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The Fight for the Middle: Upgrading, Competition, and Industrial Development in China

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Abstract

When China acceded to WTO in 2001, there were fears that Chinese firms would lose market share in key sectors to foreign-invested enterprises (FIEs). Although aggregate data often indicate a shift in favour of FIEs, indigenous firms in many cases have slowly increased market share and deepened their technical capabilities. Through an analysis of aggregate data and three sectors, we show how the dynamics of competition between Chinese and FIEs in China's domestic market enhance the upgrading prospects for Chinese firms. China represents a new model of development in several important respects: industrial upgrading efforts are often domestically-driven, within this domestic market there is intense competition between both domestic and foreign firms, and this competition is driving and stimulating the upgrading efforts of domestic firms.

Key Words

China, industrialization, FDI, upgrading, emerging markets, automotive

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China represents a new model of development in several important respects: industrial upgrading efforts are often domestically-driven, within this domestic market there is intense competition between both domestic and foreign firms, and this competition is driving and stimulating the upgrading efforts of domestic firms.

Although exports have been critical to China's growth, a key dimension of the upgrading process lies in the interaction between domestic firms and foreign-invested enterprises (FIEs) that are largely competing in China's domestic market, a market that for some key sectors has grown four to five folds in the last decade. Unlike smaller developing countries, the huge size of the Chinese market has provided ample room for entry and expansion in many sectors without the need for domestic firms to immediately launch themselves into global markets. Unlike countries that exploited large and protected markets before shifting outward, China has been much more open to foreign direct investment (FDI) and become tightly integrated with the global economy. Within the domestic Chinese market, intense competition—a product of the lower tariff barriers and entry by both foreign-invested and domestic firms leading up to and following China's accession to the World Trade Organization (WTO)—has raised the threshold level of capability that domestic firms must achieve in order to survive and has forced foreign firms to localize activities in order to cut costs. This competitive pressure expands and deepens the channels through which Chinese firms can build and upgrade their capabilities.

Industrial upgrading was not a widely anticipated outcome of WTO accession. During the first two decades of the reform period, China's central government struggled to tilt the terms of competition within the domestic marketplace in favor of indigenous Chinese firms. High tariff barriers shielded the market from global competition; foreign firms that sought access to the domestic market were pushed to transfer technology to Chinese partners, and strict domestic content requirements were the norm in many sectors. When China finally acceded to the World Trade Organization (WTO) in 2001, some policymakers in Beijing feared that liberalization was happening too quickly. Chinese firms were not yet prepared for the rigors of

global competition and the critics of the accession agreement feared that as tariff barriers fell, domestic Chinese firms would rapidly lose market share to their global competitors.

In this paper we argue that the worst of these initial fears were not realized. Following entry into WTO, market competition increased significantly, and overall, Chinese firms lost market share. However, indigenous firms gained market share in many sectors, and even where they lost, they have often deepened their capabilities in the course of making the transition into higher value-added parts of the value chain. We provide evidence of this success, and offer an explanation for it.

The argument is at three levels—the aggregate level of the entire Chinese domestic market, the level of individual sectors, and the value chains within these sectors—and the type of data we utilize varies by level. As a first step, we analyze estimates for the entire Chinese domestic market constructed on the basis of data from China's industrial census and trade statistics in order to assess trends in the relative market share of domestic firms, FIEs, and imports over time.[1] The aggregate data indicate an increase in the market share of foreign firms over the period spanning China's WTO accession. There are many sectors where domestic firms increased market share, but in the aggregate, these gains are offset by those sectors in which domestic firms lost ground.

In a second step, we analyze data for three sectors in which it appears that domestic firms lost market share after WTO accession—presumably the hard cases to show evidence of domestic upgrading—and argue that the aggregate data mask significant upgrading within the sectors. When these sectors are broken down by market segment, analysis at the OEM (original equipment manufacturer) level, i.e. firms producing final products, makes clear that domestic firms dominate at the low-end of the market, where consumers are relatively indifferent to quality and firms compete on the basis of price, and foreign firms dominate at the high-end, where consumers are less sensitive to price and quality is critical. Moreover, significant barriers to entry prevent each from easily encroaching on the share of the other: domestic firms rarely have the deep know-how to design, manufacture and market products to compete with foreign firms in the high-end and foreign firms are rarely able to meet the price points demanded by consumers in the low-end of the market. We provide evidence, however, that domestic firms

are increasingly capable of competing with foreign firms for the middle of the market, which is becoming the largest and most rapidly growing segment within these industrial sectors.

It is the fight for the middle that deepens the channels of upgrading for domestic firms in China: domestic firms strive to upgrade their product through improvement in design and manufacturing methods in order to escape the intense competition at the bottom while foreign firms seek to decrease costs in order to capture the rapidly growing market segments in the middle. The supply chain plays a central role. The cost-cutting efforts of foreign assembly firms lead them to localize their operations more aggressively than would otherwise be the case, and their localization efforts provide a new range of upgrading opportunities for Chinese supply firms. The upgrading efforts of domestic assembly firms lead them to seek out the most capable domestic suppliers in order to draw upon the combination of low-cost and strong manufacturing capabilities. Although we do not have systematic evidence of this dynamic (i.e. a comprehensive sector-wide benchmarking study), we supplement data from industrial yearbooks and other sources with information that was collected during extensive visits with leading firms (both assemblers and suppliers) in each of the three sectors. This allows us to provide illustrative examples of the localization and upgrading dynamics of key components in each sector.

In the first section of the paper we place our argument in the context of two of the dominant approaches to industrial upgrading in East Asia. In the second section we analyze the dynamics of competition in the Chinese domestic market at an aggregate level and explain why a more fine-grained analysis is necessary. Each subsequent section analyzes a particular market segment, namely, the bottom, the top, and the middle.

1. FROM EXPORT-LED GROWTH TO DOMESTIC-LED UPGRADING

An outward orientation has been a crucial element of the East Asia developmental model, and the primary theoretical frameworks for understanding industrial upgrading have focused on how governments and firms prepare for competition in global markets.

One of the most influential frameworks is that of the developmental state. As Alexander Gerschenkron argued in his classic study of late 19th century industrial development in Germany, the institutions of the state must assist industries that are technology and capital intensive in their efforts to acquire the most advanced technology (1962: 83). The most influential explanations of rapid growth in East Asia follow closely from Gerschenkron's logic.[2] Japan (Johnson 1982) and Korea (Amsden 1989; Kohli 2004) provide classic examples of an elite and coherent bureaucracy working closely with private business to formulate and implement a strategic development policy. Large business groups were granted protection and preferential access to capital by the state, which they leveraged in the domestic market to build capabilities, diversify into a broad range of industrial capabilities, and prepare for an outward push into global markets. Within the domestic markets there was competition, but it was overwhelmingly between domestic firms: FDI was limited and the preferred means of acquiring foreign technology was through licensing agreements and technical cooperation agreements.[3] Scale and scope were critical to this model. They translated into cost savings (due to fuller capacity utilization and lower sourcing costs), allowed for more learning-by-doing, and made it possible to spread the fixed cost of design and manufacturing over larger output volumes (Amsden and Chu 2003: 7). From a conceptual perspective a developmental state did not have to transition from domestic to export-led growth, however an export push on the part of national firms allowed for higher volumes, particularly for relatively small economies such as Korea and Taiwan, and allowed the government bureaucracy to evaluate the success of sectoral interventions according to export performance (World Bank 1993: 22-23; Woo-Cumings 1999: 12).

It is not our objective to outline in detail the manner in which China does and does not follow in the tradition of a developmental state; suffice it to say that there are elements of both. The critical difference from our perspective, however, is that China combines both a very large domestic market with a high level of FDI that is focused on this domestic market. There have been large domestic markets in the past (Japan) and there been states that have relied on FDI (Singapore, and to a lesser extent Taiwan), but the combination of the two has been rare. Foreign firms investing in China face a variety of restrictions, and in some sectors they are

more severe than others, but the high level of FDI means that even when a certain industry benefits from a relatively low level of import competition, the domestic firms in the industry must face significant competition from foreign firms that are operating in China. Indeed, some scholars have argued that the system is systematically biased in favor of foreign firms (Huang 2003).[4] Although many foreign firms in China are engaged in export processing, a majority of FDI is focused on the domestic market. In addition to the competition fostered by FDI, China is far more open than its neighbors were at comparable levels of development. This is particularly true after WTO accession, but according to Branstetter and Lardy (2008: 635), even prior to WTO accession the height of formal tariff barriers was sometimes deceptive.[5]

The high levels of FDI in China point to a larger trend: the globalization of production. Although there is nothing new about international production, the degree of fragmentation between firms within a value chain and across national borders has increased as a result of the liberalization of trading regimes, reductions in transport and communication costs, and the ability to codify design information in digital form. One indication of this trend is the growth of trade in intermediate goods rather than finished goods. In the world of a developmental state, government and business leaders attempt to use industrial policy to support the development of integrated product manufacturers; in a world of global production, "the mosaic of specialization and intermediate goods flows that make up distributed production systems and global value chains (GVCs) means that domestic capabilities and development cannot easily be … linked to domestic sources (Whittaker, Zhu, Sturgeon et al. forthcoming: 11)." The challenge is to control the parts of the value chain that are most profitable and maximize the benefits of participating in global production chains.

A second theoretical approach to industrial upgrading analyzes how participation in GVCs facilitates industrial upgrading among exporting firms in a developing economy, and has provided crucial insights into how the form of interaction with the global economy shapes the range of possibilities for developing countries (Bair 2005: 156). One of the core hypotheses of the value chain literature is that participation in GVCs creates the potential for industrial upgrading because knowledge flows through the chain (Humphrey and Schmitz 2002: 1020). Scholars take a variety of views on how large the potential for upgrading actually is (Gereffi

1999; Humphrey and Schmitz 2002).[6] The assumption in all cases, however, is that global markets are the objective, and this assumption skews the playing field to the advantage of global firms in either buyer-driven or producer-driven chains. In a buyer-driven chain, the core competencies of lead firms are marketing, sales, and retail. Firms in developing countries understand local markets best, and an export-oriented firm from a developing country is naturally going to find it difficult to develop brands for a foreign market. In a producer-driven chain, the core competencies of lead firms are technology and design, and firms from developing countries are generally weak in both. As Steinfeld (2004) has argued, Chinese firms are extensively involved in production for overseas markets but they are stuck in commodity manufacturing and undifferentiated activities that have low-value added.

This brings us to the central question of this paper: what if the primary markets are domestic rather than foreign? Within the value chain literature, there are scholars who have emphasized the benefits of focusing on multiple markets and participating in multiple value chains ((Lee and Chen 2000; Bazan and Navas-Aleman 2004; Navas-Aleman and Bazan 2005). Because the organization of the chains varies widely, each offers different opportunities for domestic firms. A focus on domestic markets leads manufacturing firms to broaden the scope of their activities (i.e. functional upgrading) into design, marketing, and branding. This may be because they have a better understanding of home markets than foreign markets, or it may be because domestic customers are not as powerful or concentrated as their counterparts in global value chains. Participation in multiple value chains provides the possibility of "leveraging competencies": different value chains create different possibilities for learning, and what is learned in one value chain can be applied in others (Lee and Chen 2000).

Our focus has similarities with this research, but there are important differences. The most important is the scale of the Chinese market, and the extent to which it becomes a focus not only for domestic Chinese firms, but also for multinational firms. It is not simply that Chinese firms are able to focus on the domestic market (in addition to their participation in global value chains); it is that foreign firms are doing the same. If the competitive playing field is tilted in favour of multinational firms when the market focus is advanced economies, perhaps the playing field tilts back to a level position when the focus is a developing economy. Both

the domestic and the foreign firms face their challenges—domestic firms struggle to upgrade their product through design and quality improvements in order to escape the intense competition at the low-end of the market, and foreign firms struggle to decrease costs (without sacrificing quality to the extent that the company brand is damaged) in order to capture the rapidly growing market segments in the middle of the market—and the interaction of these two dynamics gives rise to a new set of opportunities and challenges for a firm that is seeking to upgrade. The result is quite different from the dynamic described by either the developmental state literature or the global value chain literature.

In the business literature there is a growing awareness of the importance of the Chinese domestic market, and the manner in which Chinese firms utilize this market to hone the skills that they need to compete with multinational firms. Gadiesh, Leung, and Vestring (2007), in particular, describe the rise of the "good enough" market in China, which is essentially the mid-market segment, and provide excellent insight into the business strategy of domestic and foreign firms that are competing for this segment in China. Zeng and Williamson (2007) focus on how Chinese companies are able to operate at lower costs than their foreign competitors, and how their low-cost advantage allows them to move upmarket; an increasing number of authors analyze how the rising importance of emerging markets is shaping the the design activities and organizational structure of multinational firms (Brown and Hagel 2005; Immelt, Govindarajan and Trimble 2009). The purpose of these authors is neither to provide a systematic argument about the Chinese economy nor to explain why some Chinese sectors (and some firms within these sectors) have a greater potential for upgrading than others. They seek to describe company strategies in a key global market. Building on the insights of these works, we seek to provide a comprehensive view of market segmentation in China and a deeper understanding of why some domestic firms are better positioned to take advantage of it than others.

2. CHINA'S DOMESTIC MARKET: RAPID GROWTH, BUT WHO BENEFITS?

Since the onset of economic reform, growth in China's manufacturing sector has averaged more than 15% per annum in real terms. There is little consensus about what is

driving this growth and what types of firms are benefiting. Reflecting the rapid increase of foreign direct investment (FDI) flows into China and exports out of China, foreign firms and foreign trade often figure prominently in these discussions (Rodrik 1999). Some scholars stress the advantages that policy-makers have given to FIEs (Huang 2003) and the continued weakness of domestic firms (Steinfeld 2004). However, others emphasize the growing strength of Chinese firms (Gadiesh, Leung et al. 2007; Zeng and Williamson 2007). Surprisingly, there have been few attempts to systematically assess the relative market share of Chinese, FIEs, and imports in the China's domestic market and the trend over time.

