INDUSTRY STUDIES ASSOCIATION

INDUSTRY STUDIES ASSOCATION
WORKING PAPER SERIES

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

By

Loren Brandt
University of Toronto
Toronto, Ontario, Canada
brandt@chass.utoronto.ca

and

Eric Thun
University of Oxford
Oxford OX1 1HP United Kingdom
eric.thun@sbs.ox.ac.uk

2009
Industry Studies Association
Working Papers

WP-2009-04
http://isapapers.pitt.edu/

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

Loren Brandt
University of Toronto

and

Eric Thun
University of Oxford

Second Draft

7 April 2009

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 industry-level data and interview data from both OEM and key supply firms in 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 development model in which industrial upgrading efforts are domestically-driven *and* globally integrated and intensely competitive.

Key Words
China, industrialization, FDI, skills formation, developmental states, transitional economies

Contact information for Loren Brandt
Address: 150 St. George Str., 303, University of Toronto, Toronto, Ontario M5S 3G7 Canada
Tel: 416-978-4442.
Email: brandt@chass.utoronto.ca

Contact information for Eric Thun
Address: Park End Street, Saïd Business School, Oxford OX1 1HP United Kingdom
Tel: 44 1865 288789
Email: eric.thun@sbs.ox.ac.uk

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 favour 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; strict domestic content requirements were the norm in many sectors. China's leaders were impressed with the developmental success of their neighbours to the East, and a dominant lesson of the East Asian "model" of development was that government should play a role in creating the space for domestic firms to grow and develop the capabilities needed to compete globally.

When China finally acceded to the World Trade Organization (WTO) in 2001, there was a widespread fear that liberalization was happening too quickly. Chinese firms were not yet prepared for the rigours 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. Although aggregate data on the relative market shares of domestic and foreign firms often indicate a shift in favor of the latter, the worst of the initial fears were not realized. Following entry into WTO, market competition increased dramatically in China, but instead of losing market share to foreign firms, indigenous firms in many sectors have increased market share and, in some cases, deepened their technological capabilities in the course of making the transition into higher-value added parts of the value chain. The purpose of this paper is to provide evidence of this success and to offer an explanation for it.

How can we explain the capacity of Chinese firms (or lack thereof) to upgrade their capabilities in certain industrial sectors? We believe the answer to this question lays in an analysis of the competition for the rapidly expanding domestic market in China, and in particular, the middle of this market. Although exports have been critical to China's growth, an important dimension of the competition and the upgrading process lies in the interaction between domestic and foreign invested firms that are largely competing in China's domestic market, a market that for some key sectors has grown three to four folds in the last decade. The huge size of this market has provided ample room for entry and expansion in many sectors

without the need to go outside, as was often the case for Korean, Japanese and Taiwanese firms. Within this market, intense competition—a product of lower tariff barriers and an increase in imports and entry by both foreign-invested and domestic firms—has raised the threshold level of capability that firms must achieve in order to survive.

China represents a new development model in that industrial upgrading efforts are domestically-driven *and* globally integrated and intensely competitive. This combination of a domestic-market focus and intense competition offers a new set of opportunities and constraints for firms that are struggling to upgrade their capabilities.

In this paper we analyze the dynamics of competition in three key industrial sectors in China: automotive, heavy construction, and machine tools. The same trend is present in each of these sectors. At the low-end of the market, which is dominated by Chinese firms, consumers are largely indifferent to quality and firms compete on the basis of price. At the high end of the market, where quality is critical and consumers are less sensitive to price, imports and foreign-invested enterprises (FIEs) dominate. The level of competition in each of these sectors has been increasing, but domestic and foreign firms often compete in different segments of these markets. Moreover, significant barriers to entry inhibit each from easily encroaching on the share of the other. Foreign firms are rarely able to meet the price points demanded by consumers in the low-end of the market, allowing domestic firms the benefit of being insulated from foreign competitors. Analogously, indigenous Chinese firms rarely have the deep knowhow to design, manufacture and market products to compete with foreign firms in the high-end.

Neither the domestic nor the foreign firms are content to remain in their respective segment, however. For the domestic firms, the competition at the low-end is intense: low technical barriers to entry and the wide availability of designs have exposed these firms to heavy entry from below, primarily by non-state firms the last decade. Firms struggle to upgrade their technical and manufacturing capabilities so that they can escape the intense competition and low profit margins at the bottom. Success is influenced by many factors, but among the most important are the resources inherited from the planned economy and the ability to take advantage of the benefits of incorporation in the global economy (i.e. human capital,

supply relationships, etc.). For the foreign firms, rapid growth in the size of the mid-range market in China provides a powerful lure, particularly in sectors where growth in global markets is slow or stagnant. Success is influenced by their ability to adapt their products for the domestic market in China, lower costs through increased local sourcing, and more generally, their ability to adjust their operations so as to be able to achieve the price-level demanded by this market.

The result is the fight for the middle: 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 cost-cutting efforts of foreign firms lead them to localize their operations more aggressively than would otherwise be the case, and this provides a new range of upgrading opportunities for Chinese firms.

In the first section of the paper we consider two of the dominant approaches to industrial upgrading in East Asia. This review is not meant to be exhaustive, but is simply intended to demonstrate the difficulties these approaches have in explaining what is happening in China. In the second section we analyze the dynamics of competition in the Chinese domestic market 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.

I. From Export-Led Growth to Domestic-Led Upgrading

Exports have been the crucial driver of economic growth in East Asia 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 developmental state explanation of rapid growth in East Asia followed closely from Gerschenkron's logic, with Japan (Johnson 1982) and Korea (Amsden 1989) classic examples

of "late" development. 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. Scale and scope were critical to this model: they translated into cost savings (due to fuller capacity utilization and bulk purchases of inputs), allowed for more learning-by-doing, and made it possible to spread the fixed cost of design over larger output volumes (Amsden and Chu 2003: 7). The subsequent export-push of national firms was important not only because it contributed to higher volumes, but also because export performance provided the government a measure by which to evaluate the success of sectoral interventions (World Bank 1993: 22-23).

The developmental state model has had great appeal to Chinese policy-makers, but implementing this approach is not without its problems. Putting aside a recent re-evaluation of the earlier developmental state literature (Pempel 1999; Stiglitz and Yusuf 2001), it is not clear how easy it would be to adapt a developmental state approach in China. First, the rules of the WTO would make it difficult. Second, even prior to WTO accession, China was far more open than its neighbors were at comparable levels of development. As Branstetter and Lardy (2008: 635) point out, high formal tariff barriers to imports were often deceptive because of exemptions extended to imports that were required for export-processing or that were tied to foreign direct investment (FDI).[1] Even more important, and in stark contrast to its neighbors in Northeast Asia, is China's openness to FDI. 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 might 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).[2]

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 chains 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 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).[3] 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 (Bazan and Navas-Aleman, 2004; Navas-Aleman and Bazan, 2005; Lee and Chen, 2000) Because the organization of the chains vary 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. 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. We use aggregate The analysis combines

II. China's Domestic Market: Rapid Growth, but Who Benefits?

China's manufacturing sector has experienced enormous growth since the onset of economic reform, growth that has been especially pronounced during the last decade. There is little consensus about what is driving this growth and what types of firms are benefiting. Outside observers often focus on the export orientation of China, and include China in the category of developing countries that have pursued "export-led" growth. Within Chinese manufacturing, scholars have argued that domestic Chinese firms are stuck in low-value added activities (e.g. Steinfeld 2004), and the role of foreign firms has been increasing as the economy has liberalized. Aggregate figures on China's rapid export growth and the role of FDI and FIEs provide some credence to this view. In this section, we seek to provide evidence that aggregate figures often obscure the role that domestic Chinese firms play in Chinese industry and to demonstrate how a rapidly growing domestic market has provided new opportunities for domestic firm vis-à-vis foreign firms and imports.

