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Capturing Value in International Manufacturing and Supply Networks

New models for a changing world

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Capturing Value in International Manufacturing and Supply Networks: New models for a changing world

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Capabilities and competitiveness of Chinese state owned manufacturing enterprises: What has been learned over 20 years and what remains to be learned.

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Abstract

Technological capabilities in Chinese manufacturing have been transformed in the last three decades. However, the extent to which and how domestic market oriented state owned enterprises (SOEs) have developed their capabilities remain important questions. The East Asian latecomer model has been adapted to study six Chinese SOEs in the automotive, steel and machine tools sectors to assess capability levels attained and the role of external sources and internal efforts in developing them. All six enterprises demonstrate high competence in operating established technology, managing investment and making product and process improvements but differ in innovative capability. While the East Asian latecomer model in which linking, leveraging and learning explain technological capability development is relevant for the companies studied, it needs to be adapted for Chinese SOEs to take account of types of external links and leverage of enterprises, the role of government, enterprise level management motives and means of financing development.

Keywords: Chinese manufacturing, latecomer strategies, capability development.

1. Introduction

China’s share of world manufacturing output was almost 19 per cent in 2010 (calculated from UN Statistics Division (undated) data). With this share, China inched ahead of the USA to become the world’s largest producer of manufactured goods. There is apparently contradictory evidence on the technological capability of the manufacturing sector in China. The sector 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, notably in the high-tech sectors of telecommunication equipment and automatic data processing equipment and medium-tech sectors such as office machines and electric machinery (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. Based on conventional statistical evidence, China's proportion of high-tech exports is now higher than that of the EU according to Meri (2009). However, Yuqing Xing (2011) demonstrates that conventional statistics overstate Chinese high-tech capabilities since export data show the whole value of exports of high-tech sectors but the actual value added in China is relatively low and derived from relatively low-tech assembly operations. Further, much of the high-tech production is within foreign enterprises.

Therefore, important questions remain about: (a) how Chinese manufacturing enterprises attain and improve their capabilities, and (b) the levels of capabilities attained by them. A number of authors including Cho *et al.* (1998), Mathews (2001, 2002) and Hobday (1995) identify patterns of technological catch-up in other East Asian countries, notably Korea and Taiwan, which started from manufacturing competence acquired from low-tech labour intensive sub-contracting and progressed to imitation, adaptation and innovation by combining externally acquired know-how, reverse engineering, internal learning and innovation. While export-oriented sectors in China appear to 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 state owned enterprises (SOEs) engaged in manufacturing in China.

Following the initiation of the Open Door policy, China encouraged acquisition of foreign technology and know-how by SOEs through a range of channels including purchasing foreign equipment, licensing, collaborative agreements such as co-production and foreign investment in joint ventures with Chinese enterprises. More recently, some Chinese manufacturing enterprises have been acquiring foreign firms at least partly to gain access to strategic assets including technical knowledge (Xiaobo Wu and Wanling Ding, 2009; Li et al, 2012). As Mathews (2001, 2002, 2006) and Kim (1997, 1998) 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). Mathews (2002, 2006) highlights the importance of the three Ls, linkage, leverage and learning to explain latecomer strategies for acquiring key resources for attaining competitiveness, especially of enterprises in rapidly changing technologies. This conceptual framework and its relationship with the resource based view (RBV) and dynamic capabilities are developed further and applied in the next section.

While the development of advanced capabilities is evident in Chinese companies such as Konka, TCL, Haier, Huawei and Lenovo in more fast moving technology sectors (for example, see Teagarden and Dong Hong Cai, 2008; Yadong Luo and Tung, 2007), it is the manufacturing SOEs in mature sectors which face greater challenges in improving their capabilities and 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 issues investigated and study approach

In our initial studies in the 1990s, the focus was on the nature, motivations, effectiveness and value of international technology transfer between enterprises from industrialised countries and Chinese enterprises (for example, see Bennett et al, 1997, 1999 and 2001). Mathews (2002) observes that technology transfer is focused on the technology suppliers' perspective. This was not entirely the case in our studies which demonstrated that effective technology transfer required: (a) collaboration over a period of time; (b) that both the parties had the incentive to participate; (c) that Chinese recipients had the absorptive capacity (related to existing resources and capabilities and learning effectiveness), and (c) that the policy environment was conducive for technology transfer.

Since 2000 our research focus has shifted towards understanding the process of capability development of Chinese enterprises as latecomers. We have taken 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).