The challenge at the aggregate (and sector) level is determining the overall size of the domestic marketplace in China, the type of firm that is filling the domestic demand (domestic firms, FIEs, or imports), and the trend over time. These questions are difficult to answer because of the need for sector-level data on manufacturing output and exports by firm ownership, in addition to sector-level data on imports. We utilize here a combination of firm-level output data from the Chinese Industrial Census in 1995 and 2004 and trade data to provide estimates at the 4-digit CIC (Chinese Industrial Classification) level of the size and growth of the domestic market.[7] The value of using the census years is that the data include all manufacturing firms in China. The domestic market is defined as total output of all firms producing in China less exports plus imports. Sales of Chinese firms and FIEs going to the domestic market, on the other hand, are their total sales less exports.

Table 1 provides a summary picture for two manufacturing census years, 1995 and 2004. In 1995, the total value of sales (domestic plus exports) of all firms manufacturing in China was 5.44 trillion RMB. Exports represented slightly more than 20%—with the bulk of the output produced by these firms sold domestically. Total sales to the domestic market from all three sources (domestic firms, FIEs, and imports) were 5.43 trillion RMB. Chinese firms captured slightly less than two-thirds of domestic demand, with imports and sales of FIEs making up the rest. Compared to the sales of FIEs that were directed to the domestic market, Chinese firms had 85.7 percent of the market.

Insert Table 1 here

As a consequence of the rapid economic growth between 1995 and 2004, the domestic market expanded to 19.36 billion. Total sales of manufacturing firms in China grew almost as rapidly to 18.52 trillion. Over this period, exports grew most rapidly, and increased as a share of total manufacturing output to 28.0 percent. But sales to the domestic market still represented 72 percent of the output of firms manufacturing in China. For foreign firms, 58 percent of sales were to the domestic market, down slightly from 63 percent in 1995. By 2004, Chinese firms had seen their share of the domestic market slip from 67.7 to 56.0 percent. Much of this loss was to FIEs, whose share of the domestic market rose from 11.3 percent of output in 1995 to 19.1 percent in 2004, an increase of seventy percent. The share of imports rose less dramatically from 21.0 to 24.9 percent. Through 2004, this evidence appears to support the argument that the Chinese market is gradually being conquered by FIEs.

We must be careful in interpreting these data. These data are only for two points in time, and thus, they may miss either a slowing down in the trend, or possibly even a reversal. We cannot replicate the estimates for 1995 and 2004 for other years, given that the census is only undertaken once every decade, but we are able to construct estimates of the respective share of domestic and foreign firms in the domestic market exclusive of the role of imports. These estimates draw on National Bureau of Statistics annual firm-level data that include all state-owned enterprises, in addition to all other firms with annual sales greater than 5 million RMB. Sales of these firms have consistently represented 90 percent of total sales of all firms manufacturing in China. These data suggest that the decline in the market share of Chinese firms was much less between 2001 and 2007 (73.7 percent to 70.1) than it was between 1995 and 2001 (79.8 to 73.9). Moreover, the market share of Chinese firms began to rise again in 2006.

Insert Figure 1 here

Aggregate figures can be misleading for two other important reasons. First, they obscure enormous heterogeneity among the more than four hundred 4-digit manufacturing

sectors. Figure 1 graphs the percentage of the domestic market captured by each of the three sources (Chinese firms, foreign firms, and imports) in these sectors in 1995. Each dot represents a complete sector. There are sectors in which Chinese firms had almost all of the market (point A), and a few sectors primarily served by either imports or FIEs (points B and C) operating in China, but as a general rule, the domestic market was served by both domestic and foreign firms.[8] As we will explain, imports typically serve the highest end of the market, followed by FIEs and then Chinese firms serving the bulk of the market. Figure 2 provides the histogram for the change in the market share of domestic firms in these sectors between 1995 and 2004. Overall, domestic Chinese firms lose market share, but there are pronounced changes in both directions.

Insert Figure 2 here

Our purpose in this paper is not to explain these differences, but there are a few things that we can say based on results (not reported here) from simple regressions of the change in market shares on product and sector characteristics in the mid-1990s. As might be expected, the sectors in which Chinese firms are doing especially well appear to be concentrated among more labor-intensive sectors in which manufacturing requirements may not have been especially high, and China was able to take advantage of its comparative advantage in low cost labor. Conversely, foreign firms were especially successful in expanding market share in those sectors in which some combination of technology, capital-intensity, manufacturing know-how, branding and marketing were more important. This should not be totally surprising in light of China's expressed policy of trading market for technology. In key sectors, import tariffs were initially set relatively high in order to encourage foreign firms to invest and build plants in China—often as part of a JV—and transfer technology and know-how in the process. Figure 3 provides representative examples of sectors in which domestic firms gained and lost market share, usually to FIEs, between 1995 and 2004.

Insert Figure 3 here

A focus on heterogeneity between sectors is useful, but even this is not fine-grained enough. A second level of detail that is necessary is heterogeneity *within* sectors. Even in sectors in which Chinese firms have seen their overall market share decline, they may still be having success in a small but possibly rising number of market segments that portends well for the future. It is also important to keep in mind that in light of the rapid growth in the size of the domestic market, a reduction in market share can still be consistent with a respectable growth in sales. This kind of heterogeneity can only be revealed by a much more in-depth examination of such sectors, one that carefully dissects market segments within these sectors.

We define market segments according to the quality and sophistication of a product (roughly following Gadiesh, Leung et al. 2007). Product quality is measured primarily in terms of reliability and durability. The measure of product sophistication varies by sector (and is not always precise), but refers to the range of functions and/or the complexity of the technology in a product. Quality and sophistication will sometimes co-vary, but not always. Figure 4 uses the construction equipment industry to illustrate the range of market segments that are possible within a sector: the highest-end segment (and the one with the most expensive products) is the box in the upper right corner and the lowest-end segment (with the least expensive products) is the box in the lower left corner. A firm is able to move into a higher-end segment by either improving the quality of a wheel-loader (a relatively unsophisticated product) or moving into a more sophisticated product range (low-end excavator). The manufacturing requirements within the segments of an industry can vary as widely as the requirements between sectors.

Insert Figure 4 here

In order to provide a more disaggregated analysis of Chinese capability building that we believe to be necessary, we have selected three sectors: construction equipment, computer numerically-controlled (CNC) machine tools, and automotive. We selected these sectors for several reasons. First, and most importantly, these are sectors where aggregate numbers would lead us to believe that Chinese firms were increasingly losing out to FIEs. Recall that Chinese

firms lost domestic market share in more than half of all sectors. Second, although our broader research agenda seeks to explain how the characteristics of a sector affect the upgrading potential for indigenous firms, in this paper we chose sectors with roughly similar characteristics. All three sectors can be described as mature and capital-intensive with relatively slow product cycles. With possibly the exception of the auto sector in Taiwan, all three sectors were important in the industrial development of Japan, Korea and Taiwan. Finally, these three sectors are quantitatively important ones within both the Chinese and the global economy. In each of these three sectors, the Chinese domestic market is either the largest or next to largest in the world.

In the bottom half of Table 1, we provide a breakdown for these sectors that is analogous to the aggregate level.[9] In 1995, the share of domestic firms was largest in construction equipment, followed by vehicles and then machine tools. Between 1995 and 2004, domestic firms in vehicles lost the most market share, followed by domestic construction firms, and then machine tools. To help put these reductions in perspective, we observe a reduction at least as great as that in vehicles in 10 percent of all sectors, and 25 percent in the case of construction. In both sectors there is a significant increase in the role of FIEs selling in China, and this increase comes largely at the expense of the share of the market captured by domestic firms. In machine tools, the expansion of the FIEs is more modest.

In short, in all three cases it appears that the position of FIEs is strengthening over time and that of domestic firms weakening, a trend that mirrors the general situation for Chinese industry. This assessment is too pessimistic, as we will see when we look at each of these sectors in more detail.

3. THE BATTLE AT THE BOTTOM

The low-end segment provides a crucial initial stepping stone for indigenous Chinese firms. Intrinsic in much of the development literature is the idea that the gap between the expectations of export markets and the capabilities of indigenous firms is too wide to bridge. Building on Hobday, for example, Hubert Schmitz (2007) argues that late-comer firms face two

primary problems when they attempt to integrate with the global economy: a "technology gap" and a "marketing gap." The technology gap is a result of being cut-off from international sources of technology (and in particular the feedback loop between users and producers that spurs innovation), the difficulty of accessing proprietary technology, and weak national and/or local support for innovation. These technologies may include the "hard" technologies that are embodied in production machinery and product designs or "soft" managements systems such as quality control or supply chain management. "The technology gap," according to Schmitz (2007: 421), "is lower in mature industries where technological requirements are well understood and change slowly." The marketing gap is a result of the difficulty a firm will have understanding and responding to rapidly changing consumer demand when it is disconnected from the market. It is exacerbated by highly concentrated retail sectors (which shifts leverage within the value chain to the buyer) and the capital intensity of developing a brand. The combination of the technology and the marketing gap creates a barrier that firms in developing countries must overcome if they are to succeed in export markets. Too wide a technology gap also prevents a firm from benefiting from absorbing the knowledge and technology spillovers that may result from FDI (Crespo and Fontoura 2007: 413).

When a developing country firm is focused on its own domestic market, the upgrading dynamic is potentially very different. In its home market, the "technology gap" confronting a local firm is smaller because lower average income levels lead a large portion of the market to prioritize price rather than technical sophistication. As a result, the technical demands of the products within the sector are within the range of domestic firm's manufacturing capabilities: the designs for mature products are more accessible (either through copying or licensing) and the manufacturing processes are not highly demanding and/or are processes with which domestic firms have more experience.[10] These products are in contrast to those that might be demanded by export markets, products that require very high levels of manufacturing capability (i.e. to achieve a certain level of quality and consistency), and designs and technologies that are proprietary. Similarly, the "marketing gap" that indigenous firms face when exporting to advanced industrial countries will largely disappear when they focus on their domestic market. There is the possibility that foreign firms with powerful brands will continue to have an

advantage, but domestic firms will be better attuned to consumer preferences. In fact, there is a strong possibility that it is a foreign firm that will face a "marketing gap" (at least initially), particularly when the developing country is only a small portion of their overall portfolio. These firms will also likely be handicapped by a weaker sales and distribution networks.

In each of the three sectors that we analyzed in China, a similar pattern is evident. First, there is a decade prior to WTO accession when domestic firms are able to master the manufacturing processes for relatively mature products in the sectors. Government support and protection is often significant during this period (although the extent varies by sector). Second, there is extremely rapid growth of the low-end segments towards the end of the 1990s, which has invited rapid entry and intense competition. Nonetheless, the low-end segments are dominated by domestic firms. Third, despite overall fragmentation and continued competition for the low-end of the market, leading firms take advantage of their success in low-end segments to increase scale.

(a) Automotive

Until the end of the 1990s, competition in the Chinese auto sector was leisurely and the degree of segmentation in the market was limited. Efforts to develop capabilities in passenger vehicles focused on joint ventures (JVs) with foreign firms during the 1980s and most of the 1990s, and the market consisted of institutional customers (i.e. state-owned enterprises and agencies).[11] Despite pressure from the Chinese government, few of the foreign partners in the JVs were willing to bring their most recent technology to China. Volkswagen was the market leader, and by the mid-1990s it controlled over 50% of the market with a model based on 1970s technology. In many respects, this was exactly what domestic firms needed: the capabilities that were being developed throughout the supply base as a result of government localization requirements were in line with the initial level of the manufacturing capabilities of Chinese firms and the slow rate of product change gave them the time to master the required manufacturing processes. The primary complaint of the central government was that there were few independent domestic brands that could compete with the foreign-invested joint ventures

products. By the late 1990s, slightly more than half a million passenger cars were being produced in China and five out of six of these were being produced by FIEs.[12]

The characteristics of the market changed rapidly at the end of the 1990s. First, tariffs for small vehicles (1.6 liters or less) decreased from 80% in 1998 to 25% in 2006, and from an even higher base for larger cars. Tariffs on parts and components were always lower, but they too fell from 20-25% to an average of 10% in 2006. Second, tariff reduction was complemented by enormous capacity expansion in the industry, both in the form of new entry from foreign multinationals and domestic firms, and also expansion by incumbents. By 2007, capacity in passenger vehicles was more than 9 million units, and nearly 7 million cars were assembled in China. Third, the domestic market shifted from one that was dominated by institutional buyers, who were relatively insensitive to price (and often had a politically-motivated regional bias), to one that is dominated by individual buyers who are extremely sensitive to price and value. The result of these changes was intense competition within the sector. As we will show below, prices decreased dramatically at the same time that car quality improved.

Insert Figure 5 here

A far more segmented market began to develop after the late-1990s. In Figure 5, we provide a breakdown of production by six market segments for the FIEs and Chinese firms for 2000 and 2006.[13] In the Chinese auto market, quality and sophistication of products tend to co-vary with size—small and mini cars tend to be of lower quality—and we measure size according to engine displacement.[14] In 2000, the largest market segment was upper medium, to which only JVs sold cars. Included in this market segment were vehicles such as the VW Santana, Audi A4, GM Buick, etc. With the exception of a small amount of production aimed for the luxury market, Chinese car manufacturers were heavily concentrated in the production of small or mini cars, in which they had most of the market. By 2006, the center of gravity in the Chinese market had clearly shifted to less expensive cars. The fastest growth was in the lower-medium segment, in which car production totaled 1.25 million vehicles. Small car production

was just shy of a million units. Combined, these two segments represented half of all production, up from slightly less than a third in 2000. And in both of these segments, Chinese firms did well in face of significant competition and entry of new models from the JVs.