The challenge at the aggregate 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. We utilize a combination of firm-level output data and trade data to provide estimates at the 4-digit CIC (Chinese Industrial Classification) level of the size and growth of the domestic market.[4] The domestic market is defined here 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 census years, 1995 and 2004. In 1995, the total value of sales to the domestic market from all three sources was 4.61 trillion RMB. Chinese firms captured more than the two-thirds of domestic demand, with imports and sales of FIEs making up the rest. As a consequence of the rapid economic growth between 1995 and 2004, the domestic market expanded fourfold to 18.7 trillion, implying an annual rate of growth of 15.6 percent. By 2004, however, Chinese firms had seen their share of the domestic market slip from 68.3 to 59 percent. Much of this loss was to FIEs, whose share of the domestic market rose by more than fifty percent, from 13.3 percent of output in 1995 to 21.8 percent in 2004. The share of imports rose only marginally from 18.4 to 19.1 percent. This evidence appears to support the argument that the Chinese market is gradually being conquered by foreign-invested firms.

While aggregate figures are useful, they can be misleading for two reasons. First, they obscure enormous heterogeneity among the more than four hundred 4-digit manufacturing sectors. Figure 1 provides histograms for the percentage of the domestic market captured by each of the three sources (Chinese firms, foreign firms, and imports) in these sectors in 1995. There are sectors in which Chinese firms had almost all of the market, and a few sectors primarily served by either imports or FIEs operating in China, but as a general rule, the domestic market was served by all three. As we will explain, imports typically served 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.

Our purpose in this paper is not to explain these differences, nevertheless, in Tables 2 and 3 we provide “representative” examples of sectors in which Chinese firms did either especially well or experienced a sharp drop in their market share. In both tables, we sort sectors on the basis of the initial share of domestic firms in 1995. As might be expected, the sectors in which Chinese firms did 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.[5] These two tables are complemented by Table 4, which provides representative examples of sectors on the basis of the share of FIEs in 2004. Again, the results are not unexpected. Foreign firms are gaining market share in the types of sectors that we would expect, those in which IPR, manufacturing know-how, design, and/or marketing are important.

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, Chinese firms may still be having success in a small but possibly rising number of market segments that may portend well for the future. This can only be revealed by a much more in-depth examination of such sectors that carefully dissects market segments within these sectors.

We roughly follow Gadiesh et al. (2007: 83) in defining market segments within a sector according to the quality, sophistication, and price-range that is demanded by consumers. At the low-end of the market, consumers are relatively indifferent to quality, the product meets relatively basic needs with minimal differentiation between competing products, and price is the primary purchasing criteria. The middle of the market is focused on value for money: consumers are seeking a good quality product but they will also demand a reasonable price. At the high end of the market, consumers with far more purchasing power demand a high quality product that may be more sophisticated in the range of functions that it performs as well as more highly differentiated with competing products. The manufacturing requirements within these segments of an industry can vary as widely as the requirements between sectors.

The most straight-forward means of distinguishing between segments within a sector is to look at product price, since the price will reflect a broad range of product characteristics valued in the market. It is important, however, to have an understanding of the product attributes in each segment because these are the characteristics that a firm is seeking to achieve as it moves from one market segment to another. At the risk of some simplification, we focus on two broad characteristics that might push a product from a low to a high price segment: quality and sophistication.[6] These two characteristics will sometimes co-vary, but not always.

Figure 3 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 blue box and the lowest-end segment (with the least expensive products) is the red box.

In order to provide the more fine-grained analysis of Chinese capability building that we believe to be necessary, we have selected three sectors: construction equipment, numerically-controlled machine tools, and automotive. These are cases where aggregate numbers would lead us to believe that Chinese firms were increasingly losing out to FIEs, or at best, weakly holding their own. In Table 5, we provide a breakdown for these sectors that is analogous to the aggregate level provided in Table 1.[7] From the perspective of 1995, the share of domestic firms was largest in construction equipment, followed by vehicles and then machine tools.[8] Between 1995 and 2004, the behavior in construction and vehicles closely parallels the trends we observed for all of manufacturing. 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, Chinese firms hold their own, but the role of FIEs in both the domestic market and exports rises.

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 situation for Chinese industry overall. This assessment is too pessimistic, as we will see when we look at each of these sectors in more detail. In the sector analysis that follows, we supplement data from industrial yearbooks and other sources with data that have been collected during firm-level interviews in China. In each sector we visited the key domestic and foreign OEM firms in the sector. Typically, a firm visit would involve multiple interviews with the managers of key departments within the firm (i.e. purchasing/sourcing, production, R&D, sales/marketing). Semi-structured interviews were conducted in English and/or Mandarin Chinese (depending on the respondent) and generally lasted for 45 to 60 minutes. We then used the same approach in visits to key suppliers in each sector. Since 2005, we have conducted approximately 150 interviews in the three sectors.

Autos

In 1986, the central government designated the auto sector as a "pillar" of the national economy. Development efforts for passenger vehicles focused on joint ventures (JVs) with foreign firms and the development of basic manufacturing capabilities in the sector. There were also a small number of wholly-owned domestic firms that began producing small cars with licensed-technology, but the primary emphasis of government policy was leveraging the desire of foreign firms to enter China as a means of gaining access to technology.

Segmentation in the market during this early period of growth was limited, primarily because it was an "institutional" market composed of state-owned enterprises (SOEs) and agencies, and competition was leisurely. By the late 1990s, slightly more than a half a million passenger cars were being produced, five out of every six of which were produced by FIEs. Roughly half of all cars produced was by JVs involving Volkswagen with Shanghai Auto and the First Auto Works, both of which were established in the late 1980s. Much smaller volumes were produced by relatively new JVs formed between General Motors (GM) and Shanghai Auto, and Honda and Guangzhou Automotive Industrial Group.

