, the TB index shows that the trade competitiveness of China's CBUs and engines is weak as they have been negative over the period 1996-2012 (Figure 8). The TB index of automotive components have become positive since 2004. While the TB index of general automotive products became positive since after it fell t negative figures again since 2009. Nevertheless, the TB index of all the components and the CBUs have shown a trend improvement over the period.

Figure 8: G-L and TB indices, automobile industry, China, 1996-2012



Source: China automobile industry yearbook (various years)

3.2. Firm-level Evidence

In order to complement the macro-sectoral development, a firm-level survey has been done in 2012, aiming to identify the nature, level, technological capability and economic performance of automobile manufacturing firms in China. The participating firms were selected by random, but sampled to include various ownership in the industry, including assemblers, suppliers, and customers. In the end 51 sets of questionnaires were obtained through field work, out of which 40 were engaged in manufacturing, 8 as assemblers, 26 in R&D operation, 21 on industrial design and 22 in integration operation. However, in order to assure the complete confidentiality of the participating firm, the information that firms provided us will be used in an aggregate form with no individual firm data and identity being revealed. Table 7 presents a summary of the firms' demographics.

Table 7: Firm Demographics, Sampled Firms, China, 2012

Firm Demographic		**Ownership**				
		SOE	Local	JV	Foreign	Sum
Business Nature	Assembler	0	5	2	2	9
	Manufacturer	3	20	15	1	39
	R&D operations	3	11	10	1	25
	Design	2	9	10	1	22
	Integrated operations	2	8	10	1	21
Sum		10	53	47	6	116
Year Founded	<1990	0	2	2	2	6
	1990-2000	1	2	9	7	19
	>2000	1	0	**10**	9	20
		2	4	21	18	45
Employment size	<200	0	1	7	0	8
	200-1000	0	0	6	7	13
	>1000	3	1	14	10	28
Sum		3	2	27	17	49
Gross Sales	<10million yuan	0	0	0	0	0
	10m-100m yuan	0	0	3	1	4

	>100m yuan	3	3	21	6	33	
Sum		3	3	24	7	37	
Export	<50million yuan	0	0	0	0	0	
	50m-100m yuan	0	0	0	0	0	
	>100m yuan	0	2	1	2	5	
Sum		0	2	1	2	5	

Note: SOE - state-owned or controlled enterprises; 2. Local firms refer to private national firms with equity above 80 percent; JV - Joint-ventures refer to firms with foreign equity but domestic equity exceeding 20 percent but less than 80 percent; Foreign firms refer to firms with foreign equity greater than 80 percent. The sums exceed 51 because many firms are engaged in several activities.
Source: Authors survey (2013).

The survey result shows that national firms accounted for 53 percent of the industry's employment with private firms accounting for 28.6 percent of total employment respectively (Table 8). Despite the rationalization that took place since 1996, the three SOE automakers still accounted for 26.6 percent of the total employment of the participating firms. Joint-venture firms accounted for 35 percent of all the participating firms but they only employed 44.2 percent of total employment, demonstrating that average employment size of JV is above that of foreign and local private firms.

Table 8: Ownership and Employment, Sampled Firms, China, 2012

Ownership	No. of firms	Average No. of employees	Share in Total Employment
SOE	3(5.9%)	51,160	26.6%
Foreign	3(5.9%)	866	0.5%
Local	27(53.4%)	9,161	28.6%
JV	18(35.3%)	9,429	44.2%

Source: authors survey (2013).

The empirical evidence indicates that the share of firms that conduct incremental innovation activities is high at 88 percent. However, participation in R&D activities has been relatively low as only 25 firms reported participation in R&D activities out of which 23 percent reported R&D intensity exceeding 5 percent with 61 percent report between 1-5 percent. In other words, 75 percent of the firms did not participate in R&D activities in 2012, though a significant proportion of them participated in the type of innovation activities Schumpeter (1961) had noted that entrepreneurs do, i.e. in incremental engineering activities.

In addition, firm-level participation in intellectual property rights protection activities is strong for a latecomer country but weak when compared to firms in the developed countries as only 40 percent of the sampled firms reported patent registrations in 2012. Nevertheless, it is interesting to note that the share of firms registering patents (40 percent) exceeded the share of firms participating in R&D activities (25 percent) in the sample. Obviously, this suggests that incremental engineering activities have also been a route to patent take up among the sampled firms.