Insert Figure 6 here

Figure 6 provides a summary of the number of new models that were introduced by car segment. Although Chinese OEMs lost share in the small car market as models such as the GM Sail and Honda Fit were successfully introduced, these firms increased their share in the lower-medium market. In two car segments catering to higher-income buyers, namely, SUVs and minivans, Chinese firms also did well, but quantitatively, it was their success in the lower-medium market that explains their rising market share over this period.

Insert Figure 6

By 2007, the domestic market share of Chinese auto manufacturers in terms of units sold had increased to 30.3 percent, and firms such as BYD, Chery, and Geely were dominating the low-end of the market. A common explanation of this success emphasizes IPR violations, but this was only part of the story. Independent domestic firms were more flexible because, unlike the foreign firms, they were not selling products that were designed for developed (and high-cost) markets. Their primary focus was the Chinese marketplace and this created several advantages over foreign competitors. First, the domestic firms did not have to seek the approval of a global headquarters to certify new suppliers or launch new models, and when market demand shifted, they were able to respond quickly. Second, because their products were designed specifically for the low-end of the domestic market, the designs were based on a "good-enough" standard, which allowed them to increase the use of low-cost suppliers (as opposed to the global suppliers that supported the JVs). Figure 7 contrasts the sourcing patterns of a sample of foreign and domestic OEMs for their most popular models.

Insert Figure 7 here

A domestic Tier 2 supplier in Zhejiang Province that has both a JV and a wholly-owned facility manufacturing the same component provides an illustration of the relationship between quality and cost. Both the JV and the wholly-owned facility are located in the same complex, and the management is the same. The JV achieves a defect rate of 50 parts per million (ppm) compared to 300 to 500 ppm at the wholly-owned facility but has a 20% higher cost. The reason for the cost difference is that the higher quality standard requires a higher degree of automation (and hence more expensive equipment) and imported rubber seals (Interview 083007). As we will explain below, this ability of a component firm to supply both foreign and domestic OEMs is a critical reason supplier capabilities have been growing rapidly.

b. Construction equipment

The construction equipment sector includes a wide variety of products (cranes, pavers, graders, wheel loaders, dump trucks, scrapers, excavators, etc.) and we focus on two in particular: wheel loaders and excavators. In contrast to autos, product quality and sophistication do not necessarily co-vary (see Figure 4). First, there is variation in the sophistication of products. Although a wheel loader and an excavator will often perform many of the same tasks, the sophistication of the products varies widely. The engineering of the excavator is considerably more complicated. It runs on high hydraulic pressure, which makes the cylinders and the valves that control the flow within the hydraulic system critical because they are under enormous pressure during operation. The machine has to both turn and swing on the platform, and the integration of hydraulics, engine, and electronics is complex. In a wheel loader, the hydraulics that control the bucket operate at lower pressure, and this makes the valves within the hydraulics easier to manufacture; the movement of the arm is only up and down, so there is not the same need for the sophisticated electronic controls of the excavator. Second, there is quality variation within a product range. In the case of wheel loaders, for example, quarries and mines will typically demand larger and more reliable machines, as will

ports. A factory, on the other hand, will use the machine for minor utility functions and will look for the most economical model. Thus, upgrading in the sector can occur within product segments as well as between products.

Over the last ten years the sector has enjoyed explosive growth in all segments, but particularly at the low-end. The demand for wheel loaders, which grew modestly through 2000, accelerated afterwards (Table 2). Despite relatively low final tariffs, imports have been marginal in this segment, and almost all of the enormous increase in domestic demand—primarily for 3 and 5 ton wheel loaders—has been met by firms manufacturing in China (see Tables 2 and 3). These firms are almost exclusively Chinese and they are largely state-owned enterprises (SOEs). In 2006, the FIE share of the domestic wheel-loader market was only 14 percent and only one of the top five producers was not state-owned.[15]

Insert Table 2 here

Insert Table 3 here

Partly the success of domestic firms is a result of a relatively simple product technology that is well-suited to the strengths of Chinese firms. The labor intensity of fabrication and assembly, for example, confer a significant cost advantage to Chinese firms. In the machining process, an earlier generation of lathes can be used rather than computer numerically-controlled (CNC) machines; the welding can be also done manually rather than robotically. Like in the case of autos, however, the strength of domestic firms is a result of experience gained over a period of decades. As early as the 1960s, Chinese firms were using technology licensed from Japanese firms. In the 1980s, there were two primary sources of technology in the sector: the Ministry of Machinery, which licensed Caterpillar (CAT) technology for both complete vehicles and core components on behalf of core state-owned firms within the sector, and the Tianjin Heavy Machinery Research Institute, which developed its own set of designs that drew on a combination of foreign models. With the help of both CAT technical assistance and the support of the Tianjin Research Institute, firms were able to master the necessary technologies and incrementally improve on the original designs. These early designs are usually the basis for the

models that are produced today, although incremental improvements have changed them beyond recognition.

The widespread availability of designs and the familiarity with manufacturing processes offers the same advantages and disadvantages that are found at the low-end of the automotive sector. The advantage is that the slow rate of product change facilitated the development of a broad and low-cost supply base for wheel loaders. This supply base creates critical cost-savings for the OEMs, which generally out-source 60 to 70% of total costs, and is a key facet of competitive strength. The disadvantage is that the barriers to entry in the wheel loader segment are low. In 2007, there were still in upwards of 30 firms in China producing wheel-loaders—down from more than 40 a decade earlier--and in real terms prices have fallen. Despite this high level of fragmentation, however, the share of the top 4 domestic producers—Liugong, Longgong, Xiagong, and Lingong—increased from 40 percent in 1999 to 65 percent in 2007. As we will argue below, the best of these firms were able to leverage their dominance in the low-end segment into growing capabilities in higher value-added segments.

c. Machine tools

Broadly defined, a machine tool is any stationary, power-driven machine that is used to cut, shape, or form materials such as metal or wood. We focus on the dominant product within the machine tool sector, metal-cutting machines (*jinshu qiexiao jichuang)*, and distinguish between segments based on product sophistication. Manually-controlled machines are generally less sophisticated than CNC machines. Within the CNC segment, there is also a range of complexity: the low end is single-axis, single-function CNC machine tools; the mid-range are 2-axis CNC lathes and machining centers that use a single spindle; the high end are multiple-spindle, multiple axis (up to 5), multi-function, high speed and precision machine tools.[16] Metal-cutting machines represent approximately one-third of the Chinese machine tool market.

In the pre-reform era, China had an extensive machine tool industry that was dominated by SOEs. Long isolated from global markets, these firms were still producing traditional or conventional machine tools until the end of the 1970s, and it was only when research institutes

under key ministries (e.g. Beijing Machine Tool Institute and the Beijing Electrical Machinery Research Institute) and leading firms began to license and reverse engineer technology in the 1980s that CNC machines began to be produced. As was the case in autos and wheel-loaders, low barriers to entry led to a highly fragmented sector. In the mid-1990s, there were upwards of 100 SOEs producing various kinds of CNC metal-cutting machine tools, but total production volumes remained low at less than 10,000 units, and no one firm was producing more than several hundred machines.

Domestic demand for metal-cutting machine tools increased rapidly between 1997 and 2006, with the acceleration in demand particularly intense after China's entry into the WTO. Total expenditure on metal cutting machine tools rose from US $1.38 billion in 1997 to US $7 billion in 2006, and in the CNC segment from US$0.22 billion to 2.74 billion. By 2002, China was the largest machine tool market in the world. In quantity terms demand for CNC machine tools increased from 15,200 units in 1997 to 107,482 by 2006, a seven-fold increase (Table 4).

Insert Table 4

This growth in demand was especially pronounced in the lower-end segments, and much of this demand was served by domestic firms. Domestic production increased from 9,051 units in 1997 to 85,756 units in 2006, most of which was for the domestic market rather than exports. These figures include production by both indigenous firms and FIEs, and the data do not separate the two. The trends in the sector appear to be very similar to what we observed in autos and construction, however: Despite significant entry by FIEs producing in China (initially through JVs and increasingly through wholly-owned ventures), the domestic firms continue to hold much of the domestic market captured by firms actually producing in China, particularly for less sophisticated products.

CNC lathes, which are half of the overall CNC market, are illustrative. By 2006, there were more than 50 Chinese firms producing 40,000 CNC lathes, 80 percent of which were classified as economical. Overall, Chinese firms succeeded in raising their share of the domestic lathe market from 70 percent by volume (42 percent by value) in 2001 to 81 percent (60 percent

by value) in 2005 (China Machine Tool Industry Association 2007: 220). Shenyang Machine Tool and Dalian Machine Tool, with production volumes of 13,457 and 4,694, respectively, clearly dominated, but five other domestic firms achieved production volumes of 2000 or more. Clearly, domestic Chinese firms are establishing a dominant position in the less technically sophisticated product areas of the sector.

Several factors contributed to the dominance of domestic firms at the low-end. First, new entrants to the sector increased the degree of competition. SOEs continue to dominate the market, but their numbers have fallen slightly as a result of bankruptcy and M&A activity. Private firms are increasingly building upon the foundation that was established by the state sector: they take advantage of the widely-available designs for the basic class of CNC machine, they tap into the pool of expertise in CNC design and manufacturing that was nurtured by key research institutes and SOEs, and they utilize a well-developed domestic supply base for critical parts and components that has emerged.

The growing depth of the supply base is the second key advantage of domestic firms at the low-end. Again, out-sourced critical components represent approximately 70% of the cost of the final product, and localization of the supply chain offered a key cost advantage for indigenous firms. Initially, Chinese firms were forced to import many of these components—e.g. the spindle, bearings, ball screws, motors, and numerical controls—usually from the firm that licensed the original product technology (or one of its suppliers), but over time there has been nearly complete localization at the first-tier of the supply chain, especially for the economical CNC machine .[17] GSK in the case of numerical controls and Han River Machine Tool in the case of ballscrews are two prominent examples. Although the system and components produced by these two firms are not to the levels of the foreign firms, they allow domestic CNC manufacturers to achieve a level of precision and functionality that meets the demands of Chinese customers. Common machine design means that Chinese manufacturers are often buying nearly identical components from the same set of suppliers.[18]

4. Pressure at the Top

Multinational firms enjoy a privileged place in China's economic landscape. According to the research of Pankaj Ghemewat and Thomas Hout (Ghemawat and Hout 2008), multinational firms are the market leaders in China in every industry (with the exception of telecom network equipment) in which the ratio of R&D intensity to sales and/or the ratio of advertising to sales is greater than 8%. This includes packaged software, mobile phones, modern pharmaceuticals, advanced consumer electronics, semiconductors and semiconductor equipment, photographic equipment, carbonated beverages, and personal care. The aggregate data that we present in Section 3 reveals a similar pattern: the market share of foreign firms has increased most in sectors that are technology and capital intensive such as vehicles, copiers, and hydraulic turbines (see Figure 3). Similarly within sectors, the foreign firms occupy the premium segments. In the three sectors that we analyze by segment, for instance, the multinationals dominate the segments that are occupied by higher quality and more technologically sophisticated products: the luxury and upper medium segments of the passenger car market, the production of excavators and high-end machining centers.

The ability of multinational firms to leverage superior technology, sophisticated products, and powerful brands into dominant market positions in these high value-added sectors and segment is neither surprising nor a China-specific phenomenon. These are the sectors and segments where the differences between the Chinese market and global markets are minimized, and thus the foreign firms are able to exploit their strengths in capital and technology-intensive activities within the Chinese market. According to some observers this is a very durable advantage. Peter Nolan and Jin Zhang argue that the concentration of R&D expenditures and the control of leading brands by companies based in advanced economies have grown dramatically over the last two decades. "In sharp contrast," they argue, "developing countries are massively disadvantaged in the race to compete on the global-level playing field of international big business" (2002: 2092). The problem, of course, is that in an emerging market such as China, the playing field of the domestic market is very different than the global playing field: the fastest growth in the Chinese domestic market is in the middle segment and the cost structure of a multinational firm makes it difficult to compete in this segment. In order

to analyze the segmentation of sectors and the pressure on foreign firm, we again turn to the automotive, construction equipment and machine tool sectors.

In the automotive sector, multiple factors are putting pressure on foreign firms. First, as we explained in the previous section, the center of the gravity in the sector is shifting toward cars that are less expensive and less sophisticated (Figure 5). In 2008, close to 40% of the entire auto market was for cars priced below RMB 90,000 (Freeman and He 2009), and a reduction in the purchase tax on vehicles with an engine displacement of 1.6 liters and below in January 2009 accentuated the trend toward small cars, leading to a 55.5% increase in sales in this category during January to August 2009 (Xinhua 2009). Second, prices are falling: between 2000 and 2005, the average annual drop in car prices calculated at the car model level was 9%.[19] Third, the quality levels of the domestic firms that dominate the bottom of the market are rising. Although the quality level of passenger vehicles produced by domestic firms was inferior to those produced by FIEs, the gap has been shrinking. J.D. Power quality surveys, for instance, use a metric called "PP100," or problems per 100 vehicles. The surveys were first conducted in China in 2000, and the average score for domestic firms was higher than 800. In 2006, the average for domestic firms in China was 368. This was still far higher than the average of 189 for FIEs or the average of 124 for a U.S.-produced vehicle, but clearly the domestic firms that dominated the bottom of the market were making progress (Li 2007).

In the construction equipment sector, the domestic firms are increasing their quality in the lower-end product segments (wheel-loaders) and are beginning to enter the more sophisticated product segments (excavators). In the wheel-loader market, according to the analysis of a western manufacturer, there are five segments of the market: 1) world-class; 2) premium; 3) heavy construction/mining; 4) general construction; and 5) low-end (Interview no. 050709) (See Figure 7).[20] Foreign firms dominate the world-class segment, but the segment is small—approximately 100 units in 2007. In the premium segment, foreign firms compete aggressively with the most capable of the Chinese manufacturers (i.e. Liugong, Longgong, Xiagong, and Lingong) and volumes are still relatively low (approximately 3,000 units in 2007). The bulk of the market is in middle two segments (heavy construction/mining and general construction), where there were combined sales of 105,000 units in 2007. These segments are

virtually the exclusive preserve of Chinese firms. Low-end machines can be as inexpensive as RMB 30,000, and 20,000 units were sold in this segment in 2007.

