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INTERNATIONAL TECHNOLOGY TRANSFER AND DEVELOPMENT OF CAPABILITIES IN CHINESE STATE-OWNED MANUFACTURING ENTERPRISES: LESSONS FROM 20 YEARS OF CASE RESEARCH

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ABSTRACT

Technological capabilities in Chinese manufacturing have been transformed in the last three decades. However, the extent to which domestic market oriented state owned enterprises (SOEs) have developed their capabilities is not clear. Six SOEs in the automotive, steel and machine tools sectors in Beijing and Tianjin have been studied since the mid-1990s to assess the capability levels attained and the role of external sources and internal efforts in developing them. Aided by government policies, acquisition of technology and their own efforts, the case study companies appear to be broadly following the East Asian late industrialisation model. All six enterprises demonstrate competences in operating established technology, managing investment and making product and process improvements. The evidence suggests that companies without foreign joint venture (JV) collaborations have made more progress in this respect.

Keywords: Chinese manufacturing, latecomer strategies, capability development.

1 INTRODUCTION

With a share of world manufacturing output at almost 19 per cent in 2010, China inched ahead of the USA to become the world's largest producer of manufactured goods (calculated from UN Statistics Division (undated) data). The manufacturing sector in China employs about 10 times as many people as in the USA to produce a similar level of output. This difference can partly be explained by the concentration of labour-intensive production in China. Nevertheless, given the substantial progress China has made in export performance (Vaidya et al, 2007) and in meeting the growing domestic demand, questions remain on the extent to which Chinese manufacturing is continuing to rely on low labour costs or developing more advanced technological capabilities.

An important question is whether China is following patterns of technological catch-up identified by Matthews (2001) in other East Asian countries, notably Korea and Taiwan, which started from manufacturing competence acquired from low-tech labour intensive sub-contracting. While export-oriented sectors in China have followed this pattern (Lall and Albaladejo, 2004), the situation is more complex because of the diversity of manufacturing, the importance of the domestic market and the large number of SOEs. Following the initiation of the Open Door policy, China encouraged acquisition of foreign technology and know-how by SOEs through a range of channels. As Matthews (2001; 2006) and Kim (1997) show, developing internationally comparable capabilities requires progressing beyond reliance on imported technology to deepen firm level capabilities through learning and R&D (Bennett and Vaidya,

2005). Matthews (2006) highlights the importance of the three Ls, leverage, linkage and learning, in developing capabilities by latecomers.

While the development of advanced capabilities is evident in Chinese companies such as Konka, TCL, Haier, Huawei and Lenovo in dynamic high-tech sectors, it is the manufacturing SOEs in mature markets which face greater challenges in becoming competitive. The focus of this paper is therefore on how and to what extent domestic market oriented SOEs have developed their technological capabilities.

2 THE STUDY APPROACH AND ISSUES INVESTIGATED

Having studied the nature, motivations and value of international technology transfer to Chinese enterprises in the 1990s, we take a longitudinal case study approach to track six manufacturing SOEs since the mid-1990s to assess changes in their technological capabilities, the role in the changes of external sources and internal efforts and of policies. The case study enterprises are located in Beijing and Tianjin, two in the automotive sector (Beijing Benz Automotive Co Ltd, a JV subsidiary of Beijing Automotive Industries Holding Co (BAIC) and Tianjin FAW Xiali Automobile Co Ltd), two in the steel sector (Shougang Group Corporation and Tianjin Pipe Corporation (TPCO)), and two in the machine tools sector (BYJC Machine Tool Co Ltd in Beijing and Tianjin Tianduan Press Company Ltd).

In our initial studies in the 1990s, the focus was on the role of international technology transfer. Since 2000 it has shifted towards understanding the process of capability development. Semi-structured interviews were conducted with representatives of the six companies in 2006 and 2012. Contextual questions about changes in governance, major products and markets, sales, profitability and number of employees were followed by questions about technological capability (e.g. extent and nature of R&D and the number of patents taken out by the company). Company representatives were then asked to identify the most important technologies the company had developed independently and acquired from external sources. Information was also sought on the levels of the technologies developed and used by enterprises (i.e. whether they offered a lead over international or Chinese competitors, were comparable or less advanced).