The competitive dynamics of the sector were radically transformed beginning in the years leading up to China's entry into WTO, driven by multiple causes: falling tariffs, increases in domestic capacity and supply, and rapidly rising incomes. 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 have always been lower, but they too have fallen 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. 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. Prices have decreased dramatically at the same time that car quality has improved.[9] As cost pressures on firms and the supply chain have intensified, firms have been forced to look for ways to improve

efficiency and productivity. By 2007, the domestic market share of Chinese auto manufacturers in terms of unit sold had increased to 30.3 percent. BYD, Chery and Geely were among the largest of the newly emerging Chinese firms.

To make sense of the success of domestic Chinese firms in the face of increasing competition, it is necessary to divide the overall market for autos into segments. In the Chinese context, a reasonable measure for product sophistication is engine size—low-end cars tend to have an engine displacement of 1.4 litres and below (mini-cars), the middle of the market is roughly 1.4 to 1.6 litres (compact cars), and the high end is above 1.6 litres (mid-size cars and bigger)—and the size of the car tends to co-vary with quality.[10] Smaller engine displacement is also much more likely to be associated with manual transmissions, as well as drum or disk brakes rather than automatic braking systems (ABS). In Figure 4, we provide a breakdown of production by six market segments for the FIEs and Chinese firms for 2000 and 2006.[11]

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.

Figure 5 provides a summary of the number of new models that were introduced by car segment. Although Chinese assembly firms, or original equipment manufacturers (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.

Construction Equipment

The foreign share of China's market for construction equipment has increased dramatically over the last decade (see Table 5). When the evolution of the sector is broken down by market segment, however, it becomes clear that domestic firms dominate certain segments and are making gains in others.

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. These two were selected because the sophistication of the products varies widely.[12] For both types of machines, reliability is critical. Due to the expense of the machines, both machines will often be operated 24 hours a day. The machines are also often used in extreme environments, where exposure to dust, dirt, and the elements more generally, can affect the performance of the machine. This imposes additional requirements on design and manufacturing.

The engineering of an excavator however 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; the electronic controls within the cab are like a video game; and the integration of hydraulics, engine, and electronics is complex. Manufacturing requirements are also significantly higher.

Within both the wheel loader and excavator segments, there is also significant heterogeneity. 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.

The Chinese market for the less sophisticated product, the wheel loader, is dominated by domestic firms (see Tables 6 and 7). Despite relatively low final tariffs, imports have been marginal, 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. These firms are almost

exclusively Chinese, they are largely SOEs, and the dominant firms have been increasing their overall market share. The share of the top 4 producers—Liugong, Longgong, Xiagong, and Lingong—has increased from 40 percent in 1999 to 65 percent in 2007, and these firms occupy a "premier" segment within the wheel-loader category.[13] In 2006, FIEs captured at most 14.25 percent[14] of domestic demand, and half of this was the result of Caterpillar's acquisition of a Chinese state-owned firm.[15] Volvo's acquisition of Lingong in 2007 increased significantly the role of FIEs to slightly less than 25 percent.

In contrast to wheel loaders, the market for the more technologically-sophisticated excavators has been dominated by foreign firms. Tables 8 and 9 provide information for excavators comparable to that discussed above for wheel loaders. Foreign firms serve the local market both through production in China (54.5 percent[16] of the market in 2006) and through imports (40.6 percent in 2006). At the high-end of the market the position of the multinational firms is not in danger of being challenged, but the high price of the products that these firms manufacture has opened the door for less expensive excavators. In the last three or four years, there has been significant entry and a very pronounced expansion in the production of excavators by Chinese 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 11 percent in 2007. Preliminary estimates for 2008 suggest a further rise, with Sanyi and Liugong emerging as important domestic players.

In short, although the foreign firms are secure in their dominance of the construction equipment market segments characterized by both high quality and high sophistication (the upper right segment of Figure 3), the domestic firms are moving into higher quality segments of the low-end products (wheel loaders) and the low-end of the high sophistication products (excavators).

CNC Machine Tools

China's machine tool industry is an over US $20 billion industry (2007 GVIO estimate)—smaller only than those of Japan and Germany—and is made up of nearly 2,500

firms and over a half a million workers. Rapid growth and upgrading in a broad range of domestic manufacturing sectors have driven the rapid growth in demand for machine tools in China, and since 2002 it has been the largest market for machine tools in the world.

Broadly defined, machine tools refer to any stationary, power-driven machine that is used to cut, shape, or form materials such as metal and wood.[17] We focus on the largest product segment in the machine tool industry: metal-cutting machine tools (*jinshu qiexiao jichuang*), the most important of which are lathes.[18] This segment includes both manually controlled machines and computer numerically controlled (CNC) machines, and represents approximately a third of the entire machine tool segment in China. CNC machine tools also differ significantly in terms of their complexity, and at the risk of some simplification, we will divide CNC machines into three basic types: 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.[19] These machines differ in terms of the speed, precision, and the complexity of the shapes that can be manufactured.[20]

Domestic demand for metal-cutting machine tools increased rapidly between 1997 and 2006, with the acceleration 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. 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 10).

The enormous increase in demand was met by both imports and Chinese production. Domestic production rose from 9,051 units in 1997 to 85,756 units in 2006, most of which was destined for the domestic market. Imports increased from 6,200 units in 1997 to 33,693 units in 2006. The percentage of domestic demand for CNC machines met by imports declined in quantity terms from 60% in 1996 to 31% in 2006, but this is slightly misleading.[21] Imported machines tended to be the more sophisticated machines that occupied the high end segment of the market (e.g. universal CNC machines and machining centers). The price of the average imported machine rose significantly between 1997 and 2006—reflecting increasing complexity

of the "average" import--and was on average 3.5 to 4 times more expensive than a domestically-produced CNC machine.[22]

Unfortunately, we do not have data that will allow us to provide the sort of breakdown of domestic sales that we provided for autos and construction equipment. 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. In the case of CNC lathes, which are half of the overall CNC market, Chinese firms have succeeded in raising their share of the domestic 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).

Domestic firms have also made significant in-roads with more sophisticated products 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 6). 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. Price data reported in Table 11 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, the average price of which was slightly more than $US 70,000, Chinese machining centers were a third less than the price of imports.

In summary, much like in autos and construction equipment, domestic machine tool producers appear to be dominating large and rapidly growing low-end market segments and gradually increasing their share of more sophisticated product segments. The key issue to understand is how the dynamics of competition within each of these market segments help a domestic Chinese firm take advantage of existing capabilities and to develop new ones. In the three sections that follow, we examine each market segment in turn.

III. 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 create 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).

What if a firm is focusing on its home market rather than export markets? Within the Chinese domestic market the "technology gap" confronting a domestic firm is smaller because at current income levels the market places a premium on 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 are widely available

(either through copying or licensing) and the manufacturing processes are not highly demanding and/or are processes with which domestic firms have extensive experience.[23] 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 Chinese firms face when exporting to advanced industrial countries will largely disappear when they focus on their domestic market. There is the potential 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 foreign firm that will face a "marketing gap" in China (at least initially), particularly when China is only a small portion of their overall portfolio. These firms will also likely be handicapped by a weaker sales and distribution networks.