In more sophisticated product areas such as excavators, the position of foreign firms is stronger. As Tables 2 and 3 illustrate, foreign firms dominate the Chinese market for excavators both through production in China (54.5 percent[21] of the total domestic market in 2006) and through imports (40.6 percent of the market in 2006). But even in this area of strength, there are signs that high prices have opened the door for less expensive excavators manufactured by Chinese firms. In the last three or four years, there has been significant entry and a very pronounced expansion in the production of excavators by domestic firms. In 2007, total sales of Chinese firms, both domestically and overseas, nearly doubled to over 20,000 units. Much of the increase in production went to the domestic market, and the market share of domestic firms in the excavator market climbed from 5 percent in 2006 to 7 percent in 2007. Preliminary estimates for 2008 suggest a further rise, with Sanyi and Liugong emerging as important domestic players.

Machine tools differ from either autos or construction equipment (especially wheel loaders) in that foreign firms have been able to capture a significant portion of domestic market growth largely through imports. This partially reflects differences in tariff treatment between the sectors. In 1998, the average tariff on machine tool imports was 14.2 percent, and this fell to 10.3 percent by 2006.

Imports primarily serve the upper end of the market and have typically been three to four times more expensive than CNC machine manufactured domestically (see Table 4). This has not made foreign firms immune from pressures, however, as domestic firms have acquired capabilities in premium product segments such as machining centers. Between 1996 and 2005, sales of machining centers grew rapidly in China, and represented nearly twenty percent of all metal-cutting CNC machines consumed domestically in 2005. By 2005, nearly 30% of these machines were manufactured within China (see Figure 9). This percentage includes both domestic firms and FIEs, but China's Machine Tool Manufacturer's Association estimates the machining center sales of Chinese firms to be approximately 2,500 to 3,000, implying that

domestic firms were supplying roughly 20% of the domestic market for machining centers (China Machine Tool Industry Association 2007: 222, Table 4).

Insert Figure 9 here

Data reported in Table 5 supports the view that Chinese firms are succeeding in the lower-end of these more sophisticated product markets. For example, in the case of vertical machining centers, Chinese machining centers were a third less than the price of imports. These kinds of pressures on foreign firms help cast new light on the behavior of the price of imported CNC machines, which rose by more than fifty percent. As Chinese firms made inroads into the lower-end of these product markets, foreign firms succeeded in retaining market share in part by selling even more sophisticated machines to domestic users.

Insert Table 5 here

In short, FIEs in these three sectors face a similar set of challenges. The fastest growth in these sectors is in exactly the segments where foreign firms find it most difficult to compete. Even in the premium segments in which they dominate, domestic firms are beginning to make inroads (although this is less true in automotive). As one top executive at a foreign construction equipment firms succinctly explained, "[Our] value proposition does not fit the Chinese buyer (Interview 050709)." The critical question is whether this value proposition can be altered.

5. The Fight for the Middle

The automotive, construction, and machine tool markets in China are the largest in the world and the fastest growth in these sectors is in the middle segments. Foreign firms are eager to access these middle segments because the volumes are so large; domestic firms seek to access them because they are eager to escape the intense competition (and consequent low profit margins) in the bottom segments of the market. Each face different challenges: The foreign

firms must lower their cost structures while the domestic firms must raise their technical and quality standards. The interaction of these two dynamics deepens the capability building in Chinese industry.

(a) Foreign firms struggle to lower costs

The cost structure of a multinational firm is closely related to its global strategy. Ghemewat groups the global strategies of multinational firms into three different categories—aggregation, adaptation, and arbitrage—and argues that the motivations for each strategy will vary. Firms that aggregate seek to take advantage of economies of scale and scope by standardizing products and processes globally (and the motivation is usually the high cost of R&D relative to sales); firms that pursue adaptation strive to achieve local relevance by adapting to local conditions (while ideally controlling the cost of excessive variety and complexity); firms that seek arbitrage opportunities exploit the specialized advantages that are available in a diverse set of locations (and deploy these advantages globally).

The dominant strategy in the sectors that we analyze is aggregation—all are capital intensive and have high R&D costs—and this strategy shapes the cost structure of firms. Although a strategy of aggregation allows a firm to maximize global economies of scale, it can have the unintended side effect of locking a firm into a high-end segment of a market when they seek to expand into the developing world. First, because the product is designed for advanced markets, and the firm is seeking to limit the extent of adaptation, the product may be more sophisticated and of higher quality than the market in a developing economy demands. A "good enough" market (or market segment) seeks reliable-enough products at low-enough prices (Gadiesh, Leung et al. 2007). It is often not easy to lower the costs of the products because their sophistication and quality requires more capital (and technology) intensive manufacturing operations.[22] Second, the foreign firm is often required to use components from global suppliers because only these components will meet the exacting specification required by the designs (and needless to say, common components will also maximize global economies of scale).[23] In many cases, an OEM firm relies on key suppliers for design capabilities and this

dependence generates additional incentives to bring global suppliers to China (what is called "follow sourcing") or to import key components (Humphrey and Memedovic 2003; Lester and Sturgeon 2004). Finally, the location and global orientation of design activities reinforces the bias against fully utilizing low-cost domestic suppliers. The process of getting a local supplier approved by the design center at headquarters (in conformance with a global design policy) can be time-consuming and difficult, and the absence of a local design center makes it difficult to provide local suppliers the engineering support they need to upgrade their manufacturing levels to the appropriate standards.

At the aggregate level, it is extremely difficult to measure the extent to which foreign firms are localizing their operations in China. To give one indication, however, we utilized firm-level data on imported intermediate goods and total expenditure on inputs for the period between 2000 and 2005 in order to measure the extent to which FIEs in China have been reducing their reliance on imported input and increasing their use of inputs sourced in China. This is an imperfect measure because an input sourced within China could still be manufactured by a global supplier rather than a Chinese firm, but the results point to both a decline in the percentage of foreign firms using imported intermediates from 55% to 49.8%, and a reduction in their share of total input expenditure from 28% to 24.1%.[24]

Localization activities are more easily depicted at the sector level. In the auto sector, the Chinese government has always exerted pressure on foreign firms to utilize local suppliers, but given the strong incentives for global OEMs to continue sourcing from their global suppliers, government restrictions were commonly evaded.[25] Since WTO accession, two trends have changed the calculations of global auto firms. First, the ratio of Chinese versus global sales for particular models has steadily been changing in favor of the former. In 2007, the Chinese sales of the VW Jetta/Bora, the Audi A6, GM's Buick Lacrosse, the Toyota Reiz and Crown, and the Hyundai Elantra exceeded 30% of global sales. In the cases of VW, GM, and Toyota, the China sales of these models exceeded sales in their home market (Fourin 2008). The increase in the relative importance of the Chinese market creates strong incentives for global firms to locate design activities in China and to shape global platforms according to the demands of the Chinese market. Second, the increase in competition that we described in the

previous section forces localization because firms that rely too heavily on imported components (or global suppliers that import components) have difficulty lowering their costs. When Volkswagen's market share in China fell from 56% in 1996 to 16% in 2005, for example, the company announced a restructuring program that sought to reduce costs by 40% through an aggressive localization program. The intent was to increase domestic content rates for all models to above 80%.[26] Other OEM firms have made similar efforts (although the extent and timing of these localization drives varies according to the home region of the OEM) and the competitive pressure that drives these localization efforts spreads throughout the supply network.

The incentives of the market and the pressure of competition push localization down the supply chain. In 2007, for example, Firm A, a global Tier 1 supplier of braking systems manufacturing in Shanghai, was under intense pressure from its foreign OEM customers to lower costs. At the same time, it was eager to supply the domestic OEMs that were rapidly gaining market share (and which demanded even lower costs). There were two primary hurdles to lowering costs. First, the products were over-engineered. The high standards of the engineering allowed the firm to achieve the highest level of quality, but the sophisticated products required more capital investment in equipment and design. A Chinese competitor would utilize a simpler design in order to achieve an acceptable (if not exceptional) level of quality at a much lower cost (Interview 083107).[27] Second, the engineering costs imposed by the global parent firm were too high. Although the firm had a return of 25% on operating income, 80% of this (or 20% of operating income) was allocated to support technical centers in the home country (Interview 080509). Due to falling volumes for the global business unit, the successful China operations were relied upon to support an ever greater percentage of global engineering costs. Labor costs were not an issue for Firm A, since they were only .5% of total costs (as compared to 30% in its home country).

The solution to these cost problems was to increase the extent of production that was outsourced to domestically-owned Tier 2 suppliers. The challenge was to lower costs through out-sourcing while both maintaining the quality standard demanded by the OEM customer and protecting the firm's own core capability. As is quite common in a global value chain, the Tier

1 global supplier became the tutor of the Tier 2 domestic firm. For example, one of the most important of the Tier 2 suppliers, Firm B, was provided with designs, tooling, and 6 or 7 engineers to oversee the production process (Interview 051607). The defect rate at the supplier went from being 1/3—i.e. entire production batches had to be scrapped—to within the 6 ppm standard imposed by the foreign OEM (Interview 083107). The extent to which Firm A outsourced the components of a particular product depended on the balance of low cost and quality demanded by the final OEM customer, as well as its desire to preserve its technical advantage over Firm B. When the Tier 1 firm was able to out-source 95% or more by value to domestic suppliers, as was the case with drum brakes, the firm could match the price of it Chinese competitors, and it could sell to domestic OEMs. As the outsourcing rate slipped below 90%, as was the case with disc brakes, the Chinese competitors had a 10-20% price advantage (Interview 083107), but the higher quality of Firm A would continue to give it an advantage with foreign OEMs.[28] This example of a global Tier 1 supplier increasing the degree of out-sourcing and supporting the development of Tier 2 capabilities is not an isolated phenomenon. In a benchmarking survey of 3 Tier 1 global supply firms manufacturing in coastal China, the average defect rates of their lower tier suppliers—almost all of whom were domestic firms-- improved from 421.7 ppm in 2003 to 122.9 ppm in 2006 (Brandt and Van Biesebroeck, 2009).

In the construction equipment sector, the incentives offered by the middle segment of the market vary by product. The technical demands of an excavator continue to limit the possibilities for localization and the cost of design creates a strong incentive to standardize products globally. The product sold in China is identical to the global product, and if a new Chinese supplier is to be certified, it must reach the global standard.[29] Given the size of the technology gap between global and domestic suppliers, the OEM firms make careful choices. The core components—engine, hydraulics, and electronic control systems—continue to be made by foreign firms. These components are under enormous pressure during operation, and a core competitive advantage of a foreign firm is the ability to optimize the interaction of the three (sometimes working with key global suppliers). Careful choices are made in other instances: the bucket of an excavator, for instance, is outsourced to a local supplier by one

leading foreign manufacturer, but the cutting edge of the bucket is imported because it receives a proprietary heat treatment (Interview 081007b). The technical demands of the product and the consequent difficulty of out-sourcing serves as a firewall against the domestic firms that are attempting to move into excavator manufacturing: because domestic firm must also use foreign components, they have limited price advantage vis-à-vis foreign competitors, and because they have lower global volumes in this product range, the global suppliers are unwilling (and the Chinese firm is unable) to customize and optimize core components for the Chinese machine (Interview 112108). The position of foreign firms is still strong.

In the wheel loader segment, the incentives of foreign firms are very different. As described in the previous sections, the bulk of the Chinese market is in mid-range segments, price competition is intense, and the technical barriers to entry are low. Two-thirds of global wheel-loader sales (by unit) were in China in 2006, but these sales represent only one-third of global sales by value (Interview 050709). Although global firms might be tempted to focus on the fact that Chinese sales are only one-third of global sales by value, they are keenly aware of the fact that the low-cost Chinese producers are rapidly expanding global sales, and a foreign firm with over-engineered products and high overhead costs cannot hope to compete outside of the premium segment.

A solution that multiple foreign firms have adapted is to acquire (or invest in) a Chinese company: the products of the Chinese firms are designed for the domestic market (rather than high-end global markets), the firms have lower cost structures, and they have well-developed networks of domestic suppliers (Interview 120907). It is easier for a foreign firm to increase the capabilities of a low-cost domestic manufacturing operation than it is to decrease the cost at a high-cost foreign operation because the latter approach would only be successful if an entirely new product was designed. The Chinese firms are highly skilled at designing products that are easy to produce, easy to maintain, and easy to repair.

The initial emphasis of the foreign firm is on improving the product and processes at the acquired assembly plant—introducing lean manufacturing techniques and new process controls (such as production planning systems, failure analysis systems, etc.) and providing the engineering support to make product improvements (Interview 112408a). The emphasis then

begins to shift to the supply chain, and as in the example of the automotive braking firms, the foreign firm plays a key role in upgrading supplier capabilities. To give one example, Firm C is a domestic wheel loader firm that has been acquired by Firm D, a leading foreign manufacturer of construction equipment. Engineers from the foreign firm identified the engine cooling pack as being one of the key problems in the Chinese design: when operated in high temperatures, the engine had a tendency to overheat. Although Firm D had a global supplier of cooling packages that it could have turned to, Firm C identified a private sector firm in Zhejiang that was capable of quality levels similar to the global supplier at a 20% lower cost for new products and 40% lower for older (080509). Firm D used its newly-opened design center in China to design a new cooling pack for the Zhejiang supplier, and deployed a supplier development team, a design team, and a global purchasing team to develop the capabilities of the Zhejiang firm. This abundance of resources could not have been afforded by a low-cost producer such as Firm C, but because Firm D intended to integrate the Zhejiang supplier into its global procurement it could cover the cost of supplier development (Interview 112408b). The overall quality level of components purchased by Firm C has steadily improved. In 2005, the warranty ration was 3.6% of total purchasing; in 2008 it was 1.6% (Interview 112408b).