	Capability stages: Competence based on knowledge and skills
Stage 1	Manufacturing competence (production including shop floor experience and learning by doing).
Stage 2	Investment competence (installing new production capacity, expansion or modernisation of capacity).
Stage 3	Adapting and stretching competence (engineering and organisational adaptations for continuous and incremental upgrading of products, performance features, and process technology).
Stage 4	Innovation competence (product and process innovation and creation of new technology).
	Levels of attainment
Very High	Comparable with international leading companies in the sector of specialisation.
High	Competence to perform independently with external input and support which the company has decided to buy from outside and which is effectively managed by the company.
Medium	Competence to perform but with substantial external input and support required because of gaps in the company know how. Significant impact on volume and quality without the support.
Low	Low competence to perform with many emerging problems. Still at the learning stage. Requires substantial external input and support without which it would fail.

Table 1: Capability stages and levels of attainment

In the case-study analysis we adopt the East Asian latecomer development model (Bennett and Vaidya, 2005) to comprise four stages with a sequential progression from Stages 1 to 4. For each case the level of capability attained in each of the stages was assessed. The stages and levels are set out in Table 1. An inductive approach has enabled us to investigate: (a) whether there is a sequential and progressive relationship between the stages, (b) whether relying on collaborative relationships (especially JVs) and developing internal capabilities are mutually exclusive, and (c) whether developing manufacturing excellence and innovative competence are compatible (Gao et al, 2007).

3 CASE ANALYSIS

Since the case study companies are in the automotive, steel and machine tools sectors, developments in these sectors and industrial policies influencing them are briefly described as context. All three sectors

have experienced rapid growth and China is the largest producer of cars, steel and machine tools. During the 1980s and 1990s, the automotive and steel sectors became highly fragmented with many provinces promoting and supporting old and new enterprises. The machine tools sector did not see a similar proliferation of new enterprises but they ware locally protected. The "modern enterprise" reform process initiated in the 1990s reduced the SOEs' social obligations and facilitated their transformation into more commercially oriented corporatised enterprises (Yi-min Lin and Tian Zhu, 2000). Alongside these reforms, central government started addressing the fragmentation of the key manufacturing sectors. In broad terms, the approach was to identify leading enterprises in each sector and support them in taking over smaller or weaker ones with a view to improving them or rationalising production (Nolan, 2001).

Even when manufacturing output in these sectors was growing in the 1980s and 1990s, it was recognised that China as a latecomer lagged behind in manufacturing knowhow. Following the latecomer model, the broad approach was to learn from more advanced foreign knowhow and use it as a base to develop indigenous capabilities by engaging in product and process development and R&D. However, the specific approaches to learn from foreign knowhow differed between sectors. In the automotive sector, formation of JVs with foreign enterprises was the dominant mode. In the steel sector, the focus was on importing the most advanced production equipment, reverse engineering and R&D. In the machine tools sector, a wide range of modes of foreign technology acquisition, purchase of equipment, licensing, co-production and JVs have been used, to be complemented by internal efforts.

In the sectoral context outlined above, Tables 2 and 3 summarise the case study findings with Table 2 outlining developments in governance, restructuring and production and Table 3 presenting the technological capability appraisal based on the framework introduced in section 2. All case study companies have been influenced by the "modern enterprise" reform referred to above. Tianjin Tianduan is the smallest case study enterprise and a subsidiary of a holding company, formerly a Tianjin Municipality line ministry. Tianjin FAW Xiali is also a subsidiary of a larger company but of one of the largest Chinese automotive groups formed under the restructuring of the automotive sector. BAIC (Chinese parent of Beijing Benz), BYJC and Shougang are large group enterprises. TPCO was created in 1989 by Tianjin municipal administration with central government support to produce pipes for the oil and gas sector to reduce import dependence. While TPCO has made rapid progress as a producer and in its technological capabilities (Table 3), it has needed very substantial financial support and restructuring to convert debt into shares owned by state asset holding companies. All enterprises have seen rapid growth in sales over the period (Table 2). However, only Shougang and TPCO, both steel companies have exports of any size. BYJC has overseas sales but from Waldrich Coburg, its German subsidiary acquired in 2005.

All the case companies have attained **Very High** manufacturing competence (Table 3) implying either having attained internationally comparative competence or approaching it. Investment competence is also **High** or **Very High** in the companies as evidenced by the management of capacity expansion and location change implemented by the case companies. All the case companies stated that they acquired the most advanced equipment for their new plants. Shougang Group had the capacity to design and construct some of the plant while TPCO collaborated with a supplier of equipment in developing it.