The prospects for upgrading in the context of the domestic market are enhanced when the low-end segment is within the technical capabilities of domestic firms, the size of the low-end segment is large, and the rate of change within the sector is relatively slow.[24] The size of the low-end segment is important because the key benefit that a firm gains from dominating such a segment is high production volumes. High volumes facilitate learning-by-doing, support the development of a deep network of domestic supply firms (which in turn allows a domestic OEM to lower costs), and generate the revenues that support upgrading efforts. The rate of change is critical because it determines the ability of a Chinese firm to recoup the investment that upgrading requires. If the rate of change is too fast, a firm that has gone through a laborious and costly process of upgrading could find that market demand has already shifted by the time it gets its product to market. Firms will only invest in upgrading when they expect to receive an adequate return on their investment, and large low-end segments and a relatively slow rate of change increase the likelihood of high returns on the investment required by upgrading.

The sectors that we focus on in this paper all have large low-end segments and relatively slow rates of change, and these characteristics provided the foundation for upgrading activities. The low-end product in the construction equipment sector consists of wheel loaders, and this segment is dominated by domestic Chinese firms. Partly this success 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 CNC machines; the welding can be also done manually rather than robotically.

As important, however, is the depth of experience that Chinese firms have with this product. 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 use of designs that have been around for several decades in China has facilitated the development of a broad and low-cost supply base, and this creates critical cost-savings for the OEM, which generally out-source 60 to 70% of total costs.

In the Chinese machine tool industry, firms similarly combine a strong foundation in the industry with a specialization on less technically sophisticated product areas. 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 at 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. In the mid-1990s, the industry was highly dispersed. 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. Over the next decade, there was rapid expansion in CNC production, especially of economical (*jingjixing*) CNC machines. In the lathe segment of the market, there were more than 50 Chinese firms

producing 40,000 CNC lathes in 2006, for instance, 80% of which were classified as economical.

Several factors contributed to the rapid growth of CNC production at the low-end. Especially important was the entry and an increase in the number of producers. A majority of these firms were SOEs, which continue to dominate the market, but their numbers have fallen slightly as a result of bankruptcy and M&A activity. There has also been a significant increase in the number of private firms in the sector. Private firms often build 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 tap into a well-developed domestic supply base for critical parts and components that has emerged.

Key components going into the CNC machine—e.g. the spindle, bearings, ball screws, motors, and numerical controls—represent 70 percent of the cost, and are typically out-sourced. Initially, Chinese firms were forced to import many of these components, 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.[25] Common machine design means that Chinese manufacturers are often buying nearly identical components from the same set suppliers.[26]

To provide two examples, GSK in Guangzhou now dominates the market for low-end numerical controls, and in 2006, sold over 30,000 systems, or a third of the entire market.[27] Han River Precision Machinery Company in Shanxi has become the major domestic supplier of ball-screws. Both are critical to machine precision. Foreign suppliers have established operations in China, but they typically serve the high-end of the marker, including exports, and generally have prices that are 1/3 to 1/2 more expensive than their domestic competitors. Although the system and components produced by GSK and Han River 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.

The capabilities within the Chinese automotive industry at the start of the reform period were negligible, and consisted primarily of truck production. Efforts to develop capabilities in

passenger vehicles focused on joint ventures with foreign firms. The restrictions imposed on foreign firms were heavy—they were forbidden from holding more than a 50% stake in assembly projects and were required to quickly increase the percentage of components purchased form domestically-based firms—but the highly protected market and limited competition provided considerable incentive for foreign firms to be a partner in the developmental efforts of their domestic partners (Thun 2006). Few foreign firms were willing to bring their most recent technology to China—VW controlled over 50% of the market in the mid-1990s with a model based on 1970s technology—but in many respects, this was exactly what domestic firms needed: the technology that was being transferred and the capabilities that were being developed throughout the supply base was in line with the initial level of their manufacturing capabilities of Chinese firms and slow rate of change gave these firms time to improve. The primary complaint of the Chinese government was that there were few independent domestic brands that could compete with the foreign-invested joint ventures products.

When the terms of accession to the WTO were agreed upon at the end of the 1990s, few observers expected that an increase in competition would lead to the rapid growth of independent Chinese automakers, but this is exactly what happened. Firms such as BYD, Chery and Geely were able to take advantage of rapid growth in the low-end segment of the market, and currently, independent Chinese firms control nearly a third of the domestic market. A common explanation of this success emphasizes IPR violations, but this is only part of the story. Independent domestic firms are often more flexible because, unlike the foreign firms, they are not selling products that are designed for developed (and high-cost) markets. Their primary focus is the Chinese marketplace. They do not have to seek the approval of a global headquarters to certify new suppliers or launch new models, and when market demand shifts, they can respond quickly. Moreover, because their products are designed specifically for the low-end of the domestic market, the designs are based on a “good-enough” standard, which allows them to increase the use of low-cost suppliers (as opposed to the global suppliers that support the JVs).

To give one example, a domestic Tier 2 supplier in Zhejiang Province has both a JV and a wholly-owned facility that manufacture the same component. Both facilities are located in the same complex, and the management is the same. The JV achieves a defect rate of 50 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 observe in other sectors, the independent Chinese auto firms are taking advantage of a manufacturing base that was nurtured over the course of decades. A firm such as Shanghai Volkswagen was forced by the strict localization requirements to train domestic suppliers, many of which were JVs located in Shanghai, and as cost pressure increased, these suppliers were forced to train lower tier (and low-cost) suppliers in neighbouring Zhejiang and Jiangsu. These lower tier domestic firms are the core suppliers for the domestic OEMs. Summary data reported in Figure 6 from a 2006 study on OEM sourcing are illustrative in this regard. Sixty percent of first-tier suppliers to Chinese OEMs were domestic firms, compared to only 15 percent for OEMs from advanced countries producing in China.

In short, the Chinese domestic firms in the construction, machine tool, and automotive sectors achieved rapid growth by focusing on rapidly growing product segments in which the technical barriers to entry were surmountable and the rate of change was relatively slow. Domestic firms could combine their solid foundations in each of these sectors with their knowledge and capacity to meet the needs of domestic consumers in order to capture market share at the low-end. The relatively low barriers to entry in these segments are a double-edged sword, however: the competition between domestic firms within these segments is intense and profit margins are low. Product differentiation between producers of economical CNC machines, wheel loaders, and small cars is minimal, price competition is intense, and profit margins are low. This is exactly the type of dynamic that, according to Steinfeld, prevents firms from upgrading: "Once the cost pressures become too intense, rather than moving upward into higher end activities or taking the time to develop proprietary skills, the firms diversify into other low barrier markets (2004: 1976)." The expectation is that intense

competition will lead to cutthroat discounting and the proliferation of small producers because none are able to develop the proprietary knowledge that translates into a durable competitive advantage.

Despite this expectation, the evidence in the three sectors that we have analyzed indicates that the competitive environment has not prevented select Chinese firms from growing very rapidly and for gradual consolidation to have begun in some market segments.[28] The key question is why some firms emerge from the pack at the low-end and others do not. We will return to this question in Section V.