We briefly introduce here the adapted and extended East Asian latecomer model which has been used to appraise the technological capability attainment of the case study companies. The starting point is Mathews's (2002) observation that while the RBV paradigm is important for understanding the key distinctive and difficult to imitate resources on which firms rely to develop and preserve their competitive advantages, it does not explain how an enterprise, notably a latecomer, comes to acquire the key resources in the first place. According to Dierickx and Cool (1989), the ownership of key distinctive resources on which competitive advantage is based could be a matter of "luck" or some other non-rational process and not amenable to analysis. While the Dierickx and Cool position is entirely defensible if the focus is on understanding the nature of competitive advantage and how firms prolong it, it is inadequate for explaining how resource poor firms go about "acquiring resources, as a rational and calculated act" (Mathews, 2002, *p476*) to secure competitive positions in highly contested markets.

Mathews distinguishes between latecomer firms which do not possess the resources and capabilities and to compete with incumbents, and established followers who may have requisite resources and capabilities but prefer to enter a market later. Mathews then argues that East Asian latecomers have pursued a strategy of capturing resources which were then internalized and turned into dynamic capabilities which Teece *et al.* (1997) defines as 'the ability to integrate, build, and reconfigure internal and external competencies to address rapidly-changing environments'.

The gaining of dynamic capabilities for latecomers required a repeated sequence of *linking* with firms which have some knowhow to offer through *leverage* (some advantage that the latecomer firm offers) and internal *learning* processes using knowhow leveraged from links and from other sources to progress from lower level technologies to higher levels (the 3 Ls or LLL in Mathews, 2006). The repeated sequence to progress is necessary because typically it is easier to leverage lower level technology than more advanced. Further, the capability to use and adapt technology at the early stages may also be lower. We refer to this process as the *inverted RBV process* and use it as a basis for our case study investigations. It is *inverted* because it purports to explain the process of acquisition of key resources while the RBV takes them for granted. In this sense, the inverted RBV process could also be seen as a process of gaining and strengthening dynamic capabilities in the specific context of catching up by latecomers.

Mathews specifically refers to contracting to assemble based on the leverage of low labour costs as the initial step in this process in some countries though Mathews (2001) identifies three models for leveraging the development of capability, the South Korean model focused on large domestic firms, the Taiwan model under which public agencies acquired new technologies, developed product and process expertise and diffused the technology to enterprises and the FDI model followed by Singapore. Mathews (2001) recognises some features of all three models in China.

While Mathews (2001, 2002, 2006) demonstrate how the inverted RBV process, incorporating the 3 Ls, has been used to develop and combine different technologies and progressing to higher levels, it is less specific on the details on the levels and types of capabilities for a particular technology (though this is implied in starting from sub-contracting or low-tech production, imitation and innovation). In our study, we look at different stages of capability and levels of attainment at each stage as described below (see Table 1). Another difference is that the focus in the earlier studies (e.g. Cho *et al.*, 1998; Hobday, 1995; Kim, 1997) was on high-tech sectors with rapidly changing technologies while the focus in our study is on more mature stable technology sectors.

Further, Mathews (2002) does not include the supportive role of the state for latecomers and nature of the relationship between the state and latecomers which are emphasised in by, for example, Amsden (1988 and 1989) and Wade (1990) for Korea and Taiwan as latecomers. For the capability development of Chinese SOEs, the role of the state is significant. In addition, given the Chinese government's policy after the open door of encouraging technology foreign technology acquisition through different channels, there are likely to be different types of linkages of SOEs with foreign enterprises with implications for leverage and learning and the effectiveness of the latecomer strategy.

As noted earlier, our approach is longitudinal case studies over some twenty years. In addition to the information collected during the 1990s, 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).

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. Figuereido (2010) uses a classification of capability stages (from basic production to world leading innovation) with some similarities with our approach to examine innovation capability accumulation of latecomer firms in the Brazilian forestry, pulp and paper industries. Our 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).

Table 1: Capability stages and levels of attainment

	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.

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 (for example, see Tang, 2012 on the auto sector, Yu and Yang, 2010 on the steel sector and Long Nanyao, 2011 on the machine tools sector). 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 case 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. Nevertheless Tianjin FAW Xiali does appear to have a strong product development programme with its own R&D and development activities supported by the parent company, FAW.

4. Conclusions and future work

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 though their learning from JVs is limited as noted below.

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. Arguably, Stages 1 to 3 are necessary but not sufficient conditions for developing high levels of innovative capabilities for mature sectors. They may be less important for sectors with short product life cycles or disruptive technologies. Therefore, an important question is the ingredients in addition to stages 1 to 3 learning required for innovation capability.

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

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 3: Case study companies: Assessment of capability development

	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.

The repeated sequences of linking, leverage and learning in the inverted RBV process which Mathews put forward as the process of developing key resources and capabilities by latecomers appears to be relevant for the case study companies. However, to complement the 3 Ls of Mathews (2006), we propose 2 Ms, ***money*** (to represent access to financial resources) and ***motivation*** (to reflect what drives SOEs to develop their capabilities, especially innovation). ***Money***, the financial resources required for capability development may be generated by the enterprise, borrowed commercially or provided by the state either directly or through banks at subsidised rates or otherwise. ***Motivation*** is more complex and includes government objectives at the national and local levels and enterprise level objectives which may be pecuniary or government approval or recognition which may bring added advantages to the enterprises and their managers.