A similar dynamic is evident in the machine tool industry, and foreign manufacturers are setting up either JVs or wholly-owned operations as a way to lower costs and capture domestic market share. Initially, these ventures were largely involved in machining the base of the CNC machine, a relatively labor intensive activity, and components were imported.[30] Over time localization has increased both inside and outside the firm. The latter opportunities have expanded as key suppliers in the industry have also set up factories in China to service overseas customers. For less demanding parts and components, the foreign firms are able to take advantage of the low capabilities that were described in the previous section. Taiwanese CNC manufacturers in the lower Yangtze region, for instance, have been very successful in finding local suppliers for 60% of their parts and components. One JV between a Japanese and Chinese firm that we visited in 2007 succeeded in localizing 80% of the components going into a CNC lathe, some of this done in-house, and others outside. The firm's manufacturing cost in China is 50% lower than in Japan (exclusive of the costs of the technology), and most of these savings

came from lower sourcing costs (Interview 121807). The Japanese partner was considering moving all of the production of this particular product line to China, where quality was just as good.

Manufacturing in China by leading foreign CNC manufacturers is now also extending to basic vertical and horizontal machining centers, which sell for in upwards of US $100,000 to US $150,000. Again, a key motivation is costs. One of the world's premier CNC firms we interviewed set of goal of 60% domestic sourcing for their operations in China, despite its plan to continue to procure the numerical controls and spindle bearings from the overseas parent. As in the case of CNC lathes, sourcing domestically would include in-house, as well as from firms now manufacturing in China. For critical components like the balls-crew, this would be from JVs or WOS.

In all these cases, the localization of purchasing necessitates a certain amount of localization of design and engineering. A design center facilitates the localization of component purchasing because the design staff can work with local suppliers to increase their manufacturing capabilities. Several factors are important. First, the foreign firm needs trained personnel and engineers who are capable of working with local suppliers to help them improve their manufacturing and quality control processes. Quality engineers are critically important and particularly ones that speak Chinese. Both the OEM firms and the Tier 1 suppliers have large teams in China that will conduct surveys of potential Chinese suppliers, and then essentially live in the factories while working with them to improve their quality standards. The Chinese supplier is delivering a component that will go into a product with a foreign brand, so the foreign customer has every incentive to teach the supplier well. Second, the foreign firm needs the capability within house to make modest design modifications to their products in order to facilitate lower cost sourcing without sacrificing either performance or quality (and this follows a long tradition in the auto industry of changing designs for manufacturability).[31] Finally, and a point that relates equally to OEM and supply firms, a design center in China allows a foreign firm to be more responsive to the demands of domestic market.

b) Domestic firms struggle to upgrade

Which domestic firms will have the capacity to challenge the foreign firms for the middle segments of the Chinese market? While this is not a question that we can answer with any precision, we can point to three dynamics that are common to each of the sectors that we have analyzed in detail.

First, the competitive dynamics of the Chinese market deepen the channels of upgrading within the domestic supply base. In the previous section, we explained how cost pressure forces foreign firms to localize activities. Localization by foreign firms inherently involves building the capabilities of domestic suppliers, but whenever possible, a foreign firm will adapt a strategy that allows it to benefit from the lower cost structure of a domestic supplier without nurturing a future competitor (Arrunada and Vazquez 2006). In each of the examples cited in the previous section, for example, the foreign firm had thought carefully about how it could safeguard its own core technology. In the case of brakes, the foreign firms have sought to protect their advantage in anti-lock braking systems (ABS). In the case of one JV, for instance, the foreign firm continues to import the software and the electronic control unit (60% of the overall value). Another durable advantage is testing: an ABS system must be altered for every model, and this requires the model to be tested under all conceivable road conditions. The advantage of the foreign firm is its database of all past failures, and the ability to use this information to test and adapt a product for a new model (Interview 090707). In the case of the cooling package for a wheel loader, the foreign firm believed its core capability was system integration. In order to source from the Zhejiang supplier, the foreign firm deployed considerable resources to improve the manufacturing process of the supplier. Controlling the speed and temperature of the "brazing," a form of welding, is the critical skill in manufacturing an oil cooler (Interview 050909). Once the supplier has mastered this skill, of course, the resulting improvement in the quality off the component benefits all of its customers. Although the foreign firm was well aware of this, it believed that other firms would not be able to duplicate its ability to optimize the performance of the cooling package when it is placed in the engine (Interview 050709). The relationship between a foreign firms and a Chinese supplier is a complex mix of collaboration and competition.

The advantage that a Chinese supply firm has, when compared to a local supplier that is participating in a global value chain in a country with an insignificant domestic market, is the possibility of participating in multiple value chains. In the three sectors that we have analyzed in detail, the low-end segment of each market is dominated by ambitious domestic OEMs. Like their foreign competitors, the domestic OEMs rely heavily on their domestic suppliers, but in a very different way. Rather than trying to limit the advancement of domestic suppliers, the domestic OEMs, themselves weak in design capabilities, are eager to have the domestic suppliers broaden and strengthen their capabilities. Rather than force them to manufacture low-value added components in a lower tier of the value chain, the domestic OEMs encourage the domestic suppliers to occupy the first tier and provide full modules. To return to the examples from above, the domestic braking firm will sell the full ABS systems to a domestic OEM (while the foreign customers will insist on using a JV that has access to foreign software or a global supplier). Another brake supply firm sells only components of a disc brake to foreign customers, but will sell the complete front chassis (including the brakes) to domestic firms. In the case of the supplier of cooling packages, the firm works on a "build-to-print" basis with its foreign customers—i.e. it is given detailed designs to the component—but will design and test the component for a domestic OEM (and the customer will provide only general specifications).

A technical director of a domestic auto supply firm compared the relationships with a foreign versus domestic OEM to a rectangle that is sitting on end as opposed to one that is lying flat. The former symbolizes the relationship with a foreign company: it is narrow and deep. The domestic supplier can achieve a high level of competence very quickly because a global supplier will be assisting them, but the range of capabilities will be narrow. The latter represents the relationships with a domestic OEM: the domestic supplier can learn a great breadth of things, but the knowledge is not as deep because the domestic OEM is not in a position to provide as much assistance (Interview 051607b). The natural conclusion, of course, is to have both sets of relationships; the one complements the other. The increase in the capabilities of domestic suppliers supports the development of the domestic OEMs, because they are willing to utilize domestic (as opposed to global) suppliers to a greater extent than the foreign OEMs.

Second, the importance of foreign linkages extends beyond supplier relationships. FIEs in China are an important source of competition for Chinese firms, forcing them to utilize resources more efficiently and upgrade their capabilities (Brandt, Rawski and Sutton 2008), but they also create multiple channels of upgrading (For a general discussion, see Crespo and Fontoura 2007). One of the most explicit channels, and one that is present in all three sectors, is the use of joint ventures. Initial Chinese efforts to master new products and manufacturing processes often began with various forms of technical licensing and short-term cooperation. These efforts often proved inadequate, and Chinese firms turned to joint ventures as a means of developing core competencies and/or expanding capabilities in core components and related product lines. Beijing Number 1 Machine Tool, for example, established a JV with Okuma, a leading Japanese firm, for the manufacture of a basic line of CNC machines. Shenyang Machine Tool, on the other hand, has entered into a number of JVs for the purpose of expanding into more sophisticated machining centers. The leading firm in wheel loaders formed a JV that manufactures transmissions with a leading German company; leading auto firms have established JVs for the production of engines; domestic machine tool companies have formed JVs to acquire basic manufacturing knowledge, but also to expand product line. More recently, Chinese firms have begun to look outward as a way to acquire critical capabilities, and market access. Wanxiang's recent acquisition of four Dana auto-part plants in North America and acquisitions by Shenyang Machine Tool and Dalian Machine tool in the US and Germany are cases in point.

The flow of human capital from foreign to domestic firms has also been an essential part of the upgrading process in China. The domestic firms that are able to differentiate themselves from their domestic competitors are able to hire employees with training at foreign firm firms. The firms with the most resources (sometimes the result of state support) hire consultants and overseas returnees with multinational experience. One leading domestic auto firm, for instance, staffed key technical positions with former employees of companies such as Ford, Visteon, Honda, Motorola, and TRW. As a returnee manager commented, the local engineers are very smart, but they have less experience with project management and real design work (Interview 080105). The returnees, many of whom had come up against glass

ceilings abroad, have the experience necessary to harness this local talent and push the development process forward far more quickly than would otherwise be the case. Firms that are ambitious yet unable to afford the salaries demanded by returnees or pay the high fees of consultants, hire Chinese employees from the JVs and as well as recent retirees from the JVs (a slightly cheaper option).[32] As we have argued, competitive pressures force foreign firms to localize high-value added activities such as design in China, and this further deepens the pool of well-trained human capital that is available to be poached by domestic firms.

Finally, the domestic firms that are most successful in upgrading their capabilities are those that are able to take advantage of pre-existing capabilities within the Chinese economy. State-owned firms are the most direct beneficiaries, and they continue to play a critical role in autos, construction equipment, and machine tools, particularly those that are able to effectively restructure and improve governance. Although many SOEs continue to receive policy support, they also have the advantage of deep experience with a particular product range. Extensive experience with a product design and strong engineering capabilities allow an SOE to make incremental improvements over time; feedback from customers over the course of decades leads to product and process changes, and this leads to continuous improvements in product quality. These advantages are likely to be most important in sectors where the evolution of technology is incremental and the rate of change is slow.

The dominant domestic firm in the construction equipment sector, for instance, continues to be the same firm that initially licensed the 5-ton model from the Ministry of Machinery in the 1980s. When the designs for this model became widely available in the 1990s, there was a high rate of entry from private sector firms and fierce price wars, but the firm was able to maintain a dominant position through a process of steady, incremental improvement. The current 5 ton model of the firm is considered a 3rd generation model and entails significant upgrading in design and technology: it meets European and US environmental standards for road equipment, it utilizes a higher pressure hydraulic system (and has improved productivity), the engine is produced in a JV with a leading foreign firm, and the model has improved ergonomics and electronic controls (Interview 072808). The firm is also able to utilize a broad distribution network to collect feedback from customers and the

resources of a 400 person R&D centre to make the necessary changes. Although the current product is derived from the same basic model that was licensed two decades ago, it is a very different machine, and the firm is able to charge a premium of 10-15 percent over competitors.

Private sector firms also draw on the resources of the state sector. These firms are more efficient and flexible than their SOE counterparts, but they often lack the manufacturing experience as well as strong design and engineering capabilities. Since the mid-1990s, the resources of the latter have become increasingly diffuse as key research institutes—the beneficiaries of state investment, human capital, and technology licensing agreements with key foreign firms for decades—have sought to commercialize their assets. These institutes (as well as universities) are willing to work with any firm that will pay the appropriate fee. Human capital that has been nurtured in state-owned firms (particularly with respect to engineering) has also become highly mobile within China, and it flow to those firms that offer the highest wages and most attractive working conditions. Bankruptcy in SOEs also often frees up valuable human resources, including entire R&D departments. A leading private heavy construction equipment firm, for example, hired key R&D personnel from an unsuccessful JV as part of its move into excavators.

As the private sector firms struggle to gain engineering and technical skills, they compensate for their relatively limited resources by focusing their efforts. A firm will focus on a particular product niche in which the domestic competition is not intense, dominate the segment, and then use the revenue generated to fund expansion into other areas. One of the most rapidly growing firms in the Chinese construction equipment industry, for example, began producing concrete pumps in 1994, when 85-90% of the Chinese market was served by imports. The firm initially had poor quality, but as the manager in the R&D institute explained, careful analysis of foreign products made it clear that there was nothing mysterious about the technology and the key SOEs in the segment had poor management (Interview 111908a). Early efforts benefited from linkages to a local state-run construction industry research institute; key components that were beyond the firm's initial capabilities could be imported. As the firm gained market share it was able to invest heavily in R&D personnel (many of whom were hired from state-owned competitors), and initial success in pumps funded expansion into higher

value-added segments such as excavators. By 2007, the firm controlled 50% of the Chinese market for concrete pumps and total revenue was approximately 20 billion RMB (slightly less than half of which was from concrete pumps and mixers). It is the most rapidly growing firm in China's construction equipment sect.

In short, the state-owned and private firms will often have a slightly different product focus—the former rely on incremental improvements to pre-existing products and the latter focus on niche markets—but the overall strategy is similar: revenue from products that are characterized by relatively low technology gaps (relative to their capabilities) provide a secure source of revenue that can be used to help support the shift into technologically more sophisticated (and more profitable) products. Machine tool manufacturers benefit from a robust market for their traditional lathes to develop capabilities in CNC machine tools; heavy construction manufacturers leverage sales from wheel loaders (or concrete pumps in the case of a private firm) to develop capabilities in excavators; auto firms dominated in small cars (or a particular component) and then moved into more sophisticated models (or components). These firms benefit from multiple forms of linkages to the foreign-invested sector, and they benefit from the capabilities that foreign firms have labored to create within the supply base.

6. Conclusion

In comparison to other developing countries, China has distinct advantages. The most obvious is the size of the domestic market, the potential of which has been in the sights of foreign firms since as early as the mid-19th century. Through the first decade and a half of the reform period, China pursued relatively protectionist policies with respect to this market. In some sectors, entry by FIEs was difficult, and the only option was the licensing of technology to Chinese firms. In other sectors, FDI was encouraged, but often only with a state-owned partner. Tariffs were set relatively high. Local sourcing requirements were also stressed. These policies succeeded, albeit unevenly, in helping to develop local manufacturing capabilities, but there were limitations. Barriers to trade within China, restrictions on entry, and high tariffs served to

limit competition between firms and restricted growth of the domestic market. Efficiency likely suffered as a result.