IV. Pressure at the Top

Multinational firms often enjoy a privileged place in China's economic landscape. With the benefit of superior technology and powerful brands, they are able to dominate the high value-added segments of the market. These are exactly the segments that Chinese firms aspire to occupy. The problem, however, is that the highest growth is in the low- and mid-range of the market, and the cost structure of a multinational firm makes it difficult to compete in these segments.

If a foreign firm is manufacturing in China, why is it not able to achieve the same cost levels as a Chinese competitor? The cost structure is closely tied to the global strategy of a multinational firm. Pankaj Ghemewat (2007: 199) 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 result 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.[29] 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).[30] 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 has been called "follow sourcing") or to import key components. 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.

The solution is for the multinational firm to shift from a global approach that emphasizes global economies of scale to an approach that allows for localization, or what Ghemawat would call adaptation. Localization can take place at multiple levels. At the assembly level, a first step is to move manufacturing operations to China, and at this point all major automotive, construction equipment, and machine tool manufacturers have operations in China. It is at the level of purchasing that localization is most critical: 60 to 70% of the total costs of final products in the automotive, construction equipment, and machine tool sectors consist of out-sourced components and it is here that costs can be most dramatically cut. Typically, the rate of location will rise as the technical sophistication of the product or model falls.

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, there were also many means of evading these restrictions.[31] Competition in the Chinese market forces the localization of purchasing far more comprehensively than government regulation because firms that rely too heavily on imported components (or global suppliers that import components) have difficulty lowering their costs. After the market share of Volkswagen 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.[32] Other OEM firms have made similar efforts, and the competitive pressure that drives these localization efforts spreads throughout the supply network.

Firm A, a global automotive supply firm operating in Shanghai, illustrates the manner in which competition forces localization. The firm was under pressure from its foreign OEM customers to lower costs and unable to win contracts from domestic OEMs due to high costs. The solution to both problems was increased localization. The source of the problem was not labor costs, which were only .5% of total costs (as compared to 30% in its home country), but the high standard of its manufacturing operations and the equipment that this requires. The foreign OEM that was its primary customer demanded a defect rate of 6 parts per million (PPM), which required a high degree of automation and expensive testing equipment. Domestic firms that produced the same component used a more labor-intensive manufacturing processes, testing consisted of a visual check at the end of the assembly line, and the overall cost structure was much lower.[33] Firm A could compete for the business of a foreign OEM by maintaining its quality level and lowering costs through increased out-sourcing, but it could not compete for the business of domestic OEMs (which accepted far higher defect rates) without very high rates of localization. When the localization rate was at 95% or above by value (i.e. only machining and assembly is done in-house), the firm could match the price of it Chinese competitors, but as the localization slipped below 90%, the Chinese competitors would have a 10-20% price advantage (Interview 083107).

A similar dynamic is evident in the machine tool industry. Initially, firms were largely involved in the machining of the base of the CNC machine, and assembly operations using imported parts and components, but 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.[34] One JV firm we interviewed put the costs of manufacturing universal CNC machines in 2007 in China compared to Japan, exclusive of the costs of the technology, at half, with a good portion of this coming from lower sourcing costs.

In the construction equipment sector, foreign firms are under the same pressure as in the other sectors, but because their dominant product (the excavator) occupies a premium segment, the opportunities for using domestic supply firms are fewer. Firms take great care not to outsource components that could sacrifice performance or components that involve core proprietary knowledge. The cutting edge of a bucket, for instance, is proprietary at one firm (and receives special heat treatment), and this will be imported from abroad while a local supplier makes the rest of the bucket (Interview 081007b).[35] The problem, of course, is that the high cost of these products prices them out of the largest portion of the domestic market in China.

A common solution in recent years has been to purchase (or invest in) a Chinese company. The acquisition strategy is attractive because it allows the foreign firm to avoid many of the problems that have been highlighted in this section: 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). The foreign firm acquires these low-cost operations and then seeks to upgrade the product by improving upon the processes and technology that the firm employs. It is sometimes easier to increase the capabilities of a low-cost domestic manufacturing operation than it is to decrease the cost at a high-cost foreign operation.

An aggressive approach to localizing 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).[36] 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.

V. Fight for the Middle

Thus far we have described two dominant dynamics in Chinese industry: the intense competition at the low-end of the market that drives domestic firms to search for a durable source of competitive advantage and the pressure on foreign firms at the high-end of the market to lower their cost structures. It is in the middle segment of the market that domestic and foreign firms clash, and the expectation in much of the existing literature is that foreign firms should have the upper hand in this contest. The intensity of the competition in Chinese industry limits the ability of Chinese firms to upgrade their capabilities and move beyond commodity production; the superior technology of foreign firms gives them a considerable advantage when they decide to lower their cost structures and move into lower end segments (Dunning 1988).[37] The data we presented in Section II, however, demonstrates that the reality is considerably more complex: there are firms that are upgrading their capabilities, evidence of

increasing concentration among domestic firms, and there are indications (albeit mixed) that domestic firms have made inroads in the middle segments of the market vis-à-vis foreign firms.

The initial challenge for a Chinese firm is to emerge from the scrum of domestic firms that are competing at the low-end of the market. This requires an escalation in firm efforts in capability-building—through investments in R&D, human resources, management processes, physical capital, etc.—that will enable it to improve the quality of existing products and to produce more sophisticated products. Firms undertake these investments under the belief that the market will sufficiently reward them to cover the costs of their investments. A firms' success will be ultimately tied to a variety of factors including its existing set of capabilities, its ability to take advantage of potential channels of capability-building, and its ability to finance the required new investments.

Over time, a combination of development and liberalization in the Chinese economy has expanded and deepened the channels through which firms can build capabilities and upgrade. These include tapping resources formerly bottled up in the state sector, the use of consultants, and especially interactions with foreign-invested enterprises operating in China. These have been complemented by an increase in outward FDI, which through mergers and acquisitions has been used by a small, but growing number of firms to help acquire critical capabilities.

In this section we focus first on the means by which some domestic firms are able to differentiate themselves from the many competitors within a sector. We then explain how the interaction of domestic firms striving to upgrade and foreign firms struggling to lower costs offers a new range of opportunities for domestic Chinese firms.

Leveraging existing capabilities

The ability of firms to take advantage of the various channels for capability building is critically tied to their existing set of capabilities. Some SOEs have successfully leveraged past investments in human resources, especially in design, engineering and manufacturing, as well as physical capital. These pre-existing capabilities are neither necessary nor sufficient condition for successful upgrading, of course; numerous SOEs have failed, while new private

firms that are highly entrepreneurial have emerged. There are common elements in the strategies that the successful state-owned and private firms have adopted, however.

SOE dominance in some sectors can often be attributed to an explicit policy-bias, but what is unusual in the case of autos, machine tools, and construction equipment is that the state-owned firms now compete in competitive markets alongside private and foreign firms. Although many of these firms continue to receive policy support, particularly from local governments, the primary advantage is the depth of experience with a particular product range. Extensive experience with a product design and strong engineering capabilities allow a state-owned firm 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.