Interestingly, among the firms that reported participation in R&D activities in the high R&D intensity group, SOEs and national private firms accounted for 60 percent of the firms that reported R&D intensity levels above 5 percent, while joint-ventures accounted for the remaining 40 percent. This demonstrates that national firms recognize and are striving to move up the technology trajectory to compete with lead firms in the world. Among the medium R&D intensity group of 1-5 percent, 17 percent were SOEs, 58 percent were national private firms and remaining 25 percent were joint ventures. In the low R&D intensity group of less than 1 percent, 20 percent were SOEs, 60 percent national private firms and 20 percent were joint ventures. No foreign firm reported investing in R&D activities, which is a consequence of their reliance on superior R&D capabilities overseas, especially in their parent locations. They tend to specialize in production activities with significant participation in adaptive engineering activities. However, interviews show that even foreign firms are gradually targeting the introduction of R&D facilities to take advantage of R&D incentives and grants that the government introduced recently. The importance government support targeted at stimulating firm-level technological upgrading is reflected by 66 percent of the sampled firms reporting to have received government assistance to undertake R&D.

However, while participation in R&D activities in China, especially among national firms, is rising, interviews show that there are constraints that hinder technology development. Firstly, automobile assembly is scale intensive, and hence, nascent national private firms have found it difficult to compete with foreign and SOE firms as they are large and enjoy large market shares. Secondly, unlike in the component industry entering export markets have been difficult for new private firms.

Thirdly, heavy reliance on foreign technology has also made it costly for national private firms. Fourthly, with China growing rapidly and the domestic currency becoming stronger rising input costs relative to competitors abroad has made it tougher for national firms to compete. Fifthly, human capital prefer to work for higher salaries and prestigious firms than the newly established national private firms.

All in all, while existing participation records among automotive firms in China has not been impressive when compared to the record of the frontier nations, such as, Germany, Japan and the United States, the government's efforts to introduce the institutions through incentives and grants has stimulated increasing participation in R&D activities. This is impressive considering China's late entry into the automotive industry. However, national private firms still face serious challengers to upgrade and compete against the daunting currents of competition from foreign and large firms in a scale-intensive industry.

4. Conclusions

China's automotive industry has undergone massive expansion its economic were introduced in China. It has not only become the largest contributor to China's manufacturing sector value added, it has also become one of the largest exporters of automotive vehicles in the world. Market reforms and policy adjustments have been central to this expansion. While integration into global value chains have attracted intense completion, it has also stimulated firm-level technological innovation and industrial upgrading. Four significant features can be identified in evolution of China's automotive industry, namely, one, diversification boosted by increasing market demand and technological upgrading; two, the emergence and growth of national private firms as active players; three, integration into global markets triggered outward and inward FDI that generated both competition and technological deepening, and four, the emergence of indigenous innovation supported by government incentives and grants.

The analysis using the TB and the G-L indices show that the pecuniary benefits of integration in global value chains lie largely in the automotive components sector as the G-L and TB indices are either below 0.5 or negative respectively in CBUs and engines. Nevertheless, the positive thing of the results is that all indicators show trend improvements over the period 1996-2012. Also, CBU exports of automobiles using Chinese branded models have also risen strongly since 2000.

The firm-level analysis shows that 88 percent of the automotive firms participated in innovative activities with 40 percent of them having successfully registered patents, though only 25 percent reported participation in R&D activities. Interestingly, national firms – private and SOEs – participated most in R&D activities followed by joint-venture firms. No foreign automotive firm in the sample reported undertaking R&D in China but this is expected to change following the governments introduction of incentives and grants to spur R&D activity. Nevertheless, the evidence also shows that national firms have responded to the challenge of competition since global integration to increasingly invest in R&D activities. This may explain the increasing exports of CBUs using Chinese brands, albeit primarily of low-priced vehicles to the developing economies.

While the government's initiatives to offer incentives and grants to promote firm-level R&D activities is commendable, efforts must be taken to see that these rents are appropriated productively. It is also important for the government to work with the industry association to stimulate clustering between the private firms, public sector and the government towards developing a strong sectoral innovation eco-system to intensify connectivity and coordination between the participants to learn, adapt and innovate effectively. Meso-organization, such as public R&D lab and universities are important players that should be attracted to collaborate in this ecosystem to strengthen firm-level innovation activities. Meanwhile, firms' efforts to engage in the global market should be continuously encouraged as such a strategy will not only increase scale and attract productive competition it will also expand the knowledge base from where national firms can appropriate their knowledge to deepen their innovative activities.

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