Stage 3 capability in Table 2 refers to adaptation as well as development of processes and products relying on known technology with limited innovation. This is a departure from Bennett and Vaidya (2005) which specify process and product adaptation as Stage 3. This modification is an outcome of the inductive case study approach during which it has been observed that all the companies have developed products based on a combination of acquired knowhow and internal learning and adaptation without engaging in a high level of innovation. We argue that the adaptive and development capabilities require manufacturing and investment competences which deepen understanding of production processes and product features.

The stages approach implies that "Stage 4: Innovation" is sequentially dependent on the previous stages. Having acquired stages 1 to 3 capabilities, all companies recognise the need for R&D and have internal R&D complemented by links with research institutes or universities. We categorise Tianduan, Shougang and Tianjin Pipe in the **High to Very High** category because of the level of their R&D activity and the number of patents they have registered. They are not in the unequivocal **Very High** category because all three acknowledged that there were some vital technologies in which they lagged behind international leaders. With the acquisition of Waldrich Coburg, BYJC has the potential to attain **High** to **Very High** innovation competence but keeping the German subsidiary at arm's length may impose constraints. Of the two auto companies, BAIC has a more ambitious R&D programme but the companies are not strictly comparable because Tianjin FAW Xiali is a subsidiary of a large group and innovative initiatives are likely to be at the group level.

Sector	Company	Background and governance	Products, sales, exports and profits
Auto	Beijing Benz Automotive Co Ltd and BAIC	A JV between Beijing Automotive Industries Holding Co (BAIC) and Daimler AG with the ownership split 50:50 (new agreement in 2004). Originally, the first Sino-foreign automotive JV (Beijing Jeep) between Beijing Automobile Works (now subsidiary of BAIC) and American Motors (later acquired by Chrysler Corporation). The Chrysler Daimler merger in 1998 gave Daimler entry into the JV. Chrysler exited the JV after the failure of Chrysler Daimler merger in 2007.	Until 2005 JV production of American Motors/Chrysler SUVs (Jeep Cherokee, Grand Cherokee). Low production volume in 2005 (25,000 vehicles) because of high cost (including import duty) of imported components and concerns about military use of some technology. After 2004 investment and capacity expansion to assemble Mercedes Benz C and E Class and GLK. Future expansion to include an engine plant and R&D centre (both firsts out of Germany for Mercedes). Production increased from 26,000 in 2006 to 93,000 in 2011. Expected to be 300,000 to 350,000 by 2015. JV's profit in 2011 was RMB3.9b (billion).
	Tianjin FAW Xiali Automobile Co Ltd	Formerly, Tianjin Micro-Car Factory which became Tianjin Automotive Industrial (Group) Co in 1997 and was listed on the Shenzhen Stock Exchange in 1999. In 2002, it became a subsidiary of FAW (First Auto Works) Group, one of the largest five auto enterprises in China, as a part of restructuring of the automobile sector. A JV with Toyota started in 1999 and has now become part of collaboration between FAW and Toyota.	Formerly Xiali produced cars based on the 1987 Daihatsu Charade which were very popular in China as taxicabs. Newer versions launched in the 1990s. A model based on Toyota Yaris introduced after 2000. There is a continuing programme of new small low priced cars aimed at the young and non-metropolitan customers. Total production of 130,000 vehicles in 2005 was almost entirely for the Chinese market. Production in 2009 was 214,000. Sales and profit in 2009 were RMB8.57b and RMB 176m (million) respectively (both estimated to be higher in 2011). A new powertrain plant with a capacity of 400,000 was completed in 2008. A new assembly plant opened in 2011 has increased production capacity to 400,000 with further expansion in progress.