In the period leading up to and following China's entry into WTO, domestic markets were significantly liberalized and competition increased from both within and outside China. Concerns were expressed that Chinese firms would not be able to weather the competition, and would be an obvious causality, losing market to both FIEs and imports. In hindsight, Chinese firms have fared reasonably well. Our estimates suggest that the domestic market share of Chinese firms has fallen ten percentage points since 1995, but the decline slowed after 2001, and the last few years actually appears to be moving upwards. Within manufacturing, there are the expected cases of success in more labor-intensive sectors in which China has a comparative advantage, but even in more capital-intensive sectors where market share appears to have declined, there is much more going on than meets the eye.

In this paper, we argue that the success of Chinese firms in these other sectors can be viewed as an "unanticipated" consequence of reforms that enabled China to leverage its earlier efforts in capability building and better take advantage of one of its greatest potential assets: a huge domestic market. The growth of this market, which has outstripped GDP growth in numerous sectors, has had a dual impact in the sectors that we examined.

In autos, construction equipment and CNC machine tools the low-end of the domestic market is the preserve of the domestic Chinese firms. Here they benefit from natural barriers to entry, the most important of which is the inability of FIEs to lower their cost structures. Domestic market liberalization has exposed Chinese firms to intensified pressure from other domestic firms and entrants, but rapid growth in these low-end segments are allowing the more capable domestic firms to gain from scale, experience, and revenue vital to upgrading efforts and shifts to higher-end segments.

Analogously, the lure of these rapidly growing lower-end segments of the market and competitive pressures provide incentives for the foreign firms that dominate the high-end of the domestic market to localize sourcing (both of components and capital equipment) and design activities so as to lower cost and increase responsiveness to consumer demand. These localization efforts are exactly the result that the government had sought for decades, but intense

competition and expansion in the domestic market are now offering incentives that are far more powerful than protective tariffs or government fiat.

The interaction of these two dynamic forces builds on a second advantage that China has over many developing countries: the strong manufacturing capabilities that were nurtured prior to liberalization, particularly in supply networks. When the domestic market began to expand rapidly in size and competition intensified, domestic suppliers were not at global standards of productivity and quality, but they had basic capabilities. FIEs are increasingly willing to work with Tier 1 and Tier 2 domestic supply firms and transfer necessary processing and manufacturing skills because they are keen to lower their cost structure. Domestic OEMs provide less technical support, but offer these same supply firms an opportunity to increase their breadth of capabilities, along with high volume business. The opportunity to participate in multiple value chains provided complementary upgrading opportunities.

Not all Chinese firms within these sectors are in an equally advantageous position, and we are not in a position to predict which Chinese firms will emerge as strong global competitors. We see strong capabilities emerging in these three sectors, but the success and failure of individual firms depends on many factors, the scope of which is beyond this study. What we can say with confidence is that, given the manner in which the dynamics of competition lead to capability building within China, there is less need for Chinese policy-makers to worry about where exactly these capabilities reside within these sectors (i.e. with SOEs, private firms, or FIEs), and more on fostering an environment in which these capabilities are nurtured and allowed to grow. This includes providing a level playing field for all firms and ensuring continued competition in sectors, allowing an effective re-allocation of resources within the Chinese economy, both to SOEs that are successfully re-structured and to the private sectors firms that are the most entrepreneurial, and supporting supplier development.

It should also be noted that the sectors that we have focused in this paper are not representative of all sectors in the Chinese economy. In addition to the variables that we have just pointed to—the large size of the low-end segment in these sectors and the strong pre-existing capabilities—the most important characteristic is that they are relatively mature sectors. The rate of product and technical change varies by sector, but is relatively slow in

each. Change in manufacturing processes also tends to be slow. The rate of change is critical because it determines the ability of a Chinese firm to recoup an investment in either product or process upgrading. If the product characteristics within a sector change too rapidly, a firm that has invested in a laborious and expensive process of upgrading may soon find the capabilities it invested are obsolete. In our future research, we seek to understand how the characteristics of the sector alter the competitive dynamics that we have described in this paper.

Who will prevail in the fight for the middle? It is not yet clear who will win in the race between the domestic OEM firms that are labouring to upgrade their capabilities and the foreign firms that are struggling to lower their costs. The dynamics of competition that we have described in this paper are providing a window of opportunity for the domestic firms, but this window will not be open indefinitely. Foreign firms will succeed in lowering their costs, while rising incomes and increasing consumer sophistication may lead to increasing demand for the high-end goods that favour foreign firms. In either case, the strongest firms are likely to be those that rely heavily on the strong capabilities that have developed within China, including those within the Chinese supply chains.

[1] The category of FIE includes both wholly-owned foreign enterprises and joint ventures.

[2] There is no single model of a development state. Much to the contrary, there is significant variation (Önis 1991: 118). In the wake of the Asian Financial Crisis, there was also a re-evaluation of the efficacy of the developemental state approach (Pempel 1999; Stiglitz and Yusuf 2001).

[3] FDI played a more important role in Taiwan than in Korea and Japan, but Wade (1990: 149) argues that its importance is often exaggerated: "as a source of capital [FDI] accounted for only 3 to 10 percent of gross domestic capital formation over the 1970s, averaging 4 percent, and 8 percent of manufacturing investment." Korea relied heavily on Japanese technology (see Kohli 2004: 114-115), but as Amsden (1989: 74) notes, "direct foreign investment in the form of equity ownership by foreigners of production facilities in Korea has been minimal. Singapore is a key exception: with a population of less than 3 million and little domestic industry, the city-state relied almost completely on foreign direct investment.

[4] Since much of the technology transfer incurred in the context of JVs, in which SOEs were often partners, the bias favoured SOEs and worked against non-SOEs. In numerous sectors, including several we look at, the hope was that the transfer of manufacturing and managerial knowhow would benefit the "independent" manufacturing operations of the SOE partner.

[5] See also Kennedy, S. (2005). China's Porous Protectionism: The Changing Political Economy of Trade Policy. *Political Science Quarterly* 120(3), 407-432..

[6] Gereffi, in his analysis of the garment industry, sees a fairly steady progression from OEM to ODM to OBM. He describes an iterative process: the buyers work with suppliers in order to assure quality standards and gradually suppliers gain capabilities through a process of "learning-by-doing." As the suppliers improve their capabilities, buyers (who are usually under intense competitive pressure) are more than willing to transfer a broader range of activities to the supplier. Martin Bell, in his analysis of the footwear industry, suggests that buyers are careful to limit the potential for their suppliers to engage in design, branding, and marketing because they do not want to create their own competitors. Humphrey and Schmitz argue that the form of governance within the chain, and in particular the nature of the linkages between firms within the chain, is a key determinant of the type of knowledge that is transmitted between firms.

[7] The firm-level data are from the Industrial Census provide detailed firm-level information for key economic variables such as output, sales, exports, etc., as well as information on ownership In 2004, for

example, there were more than 1 million manufacturing firms. Firm level data available for other years are for SOEs, and firms with sales larger than 5 million RMB. The trade data are at the 8-digit HS level, and have been aggregated to the 4-digit CIC level on the basis of a concordance we constructed between the two. Thus, for each 4-digit CIC sector, we have information on: 1) Total manufacturing output, disaggregated between Chinese and FIEs; 2) total exports, disaggregated between Chinese firms and FIE; and, 3) total imports. FIEs include both joint-ventures and wholly-owned subsidiaries.

[8] Along line segments AB, BC and CA, the markets are served exclusively by domestic firms and imports, FIEs and imports, and FIEs and domestic firms.

[9] At the 4-digit level, "vehicles" is made up of cars, buses and trucks, while CNC machine tools are included in "machine tools."

[10] At the most basic level, manufacturing capability refers to the process skills that are necessary to transform inputs into outputs and is distinct from design and engineering capabilities. The processes that would be included in manufacturing capability include: supply chain management, production scheduling, quality control, trouble shooting to overcome problems encountered in manufacturing, and the ability to adapt processes to changing circumstances (Amsden 2001). A firm with basic manufacturing capabilities will be able to utilize a design to manufacture a basic product, and as process technologies are upgraded it will increase the productivity of its operations and the quality of the product produced. Design and engineering capabilities refer to a firm's ability to adapt and develop the design for new products. A firm with no design capabilities will utilize externally-acquired designs (and quality will be determined by the extent of its manufacturing capabilities). As the firm gains design and engineering skills it will have an increased capability to alter and adapt products. A firm with a high level of design and engineering capabilities will have the ability to develop its own products.

[11] For background on the Chinese auto industry, see Thun 2006.

[12] Foreign-investment in an automotive assembly JV continues to be limited to a 50% equity stake. From the perspective of the Chinese government, there is thus less reason to discriminate against a JV, since they are at least 50% domestic. Product design and technology come from the foreign partner.

[13] The data we draw on identify 8 market segments in China: Luxury, Executive, SUV, Minivan, Upper Medium, Lower Medium, Small and Mini. Engine Displacement declines monotonically through the group from a high of 2.6 to a low of 0.9. To simplify slightly, we collapse the top two (luxury and executive), and the bottom two (small and mini) into single segments.

[14] Larger vehicles are also much more likely to have ABS braking systems and automatic transmissions.

[15] We do not have an exact breakdown of FIE sales between the domestic and overseas markets. The 14.25 percent is calculated under the assumption that all of FIE's sales were to the domestic market. In 2005, Caterpillar took a minority position in Shandong Equipment Manufacturer (SEM), and SEM accounts for half of the FIE share in 2006. Similarly, Volvo acquired Lingong in 2007 and this increased the FIE share to slightly less than 25%.

[16] A lathe, the most important metal-cutting machine tool, spins a block of material to perform various operations such as cutting, sanding, drilling, etc. with tools that are applied to the work piece. In a machining center, by contrast, the piece of material remains fixed. Multiple-spindle, multiple-axis machines also allow machining to be done as part of an integrated process as opposed to a series of discrete steps, thus saving time and often contributing to higher precision.

[17] At the first tier, other kinds of intermediates such as the integrated circuits used in the numerical control systems, or metal alloys continue to be imported or sourced from foreign firms.

[18] One advantage of this is that it has helped these suppliers achieve economies in production, and thus likely lowered costs.

[19] Estimates of changes in car prices are based on car models for which we have more than one year of data (40 models in all). The raw data were generously provided by the China Automotive Technology and Research Center (CATARC). In general, trends in car prices are difficult to measure because of the introduction of new car models, changes in "standard equipment," and changes in quality levels. We estimate a simple hedonic regression for car prices that allows us to control for car model and the standard equipment that is included in the sale price.

[20] The wheel loader product segment can be segmented according to product size and then again by price. In 2007, nearly 60% of the market was for 5 ton wheel loaders, 30% was for the 3 ton, and 10% was for the 8 ton. In the case of the 5 ton product, which has been the most rapidly growing market segment since the late 1990s, critical price points are 270,000 RMB and above (premier products), 230-270,000 (mid-range products), and below 230,000 (low-end products).

[21] We make a similar assumption here about exports of FIEs as we do for wheel loaders, and that all exports were by Chinese firms.

[22] This is not always the case. It is common for foreign manufacturers of construction equipment, for instance, to use more labor-intensive production processes. As one multinational firm explained, the designs for their products are "robust" enough that they can be produced using either automated techniques or more labor-intensive approaches. The strategy of the firm is to use imported equipment

only where it is absolutely essential to safety and performance. Manual welding, for instance, was thought to produce "every bit as good" as results as were achieved by automated facilities in Japan. "The economic formula in China is very different: you don't have to eliminate labour costs and the quality is equal (Interview 122107)."

[23] In many cases, OEM firms have pushed the responsibility for the design of components (and even entire modules) onto their global suppliers, and this makes "follow-sourcing" a necessity (Humphrey and Memedovic (2003).

[24] These calculations are based on the sample of FIEs in the National Bureau of Statistics' annual firm-level data that we matched with firm-level trade transactions data.

[25] Foreign managers in the 1990s sometimes spoke of "veneer localization." A Tier 1 supplier was located in China, and thus conformed to Chinese regulations, but relied extensively on imported components. Japanese and Korean auto firms entered China relatively late, and they relied heavily on localization strategies of this sort (Thun 2006: 238-241).

[26] "Volkswagen Group in China: Automaker bolsters localization of key components in China," *Fourin China Auto Weekly*, January 7, 2008, p. 3.

[27] To give a simple example, quality tests at one stage of the manufacturing would be performed by a US $100,000 machine at the foreign firm and a visual inspection at a Chinese firm (Interview 083107).

[28] Firm A had achieved a local content percentage of 95% for drum brakes, and could meet the price of its closest Chinese competitor; it has achieved 90% for disc brakes, and its price was

[29] In order to get around the obstacle of a premium segment, one foreign firm producer developed a "de-featured" excavator in 1998-1999, but the feedback from consumers was that it looked "cheap" and the firm abandoned the effort. Interview 122107.

[30] Labor input measured in hours was higher in China, but this was more than offset by the lower wages.

[31] In the case of a foreign firm making braking systems, for example, design changes to the caliper reduced the complexity of the machining that was required, and thus the type of CNC machines that suppliers need to use. This allowed the foreign firm to significantly increase local sourcing.

[32] Chery provides an example of this dynamic. The QQ, the model that was the key to its rapid rise, is often used by foreign firms as an example of IPR violations. A Chinese version of the story is that the key designer on the project, Ni Shaoyong, developed a mini-car at Dongfeng-Citroen, but was so frustrated by the limited power of a local designer to push a project within a JV structure that he moved

with 14 colleagues to Chery's home-base of Wuhu and started a design firm that worked under contract for Chery. Liu Tao, "China's Auto Design: Paths and Dreams," *China Entrepreneur*, 20 January 2007.