The most important leverage for the case study companies are the access they offer to the Chinese market or finance and policy support for purchasing technology. Market access has been instrumental in developing JVs and other collaborations with foreign firms (e.g. BAIC, Tianjin FAW Xiali, BYJC Machine Tools Co and Tianjin Pipe, the last in collaborating with an equipment supplier). Examples of purchasing knowhow are BAIC for SAAB technology, Tianjin FAW Xiali for earlier purchase of Daihatsu / Toyota technology, the purchase of advanced foreign machinery by Tianjin Tianduan and Shougang and the purchase of Waldrich Coburg by BYJC.

BAIC's JVs and BYJC's earliest JV have had limited technological capability development impact on the Chinese companies beyond demonstration effects at a general level and in management practices. However, the cash generation and profitability of the JVs (***money***) has enabled the firms to engage in capability development by other means since different types of linkage and leverage have not been mutually exclusive. The learning has been facilitated by linkage and leverage and the 2 Ms, ***money*** to finance learning and R&D and ***motivation*** in the form of national and local government strategies for the sector and promotion of R&D, for example by linking recognised sectoral research centres to enterprises (e.g. for Tianjin Tianduan and TPCO).

Most of the enterprises appear to have expanded their production and sales profitably over the period and have therefore demonstrated capacity to contribute financially to their learning efforts. However, some enterprises such as TPCO, although highly successful in process and product development have a heavy debt burden and therefore are reliant on policy level motivation for financial support in the form of low interest loans and low returns to shareholders. At the enterprise level, important motivation is to operate profitably. However, an additional form of motivation is managerial (for example, see Williamson, 1974) under which it is in the interest of the managers of SOEs to be in charge of larger and more diversified enterprises. The objectives of SOE managers will also be influenced by government objectives and policies on sector restructuring, profitable operation and innovation. For example, if government policy is to rationalise a sector by reducing the number of enterprises, managers will pursue a strategy of expansion to be among the larger enterprises. If government policy focus is on innovation and enterprises engaged in innovation are favoured, this will influence enterprise level decisions.

The general findings in this study require more detailed micro-level investigations to understand the nature and relative importance of the 3 Ls and 2 Ms in the capability development processes and the associated accumulation of skills. More specifically we need to develop and test hypotheses on the relationship between manufacturing and innovative capabilities, the role of skills and human capital in innovation, the relative importance of enterprise level and policy level motivation in innovation, the interaction between internal innovation activities and external influences and learning and innovation models adopted by the enterprises.

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References

Amsden, A.H. (1988). Private enterprise: the issue of business-government control, *Columbia Journal of World Business (continued as Journal of World Business)*, 21/1, 37-51.

Amsden, A.H. (1989) *Asia's Next Giant*: *South Korea and Late Industrialisation*. New York: Oxford University Press.

Bennett, D. J. and Vaidya, K. G. 2005. Meeting technology needs of enterprises for national competitiveness. *International Journal of Technology Management,* 32 / 1/2, 112-153.

Bennett, D. J., Zhao, H., Vaidya, K. G. and Wang X. M. (1997). Transferring manufacturing technology to China: Supplier perceptions and acquirer expectations, *Integrated Manufacturing Systems: The International Journal of Manufacturing Technology Management*, 8/5, 283-291.

Bennett, D. J., Vaidya, K. G. and Zhao. H. (1999). Valuing machine tool technology transferred to China: Relating value to product attributes and customer preferences", *International Journal of Operations and Production Management*, 19/ 5/6, 491-514.

Bennett, D. J., Liu, X., Parker, D., Steward, H. F. and Vaidya. K. G. (2001). Technology transfer to China: A study of strategy in 20 EU industrial companies, *International Journal of Technology Management*, 21/ 1/2, 151-181.

Cho, D. S., Kim, D. J. and Rhee, D. K. (1998). Latecomer strategies: Evidence from the semiconductor industry in Japan and Korea, *Organization Science*, 9/4, 489-506.

Dierickx, I. and Cool, K. (1989). Asset stock accumulation and the sustainability of competitive advantage, *Management Science* 35, 1504–1511.

Figueiredo, P. N. (2010). Discontinuous innovation capability accumulation in latecomer natural resource-processing firms, *Technological Forecasting & Social Change*, 77, 1090–1108.

Gao, X, Zhang, P. and Liu, X. 2007. Competing with MNEs: developing manufacturing capabilities or innovation capabilities, *Journal of Technology Transfer,* 32, 87–107.