Machine tools	BYJC Machine Tool Co Ltd	Formerly Beijing No 1 Machine Tool Works. In the 1990s started transitioning from a traditional SOE to commercial orientation. Core enterprise in the restructured machine tool sector in Beijing. Since 2000, JVs with Japanese, Korean and French firms and acquisition of German co-production partner, Waldrich Coburg.	Continues to manufacture milling, boring and drilling machines of various types including machining centres and super heavy machines. Works with customers to install production lines. Total sales value in 2005 was RMB1b (over 3 times that in 1997) and about RMB3.3b in 2011. Some of the increase may be because of acquisitions and restructuring.
	Tianjin Tianduan Press Co Ltd	In the 1990s an enterprise under the Tianjin Ministry of Machinery Industry. By 2012, a restructured subsidiary of Tianjin BENEFO Machinery & Electric Holding Group Ltd - formerly the Tianjin Machinery Industry Bureau. Reportedly, company management shares in profits through 20% share ownership.	The company is the largest producer of hydraulic presses in China (40% market share) and produces presses of varying capacities and meeting special requirements such as heavy presses and presses for aircraft panels and glass fibre. Sales revenue in 2005 was RMB260m with a profit of RMB2m. In 2010 the respective figures were RMB676m and RMB18m.
Steel	Shougang Group Corporation	In the mid-1990s, one of the largest Chinese steel manufacturers identified to be the core of a restructured national steel sector. Freedom to make investment decisions, vertically integrate backwards into mining and logistics and forward into trading. Now a conglomerate with complex cross-ownerships and a number of subsidiaries engaged in steel and non-steel sector activities. Number 295 in the Global Fortune 500.	An integrated iron and steel enterprise involved in extraction and processing of iron ore, steel production and heavy equipment manufacture. In the 1990s, steel production was lower grade. In 2006, steel production was 12.5mt (million tonnes) (constrained by relocation of Beijing steel plant). In 2010-11, annual steel production increased to 30mt through the new coastal plant at Caofeidian coming on stream and acquisition of other steel producers as part of restructuring. Lower value added long products reduced to one-third of total production. By 2015, Group plans to produce 40mt of total crude steel output per year.
	Tianjin Pipe Corporation (TPCO)	Created by Tianjin Municipal Government in 1989 and under Municipal Government ownership. Heavily indebted to municipality and banks until late 1990s when debt was converted to equity. Since 2005 Tianjin Economic & Technological Development Area (TEDA) and other state owned entities are shareholders but TPCO also benefits from some low interest rate loans.	An integrated steel plant specialising in pipes for the oil and gas sector. In 2005, a wider range of products with improved quality and large expansion of production of seamless pipes. About 3-fold increase in production between 1997 and 2005 (1.4mt). Production and sales in 2010 about 2.7 million tonnes valued at about RMB17b (adversely affected by US anti-dumping action). Exporting to many oil producing countries. Many major international oil companies are customers. Profit in 2005 about 5% of sales. Before the US anti-dumping action in 2012, profits were in the RMB2b to RMB3b range.