In the construction equipment sector, for instance, there are hundreds of firms that produce wheel loaders, and most of them produce models that are derived from one of the three designs (3, 5, and 8 ton models) that the Ministry of Machinery licensed from Caterpillar in 1987. The dominant firm in the sector, however, continues to be the same firm that was the initial licensee of the 5-ton model. 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 Firm B 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.

A long history as an SOE also has disadvantages and many of these firms are struggling to restructure and improve governance, while at the same time seize the opportunity

provided by the depth of their resources. SOEs will often be less flexible than private firms (and thus products cannot change rapidly) and less efficient. In every sector, there are SOEs that have fallen by the wayside and ones that have continued to thrive. Our purpose here is not to explain this heterogeneity, but to note that some SOEs have made significant progress towards transforming themselves.

Private sector 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. They also face financing constraints compared to some SOEs. Nevertheless, in many cases they have managed to emerge as strong competitors. The most successful means of compensating for limited resources is to concentrate resources. 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.

Firm C, for example, is one of the most rapidly growing firms in the Chinese construction equipment industry. When the firm began producing concrete pumps in 1994, 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 (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. The primary competitors in the 1990s were SOEs that had management difficulties.

As Firm C 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. Total revenue was approximately 20 billion RMB, slightly less than half of which was from concrete pumps and mixers. In the automotive parts sector, many of the most successful private sector firms have employed similar strategies: they choose a component segment that they can dominate and then use the revenue from this segment to fund investment in upgrading.

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 products. Machine tool manufacturers benefited 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).

Channels of capability building: State sector resources

One of the most important channels for capability building is to draw on the resources that have been built up in the state sector over several decades. Key firms and research institutes were beneficiaries of state-allocated investment capital, human capital--particularly in design and engineering--and technology licensing arrangements with firms from advanced countries. These state-owned firms and institutes continue to play critical roles in these sectors, as do publically-funded universities, with which firms cooperate.

Since the mid-1990s, resources from the state sector have become increasingly diffuse as commercialization of research institutes, and market competition within individual sectors has increased. Both private and state-owned firms work with the former state-run research institutes as well as universities; the human capital that has been nurtured in state-owned firms (particularly with respect to engineering) begins to flow to those firms that offer the highest wages and most attractive working conditions; and bankruptcy in SOEs also often frees up valuable human resources, including entire R&D departments.

Channels of capability building: Role of the foreign sector

For both state and private firms, foreign firms have become a key source of knowledge and technology. The last decade, China has been the largest recipient of FDI in the world, and

in 2008 FDI exceeded $US 90 billion. FIEs have become an important source of competition for some Chinese firms, and forced them to utilize resources more efficiently and upgrade their capabilities. At the same time however, FIEs have become the most important channel of upgrading through demonstration and imitation effects, labor mobility, and backward and forward linkages (For a general discussion, see Crespo and Fontoura 2007). Many of these have already been alluded to. Foreign-invested firms have provided a demonstration of how to improve management processes, they train Chinese managers, introduce new technologies into the marketplace, and incorporate Chinese firms in their global supply chains (and thus increased the export capacity of Chinese firms).

One of the most explicit channels of upgrading 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 (Firm B above) 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).[38]

Uniqueness of Domestic-Foreign Interaction in China

What is unusual in China is not the form of the channels that transmit knowledge and technology from foreign-invested firms to domestic firms, but the manner in which competitive dynamics of the Chinese market affects the depth of these channels. The pressure on foreign firms to shed costs and capture a higher share of the middle segments of the market forces them to localize operations to a greater extent than otherwise, providing new opportunities for domestic firms. Labor mobility and supply chain linkages provide the clearest example of how the fight for the middle fosters upgrading opportunities.

Although the flow of talent between foreign-invested and domestic firms is hardly unique, the pressure on foreign firms to lower their costs in China encourages a shift of R&D activities from the home country to China. Having design capability within China facilitates the localization of purchasing and allows the customization of designs for the Chinese marketplace. It also serves to train Chinese engineers in the types of activities which, if not for the growing importance of the Chinese marketplace, would be conducted off-shore. As foreign firms expand their R&D efforts in China, they also expand the talent pool of engineers that can be tapped by domestic firms.

The incentive to localize the sourcing of components is similarly accentuated by the competitive pressures of the Chinese market. Again, the dominant global strategy of the firms in these three sectors is one of aggregation: they seek to maximize global economies of scales and limit the degree of adaptation to individual markets. In the high-end segments of the Chinese market, this strategy is feasible, but as firms move into the middle segments of the market, the degree of localization must increase both to lower the cost of the product and in order to adapt the product to the local market. In many instances the changes might be slight, but they can have a major impact on the structure of the supply chain.

In the auto sector, for instance, a foreign OEM is likely to continue to use a global supplier for systems that require extensive testing (such as airbags, ABS, and automatic transmissions for autos) and are technically sophisticated, but the price pressure exerted by the OEM firm will force the Tier 1 global supplier to outsource extensively to domestic firms. As the technical director at a domestic supply firm explained, a Tier 1 global supplier will receive a contract from an OEM firm for a module that might contain 20 components, but only 5 of these can be profitably manufactured in-house. The remainder is out-sourced to Chinese firms, but because the Tier 1 global supplier is responsible for quality levels, its engineers will carefully train and monitor the domestic firm (Interview 051607).[39] Similarly, as the OEM firm begins to design the products specifically for the Chinese domestic market, the integrated nature of vehicle design means that even small changes in a global design can have a large impact on the supply chain. Tier 1 suppliers in China must upgrade their design capabilities and each subsequent tier must increase their capabilities in order to meet the raised expectations.

Foreign firms in the construction equipment sector have been aggressively establishing design centres in China, and a primary purpose is to improve the capabilities of domestic suppliers in the interests of lower overall cost structures. One of the key characteristics that differentiate a foreign firm from a domestic firm in this sector is the ability to optimize the system in a product. The hydraulic system, for instance, needs to be synchronized with the rest of the excavator, and this requires close collaboration between individual components, subassemblies, and the final assembler (Interview 112108). As is common to firms in many

sectors when they first enter China, the foreign excavator firms initially rely heavily on foreign suppliers and imported components, but gradually seek to increase domestic content. The development of design capabilities within China allows the foreign firms to send design teams and quality engineers to the Chinese suppliers.

The competitive dynamic of the Chinese market not only accentuates the pressure on foreign firms to increase their utilization of domestic Chinese suppliers, thereby deepening the channels of upgrading created by these relationships, it also offers a new set upgrading opportunities for domestic suppliers with other domestic customers. This is of critical importance because the relationships between foreign firms and their domestic suppliers are a complex mix of collaboration and competition. At the same time that the foreign OEM firm seeks to pull a domestic supplier up the capability ladder, it will also seek to safeguard its own core technology. It wants to avoid nurturing a future competitor. However, the same domestic supplier will also have relationships with domestic OEM firms, and the needs of a domestic OEM are very different than a foreign OEM. 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. Whereas a foreign customer will work on a "build-to-print" basis—i.e. give the supplier detailed designs to a component—a domestic OEM will give the supplier the general specs of what is needed, and expect the supplier to provide designs and testing.