Gao, X. (2011). Effective strategies to catch up in the era of globalization: Experiences of local Chinese telecom equipment firms, *Research - Technology Management,* 54, 42-49.

Hobday, M. (1995). East Asian Latecomer Firms: Learning the Technology of Electronics, *World Development,* 23/7, 1171–1193.

Kim, L. (1997). The dynamics of Samsung's technological learning in semiconductors, *California Management Review* 39, 86-100.

Kim, L. (1998). Crisis Construction and Organizational Learning: Capability Building in Catching-up at Hyundai Motor, *Organization Science*, 9/4, 506-22.

Lall, S. and Albaladejo, M. (2004). China's competitive performance: A threat to East Asian manufactured exports? *World Development,* 32, 1441–1466.

Li, Jing, Li, Yong and Shapiro, D., (2012) Knowledge Seeking and Outward FDI of Emerging Market Firms: The Moderating Effect of Inward FDI, April 26. Retrieved July 15, 2012, from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2046753

Long Nanyao (2011) Chinese Machine Tool Producers: A Long and Slow March Ahead November 10, InterChina Consulting, Retrieved March 22, 2012, from

http://www.interchinaconsulting.com/files/chinese_machine_tool_producers.pdf
Mathews, J. A. (2001). National systems of economic learning: The case of technology diffusion management in East Asia, *International Journal of Technology Management* 22/ 5/6, 455-479.
Mathews, J. A. (2002). Competitive Advantages of the Latecomer Firm: A Resource-Based Account of Industrial Catch-Up Strategies, *Asia Pacific Journal of Management,* 19, 467–488.
Mathews, J. A. 2006. Dragon multinationals: New players in 21st century globalization. *Asia Pacific Journal of Management* 23:5–27.
Meri, T. (2009). "China passes the EU in high-tech exports," Science and Technology, Eurostat Statistics in focus. Retrieved August 15, 2012, from
http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-SF-09-025/EN/KS-SF-09-025-EN.PDF
Nolan, P. (2001) *China and the global business revolution.* Basingstoke and New York: Palgrave.
Nolan, P. and Yeung, G. (2001). Big business with Chinese characteristics: Two paths to growth of the firm in China under reform. *Cambridge Journal of Economics* 25:443-465.
Tang R (2012) China's Auto Sector Development and Policies: Issues and Implications.
June 25, Congressional Research Service 7-5700, R40924. Retrieved August 15, 2012, from http://www.hsdl.org/?view&did=718658
Teagarden, M.B. and Dong Hong Cai (2008). Learning from Dragons who are Learning from Us: Developmental Lessons from China's Global Companies. *Organizational Dynamics,* 38/1, 73–81.
Teece, D.J., G. Pisano, and A. Shuen. (1997). Dynamic Capabilities and Strategic Management." *Strategic Management Journal,* 18, 509–534.
United Nations Statistics Division. (Undated). National Accounts Main Aggregates Database. Retrieved June 25, 2012, from http://unstats.un.org/unsd/snaama/dnlList.asp
Vaidya, K. G., Bennett, D.J. and Xiaming Liu. (2007). Is China's manufacturing sector becoming more high-tech? Evidence on shifts in comparative advantage, 1987-2005. *Journal of Manufacturing Technology Management,* 18/8, 1000-1021.
Wade, R. (1990) *Governing the Market*. New Jersey: Princeton University Press.
Williamson, O. (1974) *Economics of Discretionary Behaviour: Managerial Objectives in a Theory of the Firm.* London: Kershaw Publishing.
Xiaobo Wu and Wanling Ding (2009). Chinese Firms' Internationalization Paths by Strategic Asset-seeking Outward Foreign Direct Investment, *Portland International Conference on Management of Engineering & Technology (PICMET),* 2-6 August.
Yadong Luo and Tung, R.L. (2007). International expansion of emerging market enterprises: A springboard perspective, *Journal of International Business Studies,* 38, 481–498.
Yi-min Lin and Tian Zhu. (2000). *Ownership reform and corporate governance: The case of China's state-owned enterprises.* Retrieved July 10, 2012, from
http://147.46.167.195/~ecores/activity/00sympo/ownership.pdf
Yu Hong and Yang Mu (2010). *China's Steel Industry: An Update, EAI Background Brief No. 501,* East Asian Institute, National University of Singapore, 14th January. Retrieved August 15, 2012, from http://www.eai.nus.edu.sg/BB501.pdf
Yuqing Xing (2011). *China's High-tech Exports: Myth and Reality.* GRIPS Discussion Paper 11-05. National Graduate Institute for Policy Studies. Japan, June. Retrieved July 10, 2012, from http://r-center.grips.ac.jp/gallery/docs/11-05.pdf