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Table 1: Domestic Output and Market Shares

Year	Total Domestic Output	Exports	Imports	Total Domestic Sales	Market Shares		
					Domestic firms	FIEs	Imports
	Billion RMB	Billion RMB	Billion RMB	Billion RMB	%	%	%
				Aggregate			
1995	5440.0	1147.8	1143.6	5435.8	67.7	11.3	21
2004	19362.1	5460.1	4516.1	18418.1	56	19.1	24.9
				Construction Equipment			
1995	11.3	0.8	2.9	13.5	73.0	4.9	22.0
2004	59.7	4.2	13.8	69.3	59.8	20.4	19.5
				Vehicles			
1995	106.9	1	8.2	114.2	64.2	26.6	7.2
2004	562.6	5.1	39.1	596.6	37.3	56.1	6.6
				Machine Tool			
1995	10.4	1.7	14.1	22.8	36.8	1.4	61.8
2004	36.6	5.3	50.1	81.5	33.5	5.0	61.5

Source: China's Industrial Census, 1995 and 2004, and UNCOMTRADE data.

Table 2: Heavy Construction Equipment Market in China

Year	Total Sales by Firms Mfg in China		Domestic Demand		Imports		Exports		JV-WOS % of Domestic Market		Imports % of Domestic Market		Chinese firms % of Domestic Market	
	WL	EX	WL	EX	WL	EX	WL	EX	WL	EX	WL	EX	WL	EX
1997	17,404	3293	15,704	9202	1,164	6623	2,863	714			7.41	71.97		
1998	17,254	4238	17,296	8753	431	4728	389	213			2.49	54.02		
1999	18,819	5988	18,991	7434	438	1602	266	156			2.31	21.55		
2000	20,857	7926	20,748	9034	297	1333	406	225			1.43	14.76		
2001	26,352	12397	26,076	13451	217	1624	493	50			0.83	12.07		
2002	43,348	19710	42,693	22259	287	2886	942	337			0.67	12.97		
2003	69,666	33982	69,723	61392	441	28200	384	790			0.63	45.93		
2004	91,334	33614	90,985	48848	568	18673	917	2874			0.62	38.23		
2005	107,354	33862	103,620	48040	396	18017	4,130	3839			0.38	37.50		
2006	129,834	49625	120,946	70018	469	28397	9,357	8004	14.25	54.42	0.39	40.56	85.36	5.03

Source : 1997-2006: China Construction Machinery Industry Yearbook, 2007, pp. 10-12.

Table 3: Top 10 Wheel Loader and Excavator Manufacturers in China, 2006

	Wheel Loaders		Excavators	
Rank	Firm	Sales # of units	Firm	Sales # of units
1	Liugong (D)	20,193	Sumitomo (F)	8,354
2	Longgong (D)	20,016	Komatsu (F)	6,891
3	Xiamen gongcheng jixie (D)	16,734	Hitachi (F)	4,955
4	Lingong (D)	14,273	Cat (F)	4,477
5	Xuzhou gongcheng jixie (D)	9,222	Hyundai (F)	3,440
6	Shandong shangong (F)	8,049	Hyundai (F)	3,155
7	Chengdu shengang gongcheng jixie (F)	7,230	Guangxi wanglin (D)	3,426
8	Changlin (DE)	6,374	Chengdu shengang (D)	2,923
9	Shandong futian zhonggong (D)	5,159	Shandong fulin (D)	2,107
10	Zhongguo yila jituan (D)	4,385	Zhongguo yila jituan (D)	1,734
All Firms		129,834		49,625
Of which:	Foreign	17,235	Foreign	38,102

Note:

a. Total sales refers to the number of units sold both domestic and overseas.

b. D refers to a domestic firm, and F to a foreign firm.

c. Caterpillar took a minority position in Shandong shangong in 2005, and then later acquired the rest.

Source: China Construction Industry Yearbook, 2007.

Table 4: Production, Consumption, Trade and Pricing of Metal Cutting Machine tools, 1997-2006

	1997	2000	2003	2006
PHYSICAL UNITS				
Production	9,051	14,053	36,813	85,756
Consumption	15,200	23,480	52,383	107,482
Imports	6,200	11,155	23,320	33,693
Exports	965	1,728	2,840	11,967
VALUE TOTALS (US$ Billion)				
Sales of Domestic Producers	0.22	0.49	0.74	2.74
Consumption	0.74	1.27	2.87	7.00
Imports	0.54	0.81	2.18	4.47
Exports	0.02	0.03	0.06	0.28
Market Share of Imports (% of Sales)	73.3	64.1	76.0	63.9
Market Share of Imports (% of Units)	40.8	47.5	44.5	31.3
Unit Value CNC Imports ($US)	87,419	72,972	93,396	132,669

Unit Value CNC Exports ($US)	22,798	19,676	19,366	23,063
Unit Value of CNC domestic sales by domestic producers	24,363	36,998	20,297	33,352
Ratio of unit values of Import:Export	3.8	3.7	4.8	5.8
Ratio of unit values of Import: Domestic Sales	3.6	2.0	4.6	4.0

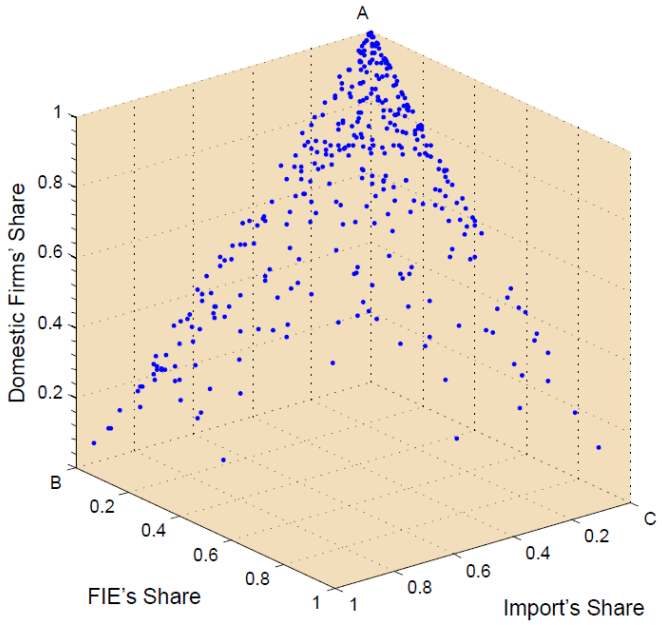
Source: China Machine Tool and Tool Industry Yearbook, various years

Table 5: Domestic Consumption of Machining Centers, 2005

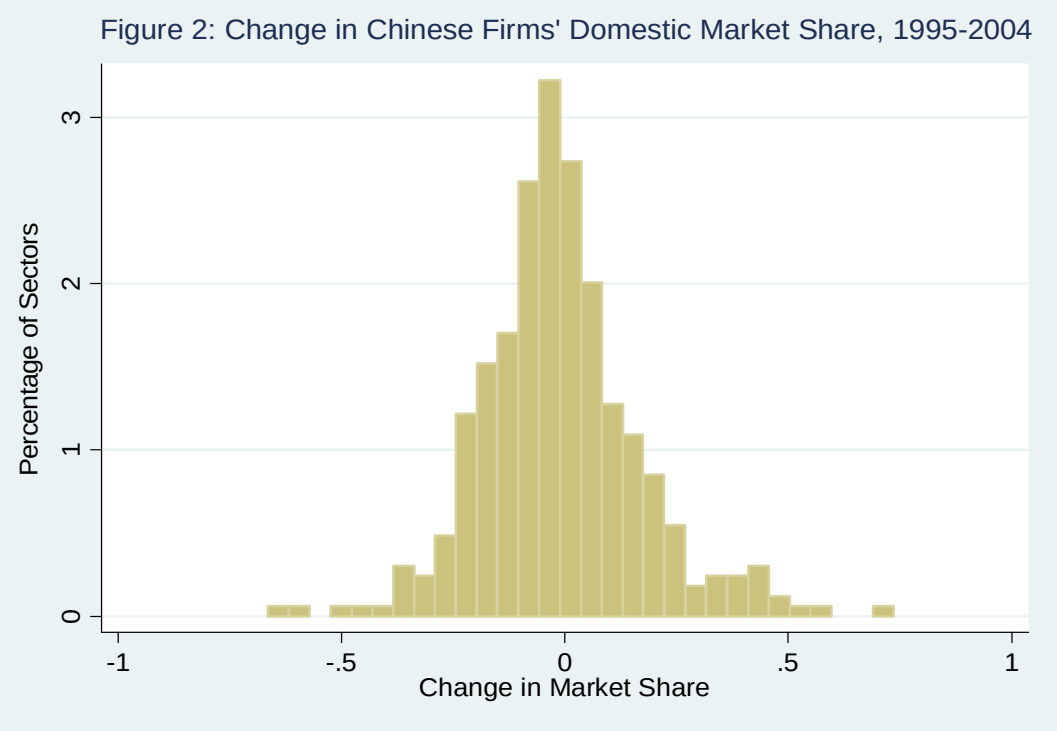
	Quantity				Value (Billion $US)				Average Price		
Type	Total	Imported	Domestic	% Imported	Total	Imported	Domestic	% Imported	Imported	Domestic	Ratio
Vertical	11625	8133	3492	0.70	0.823	0.637	0.186	0.77	78,323	53,265	1.47
Horizontal	1950	1326	624	0.68	0.544	0.460	0.084	0.85	346,908	134,615	2.58
Plano	600	295	305	0.49	0.215	0.123	0.092	0.57	416,949	301,639	1.38
Other	825	589	236	0.71	0.088	0.078	0.010	0.89	132,428	42,373	3.13
Total	15000	10343	4657	0.69	1.67	1.298	0.372	0.78	125,496	79,880	1.57

Source: China Machine Tool and Tool Industry Yearbook, 2006, pg. 222.

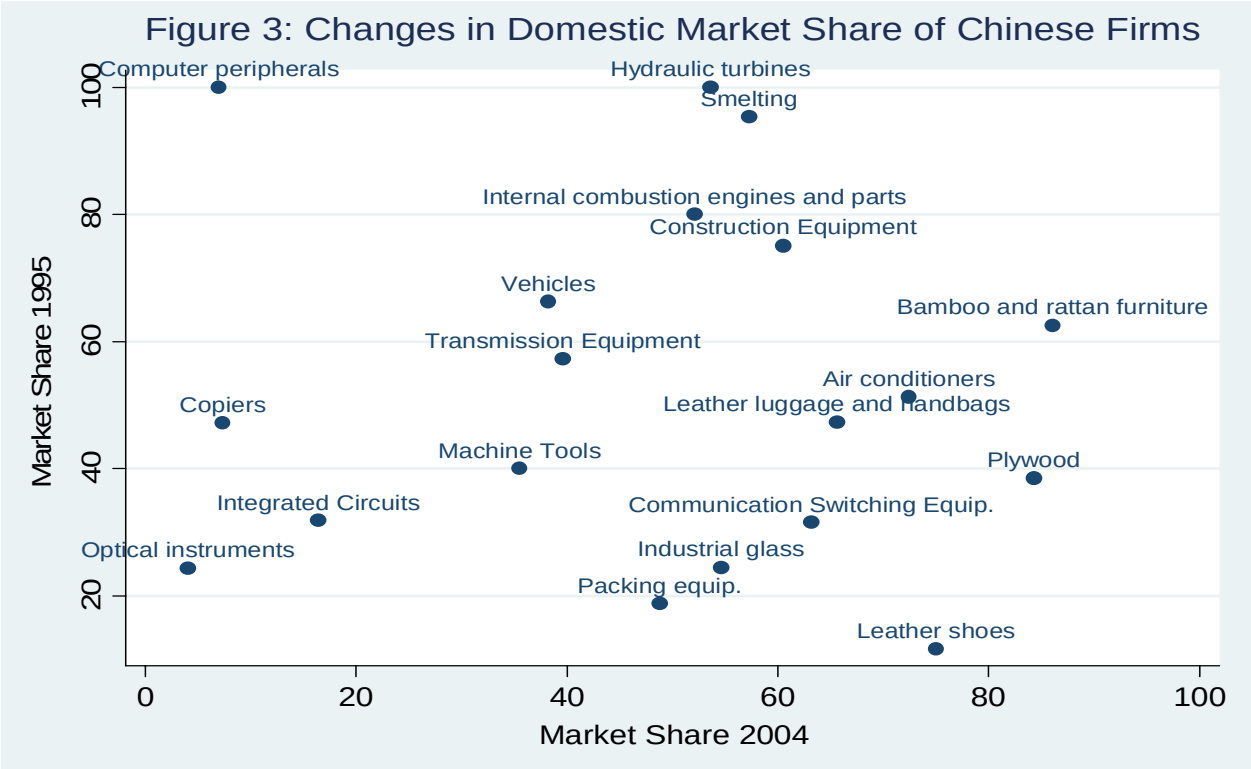
Figure 1: Domestic Market Shares



Source: Based on data from the 1995 Industrial Census and UN Comtrade data for China.

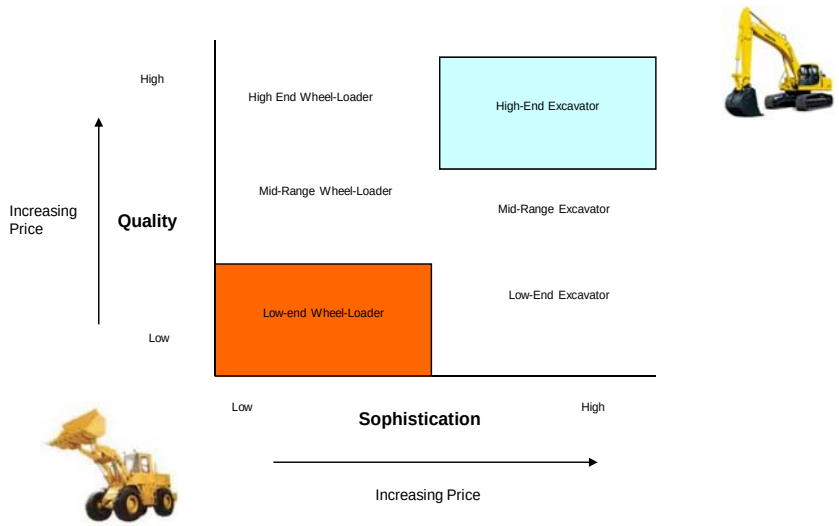


Source: Based on data from the 1995 and 2004 Industrial Census and UN Comtrade data for China for the same years.