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. The natural conclusion, of course, is to have both sets of relationships; the one complements the other.

VI. Conclusion

In this paper we have sought to show how domestic Chinese firms in certain sectors have managed to upgrade their capabilities and capture market share, despite aggregate numbers to the contrary. In autos, machine tools as well as construction, several factors seem to be especially important to the upgrading prospects: the absolute size of the low-end of the market, the technology (product or process) in the sector relative to the capabilities of domestic firms, and the rate of change in the sector.[40]

The presence of a large (and rapidly growing) low-end of the domestic segment within the existing capabilities of firms provides an opportunity for domestic firms to increase production volumes and gain experience. It is the bottom rung on the upgrading ladder, and the production volumes and revenue generated within this segment that supports the upgrading activities underpinning the shift into the higher-end segment. The rate of change in the sector is also important. If the product characteristics within a sector change too rapidly, a firm may soon find the capabilities it invested in to be obsolete as market demand shifts.

When this market is demanding products that are of a technical or quality level such that only the strongest domestic firms within a sector are able to meet the demand (i.e. barriers to entry from below) and at a price that makes it difficult for foreign firms to compete (i.e. barriers to entry from above), there is a window of opportunity for strong domestic firms to emerge. This window may not be open forever however. Rising incomes and an increase in demand for higher quality and more sophisticated products in the domestic market may shift the advantage towards foreign firms.

The pressure on foreign firms to capture a larger share of the rapidly growing middle market segments is essential to the dynamic: it leads them to accelerate the localization of their China operations, thereby providing further opportunities for domestic firms. The role of this

pressure is a reminder of how important continued entry at both ends of the market can be to the upgrading process in China.

Perhaps the most beneficial consequence of the "fight for the middle" dynamic is the manner in which it bolsters supplier capabilities. A domestic OEM firm can often rapidly launch more sophisticated products by relying extensively on core foreign-made components. This may give the appearance of product upgrading, but it is a problematic strategy over the long-run because it often brings no cost advantage.[41] Upgrading at the OEM level must be accompanied by upgrading at the supply level, and both foreign and domestic OEMs play distinct and important roles in this process.

Because the foreign OEM firms are struggling to lower costs, they are increasingly willing to utilize domestic firms, and they work with these suppliers to improve their capabilities. Domestic OEM firms provide less technical assistance, but they provide suppliers with an opportunity to increase the breadth of their capabilities, and often high volume business. The combination of these two dynamics fosters capabilities at multiple levels in the value chain, with the depth of capabilities in the supply chain providing domestic firms a strong source of competitive advantage. The result is a developmental story that is quite different from the conventional export-led model: despite the intense competition within an open marketplace, domestic firms are able to build capabilities and move into higher value-added segments of the value chain.

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

[2] 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.

[3] 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.

[4] The firm-level data are from the 1995 and 2004 Industrial Census, which provide detailed firm-level information for all manufacturing firms in China on 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. 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 foreign-invested enterprises; 2) total exports, disaggregated between Chinese firms and FIE; and, 3) total imports. FIEs include both joint-ventures and wholly-owned subsidiaries.

[5] For example, starting from a very low base, the share of Chinese firms in the manufacture of leather shoes sold domestically rose from 11.6 to 75 percent. Chinese bamboo and rattan furniture makers, which in 1995 already supplied 62.5 percent of the market, succeeded in raising their share to 86.1 percent by 2004. These successes can be contrasted with sectors such as copiers, vehicles, perfumes, and hydraulic turbines, in which Chinese firms have loss significant market share. In these sectors, some combination of technology, manufacturing know-how, branding and marketing were more important.

[6] Quality refers primarily to product quality, measured in terms of reliability, durability, etc. but might also refer to quality of service (and in particular after sale service). Product sophistication is imprecise, but refers to the range of functions or the complexity of the technology in a product.

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

[8] In terms of size, the vehicles sector was clearly the largest; the total value of domestic output in 1995 was 107 billion RMB, or ten times the size of either of the other two sectors. One potential explanation for the differences is the tariff rates that were applied to these sectors in 1995. For 1998, we constructed estimates of tariffs at the CIC level. For vehicles, the tariff was 62.l percent, compared to 14.2 in heavy construction and 14.6 in metal cutting machine tools.

[9] Between 2000 and 2005, for example, the average annual drop in car prices calculated at the car model level was 9 percent. J.D. Power quality surveys indicate that cars produced by domestic firms continue to be far inferior to international levels, but much improved. J.D. Power uses a metric called "PP100," or problems per 100 vehicles. In 2006, the average for domestic firms in China was 368. This was far higher than the average for FIEs in China (189) or a U.S.-produced vehicle (124), but a significant improvement over the average for domestic firm's in 2000 (834). Lubo Li, "The Quality Drag on China's Car Industry," *Business Week*, June 29, 2007.

[10] This is largely a result of consumer preferences: the consumers that demand the highest quality in China also tend to prefer larger, more luxurious cars. In Europe, by contrast, small cars can be high or low quality.

[11] 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.

[12] Wheel loaders and excavators can also be used to perform some of the same tasks.

[13] 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).

[14] We do not have an exact breakdown for these firms of sales between the domestic and overseas markets. The 14.25 is calculated under the assumption that all of FIE's sales were to the domestic market.

[15] In 2005, Caterpillar took a minority position in SEM, and then acquired the rest of it in 2007.

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

[17] This would include: 1. metal cutting machines, e.g. lathes; drilling, boring and milling machines; grinding machines; machining centers; 2. metal forming machines, e.g. forging or die-stamping machines; forming and bending machines; 3. wood-working machines; 4. cutting tools; and 5. the mfg of machine parts and components, including numerical control devices, accessories, etc.

[18] A lathe is a particular type of machine tool that 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 contrast, for a machining center, the piece of material remained fixed.

[19] Table A.1 in the Appendix provides a more detailed breakdown in the case of lathes.

[20] 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.

[21] The fall in the percentage of CNC machines consumed domestically that were imported is actually even larger than suggested by the table. The Asia Financial Crisis in 1997 had a significant impact on demand in the sector, and imports dropped sharply the next few years. In 1996, imports represented 60 percent of domestic consumption.

[22] In interpreting the rise in unit values as an indication of rising quality, it must be remembered that falling tariffs, expanded entry, and increasing competition, all should have been putting downward pressure on prices.

[23] 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 refers 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.