Note: RMB is Renminbi, Chinese currency. US$1 was approximately RMB6.4 in July 2012.

Table 2: Case study companies: Background, governance and general information

	Capability stages			
Company	**Stage 1: Manufacturing**	**Stage 2: Investment**	**Stage 3: Adaptation**	**Stage 4: Innovation**
Beijing Benz (JV) & BAIC	**Very High** in JV with Daimler AG and in BAIC with accumulated experience of manufacturing different types of vehicles (passenger cars and commercial and military vehicles).	**Very High** in JV. Investment in assembly and engine plant in collaboration with JV partner. **High** in BAIC with a range of past and current investment projects for different types of vehicles.	Not relevant for the JV with foreign knowhow. **High** in BAIC – evidence of development of vehicles based on acquired technology (e.g. military vehicles, models based on SAAB designs including electric vehicles).	Not relevant for the JV not engaged in innovation. **Medium to High** in BAIC. Independent development of military vehicle claimed. BAIC has set up an electric vehicle subsidiary, R&D base and supply chain. Prototypes of "new energy" vehicles were shown in 2011.
Tianjin FAW Xiali Automobile Co	**Very High** competence in operating established technology through experience of manufacturing components and assembly (2.4 million cars).	**High:** Demonstrated by the substantial implemented and continuing investment programme (assembly and major component manufacture).	**High:** Demonstrated by competence to adapt and develop models based on imported technology. Supported by own R&D department and that of FAW for advanced engine development.	**Medium:** Long established R&D programme for model design and development of small economy cars based on established technology.
BYJC Machine Tool Co Ltd	**Very High** competence in operating established technology augmented by acquisition of Waldrich Coburg and exchanges of staff with JV partners.	**High:** Managed installation of new factory outside Beijing. Other investment projects related to restructuring continuing.	**High:** Product and process adaptation and development (assembly lines with JV partner), especially super heavy milling machines in collaboration with foreign subsidiary.	**Medium to High:** Company has 5 pragmatic patents (see note). Prefers not to patent important technologies. Waldrich Coburg operates independently with separate R&D.
Tianjin Metal Forming Machine Tools General Works	**Very High** competence in operating established technology and managing suppliers of components. Capacity to learn quickly when new equipment is introduced.	**High:** Managed construction of new factory. Normal reliance on suppliers when new equipment is introduced. Most advanced foreign equipment installed.	**Very High:** Increased the range of products and capacity of presses. Restructured the business to outsource standard components to focus on producing key components and assembly. Work with customers to design presses to meet specific requirements.	**High to Very High:** Developed specialist presses for aircraft panels, glass fibre and nuclear power station component, requiring high precision. Company owns 540 (80%) of patents in the sector (of which 30% are "invention" patents – see note).
Shougang Group Corporation	**Very High** competence demonstrated by fully comprehensive management of operations in the old and new and recently acquired plants.	**Very High:** Management of new plant construction. Blast furnaces designed and constructed by design and engineering subsidiary. Most advanced steel rolling mills installed. An 80 tonne ladle furnace (to produce purer steel) was purchased and then 2 copies made.	**Very High:** Since early days, reliance on internal development and adaptation of technology and purchase of imported technology when necessary (Nolan and Yeung, 2001). Very high ability to adapt and develop processes and products and large improvements in environmental protection.	**High to Very High** level of research competence and a continuing programme of internal and cooperative research with universities, research institutes and companies. Between 1986 and 2006, ranked fifth among Chinese companies in registering Chinese patents.
Tianjin Pipe Corporation (TPCO)	**Very High** competence in fully integrated steel production and pipe manufacture. Increase in range of products with limited external support and problem solving for customers.	**High:** Expansion of production capacity with normal support from equipment suppliers, installation of seamless pipe capacity, and collaboration with supplier in designing new equipment. New 500,000 tonne plant being constructed in Texas.	**Very High:** Increase in range of products for the oil and gas sector and diversification into other products (e.g. low and high pressure cylinders). Designing customised products. Obtained international certifications for products.	**High to Very High:** Has developed own proprietary TP (Tianjin Pipe) products. By far the leading Chinese innovator with most national "invention" patents in the sector. Developments since 2006 include high grade steel pipes and special pipe connectors. Research in new areas being undertaken to diversify.

Note: There are different types of patents in China. An "invention" patent is granted for a new technical solution relating to a product or process. "Utility" or pragmatic product development patents are for new shape or structure of a product made to change functionality and not just for aesthetics.

Table 3: Case study companies: Assessment of capability development

4 SUMMARY AND CONCLUSIONS

Returning to questions posed at the end of section 2, the progressive relationship between stages holds up with the following caveat. Product development can take place without ground breaking innovation and could therefore either be subsumed in Stage 3 competence or be added as an additional stage between stages 3 and 4. This raises a broader question about the nature of industrial innovation in the latecomer context which requires further investigation. On the issue of compatibility between JVs and developing internal capabilities, three of our case companies (BAIC, Tianjin FAW Xiali and BYJC) show that these are not mutually exclusive. All three demonstrate internal learning and progress in innovation. Arguably, if JV subsidiaries contribute substantial profits, as is the case in all three, they are cash cows which may finance innovation expenditure. Having said that, these three companies have been categorised lower in their attainment of Stages 3 and 4 competences than the other three case companies. Therefore, there is evidence to support the hypothesis that the pace of capability development is slower with foreign JV participation, though less sharply than demonstrated by Gao (2011). On the third question of manufacturing versus innovation competence, according to the sequential capability development model, the latter has to be built on Stages 1 to 3 competences and an understanding of the market and valued product features derived from these. This appears to be valid for mature sectors but may be less so for sectors with short product life cycles or disruptive technologies.

This paper has provided a summary of the findings from the study. The next stage is to examine the capability development processes and the associated accumulation and role of skills in more detail, incorporating the nature and relative importance of the 3 Ls (leverage, learning and linkage). To complement the 3 Ls of Matthews (2006), we propose 2 Ms, ***motivation*** (to reflect what drives SOEs to develop capabilities) and ***money*** (to represent access to financial resources) - both required for the capability development process.

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