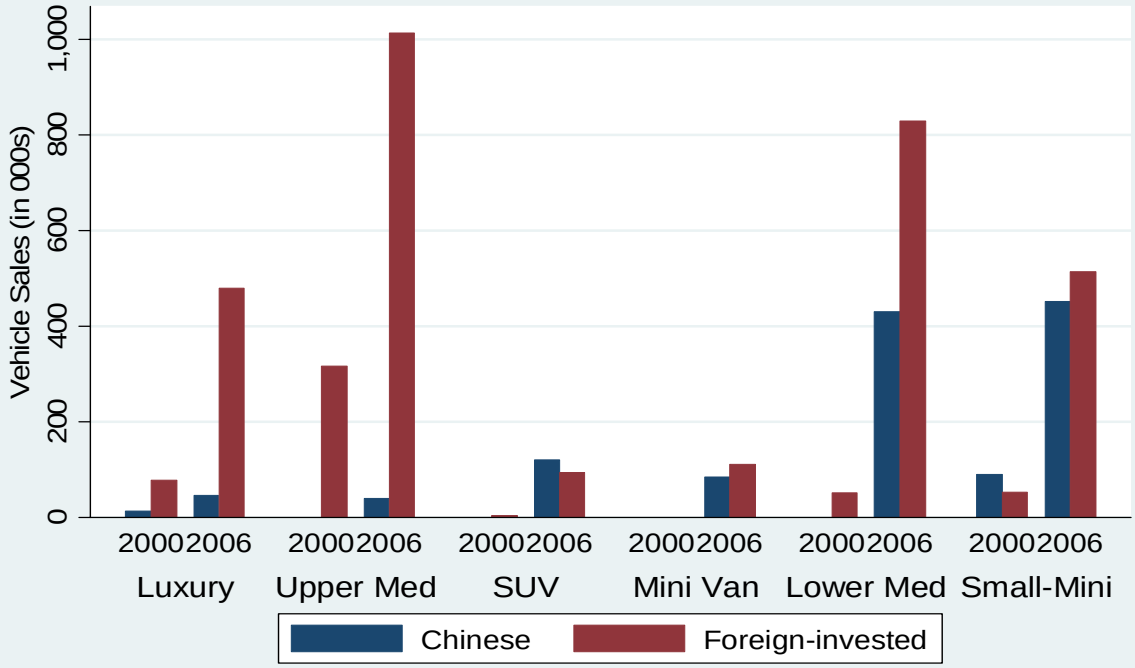
Source: See Figure 2.

Figure 4: Market Segments in the Construction Equipment Sector

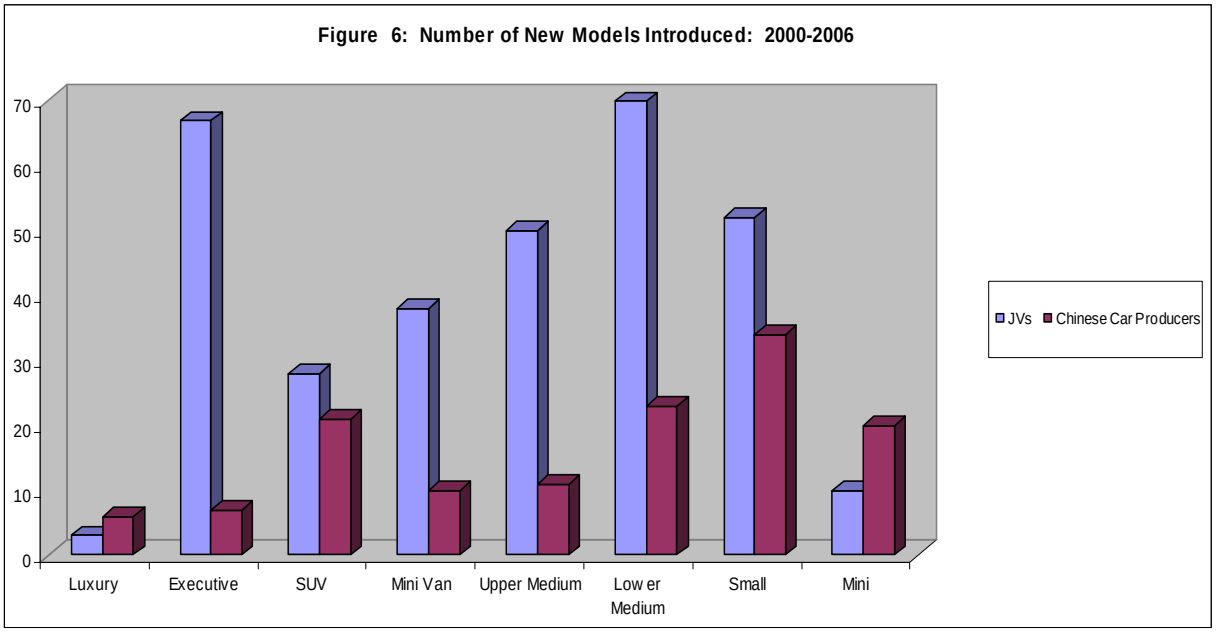


Source: Firm interviews.

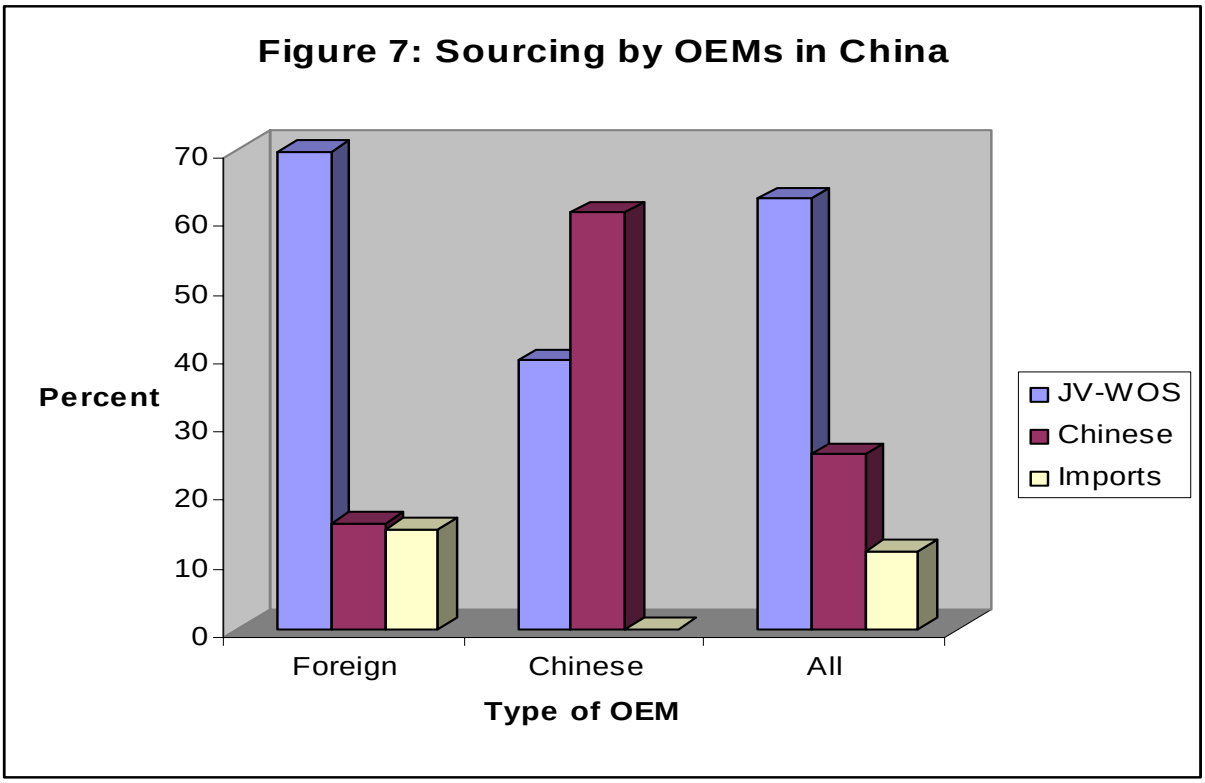
Figure 5: Car Production in China by Market Segment and Ownership



Source: Author's calculations based on data from JATO Dynamics.

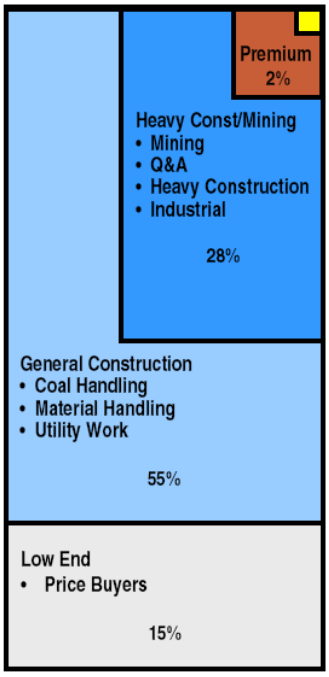


Source: See Figure 5.



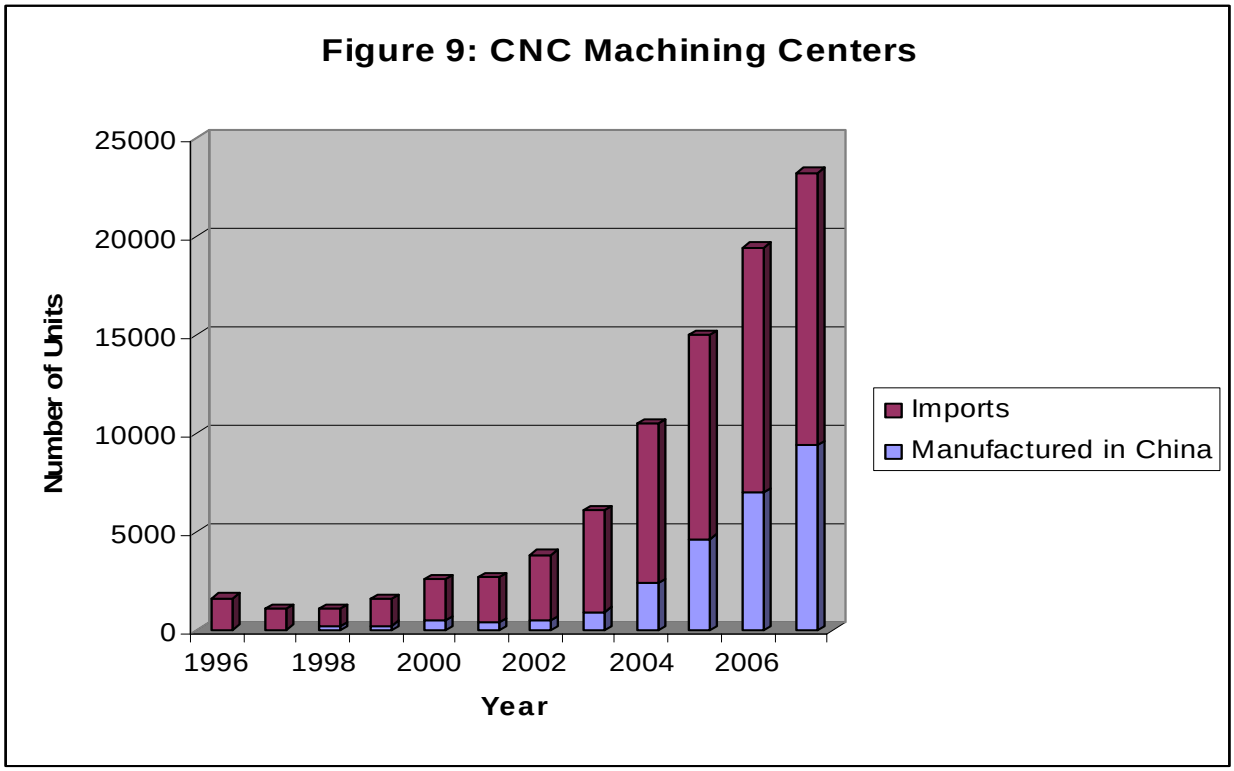
Source: Author survey of OEMs (6 foreign and 2 Chinese) in China.

Figure 8: Segmentation in the Chinese Wheel Loader Market



Customer Profile	Industry 2007	Industry 2016	Main Competitors
World Class Segment: best machine, with the best technology and custom-ized service; product is dealer-maintained with total product support	~100	~1500	CAT, VOLVO, KOMATSU
Premium Segment: buy machines because uptime is critical and customers have a long-term planning horizon.	~3000	~14000	KOMATSU, LiuGong, SEM
Heavy Const/Mining Segment: machines for use in aggressive environments with good reliability performance. These customer have slightly longer time horizon and desire good support.	~35000	~55000	LiuGong, SEM, XCMG, SDLG
General Construction Segment: buy machines for material handling and general construction applications. Focus is on price, quality, support. Generally short-term horizon.	~70000	~65000	中国龙工, 厦工机械, CHENGGONG
Low End Segment: New entrant customers with extremely short-term focus and buy only on price	~20000	~7000	

Source: Internal Analysis of Leading Multinational Construction Equipment Manufacturer.



Source: China Machine Tool and Tool Industry Yearbook, 2006 and 2008.