[24] Our primary focus is on product change, and the product lifecycle varies widely between industries. In the shoe industry, a particular style of shoe might remain popular for six months; in the semiconductor industry, the life of particular family of microprocessors will tend to stay in the market for two to four years; in the aircraft industry, an aircraft design can endure for three decades (Fine 1998). Fine points to three types of change within an industry: product, process, and organizational. Fine, C. (1998). *Clockspeeed: Winning industry control in the age of temporary advantage*. Reading, MA: Perseus Books.

[25] 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.

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

[27] GSK is interesting in its own right. Numerical controls were initially imported from companies such as Siemens and Fanuc. By the late 1980s, early 1990s, a number of Chinese firms, including GSK, developed their own systems. Several of these firms left the market in the face of price wars with firms such as Siemens, but several have survived, and serve the low to low-middle end of the market. GSK has also invested heavily in developing NC systems for universal CNC machines, and more complex machining centers.

[28] For a discussion on the dynamics of entry, firm turnover, and market consolidation in China during this period, see Brandt, L., T. G. Rawski, et al. (2008). China's industrial development. *China's Great Economic Transformation*. L. Brandt and T. G. Rawski. New York, Cambridge University Press**,** 569-632.

[29] 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)."

[30] 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).

[31] 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).

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

[33] "In China, exceeding customer expectations is wrong!" the manager of the global firm explained. "You meet customer expectations. If you exceed customer expectations you will not be able to meet the price pressures (Interview 051807)." Depending on the component being produced, it is sometimes possible for a domestic firm to lower costs by changing the manufacturing process without sacrificing quality.

[34] Interview 070805.

[35] 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.

[36] 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.

[37] Technology, patents, management processes, and trade secrets are common examples of firm specific advantages.

[38] Chery provides on 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.

[39] At the same time, the global supplier will take care to prevent the domestic firm from acquiring core technologies and contracts will often specify the domestic firms from selling the component in particular markets.

[40] In future work, we will expand our analysis into sectors in which one or more of the above may have been missing. This will serve two purposes. First, it will help to confirm the role of the factors we identified. Second, it may help to see how government policy is trying to compensate.

[41] In fact, a domestic firm that is heavily utilizing foreign components will often pay a higher price than a foreign competitor because it is operating at lower volumes.

Amsden, A. A. (1989). *Asia's next giant: South Korea and late industrialization*. New York and Oxford: Oxford University Press.
Amsden, A. H. and W.-w. Chu (2003). *Beyond late development: Taiwan's upgrading policies*. Cambridge and London: MIT Press.
Bair, J. (2005). Global capitalism and commodity chains: Looking back and going forward. *Competition & Change* 9(2), 153-180.
Brandt, L., T. G. Rawski, et al. (2008). China's industrial development. *China's Great Economic Transformation*. L. Brandt and T. G. Rawski. New York, Cambridge University Press**,** 569-632.
Branstetter, L. and N. R. Lardy (2008). China's embrace of globalization. *China's great economic transformation*. L. Brandt and T. G. Rawski. New York, Cambridge University Press**,** 633-682.
China Machine Tool Industry Association (2007). *China Machine Tool and Tool Industry Yearbook*. Beijing: China Machine Press.
Crespo, N. and M. P. Fontoura (2007). Determinant factors of FDI spillovers - What do we really know? *World Development* 35(3), 410-425.
Dunning, J. H. (1988). The eclectic paradigm of international production: A restatement and some possible extensions. *Journal of International Business Studies* 19(1), 1-31.
Fine, C. (1998). *Clockspeeed: Winning industry control in the age of temporary advantage*. Reading, MA: Perseus Books.
Gadiesh, O., P. Leung, et al. (2007). The battle for China's good-enough market. *Harvard Business Review*, 81-89.
Gereffi, G. (1999). International trade and industrial upgrading in the apparel commodity chain. *Journal of International Economics* 48, 37-70.
Gerschenkron, A. (1962). *Economic backwardness in historical perspective*. Cambridge: Belknap.
Ghemawat, P. (2007). *Redefining Global Strategy: Crossing borders in a world where differences still matter*. Boston: Harvard Business School Press.
Huang, Y. (2003). *Selling China: Foreign direct investment during the reform era*. New York: Cambridge University Press.
Humphrey, J. and H. Schmitz (2002). How does insertion in global value chains affect upgrading in industrial clusters? *Regional Studies* 36(9), 1017-1027.
Johnson, C. (1982). *MITI and the Japanese miracle: The growth of industrial policy, 1925-1975*. Stanford: Stanford University Press.
Kennedy, S. (2005). China's Porous Protectionism: The Changing Political Economy of Trade Policy. *Political Science Quarterly* 120(3), 407-432.
Pempel, T. J., Ed. (1999). *The politics of the Asian economic crisis*. Ithaca: Cornell University Press.
Schmitz, H. (2007). Reducing complexity in the industrial policy debate. *Development Policy Review* 25(4), 417-428.
Steinfeld, E. S. (2004). China's shallow integration: Networked production and the new challenges for late industrialization. *World Development* 32(11), 1971-1987.
Stiglitz, J. E. and S. Yusuf, Eds. (2001). *Rethinking the East Asian miracle*. Oxford: World Bank and Oxford University Press.
Thun, E. (2006). *Changing lanes in China: Foreign direct investment, local governments, and auto sector development*. New York: Cambridge University Press.
Whittaker, D. H., T. Zhu, et al. (Forthcoming). Compressed development.
World Bank (1993). *The East Asian miracle: Economic growth and public policy*. Oxford: Oxford University Press.
Zeng, M. and P. J. Williamson (2007). *Dragons at your door: How Chinese cost innovation is disrupting global competition*. Boston: Harvard Business School Press.

Table 1: Domestic Market Shares

	Total Domestic Sales	Domestic firms	FIEs	Imports
Year	Trillion RMB	%	%	%
1995	4.6	68.3	13.3	18.4
2004	18.7	59	21.8	19.1

Table 2: Sectors with Big Increases in Domestic Market Share

		1995	2004	Change
Low Base: 0-25	0-25			
	Mini-motors	0	44.5	44.5
	Leather shoes	11.6	75	63.4
	Packing equip.	18.7	48.8	30.1
	Sports balls	19.3	68.2	48.9
	Industrial glass	24.4	54.6	30.2
Medium: 25-50				
	Communication Switching Equip.	31.5	63.2	31.7
	Cutlery	34.4	69.6	35.2
	Irrigation Equipment	35.4	71.4	36
	Compound Fertilizers	37.5	74.7	37.2
	Plywood	38.5	84.3	45.8
	Other ceramics	45.5	80.4	34.9
High: 50+				
	Bamboo and rattan furniture	62.5	86.1	23.6
	Leather luggage and handbags	47.3	65.6	18.3
	Air conditioners	51.3	72.4	21.1
	Household rubber pdts	60.1	82.5	22.4
	Metal structures	66	83.7	17.7

Table 3: Sectors with Significant Reductions in Market Share

		1995	2004	Change
Low base: 0-50				
	Optical instruments	24.3	4	-20.3
	Carbonated beverages	31.7	11.5	-20.2
	Motion picture equipment	32.8	3	-29.8
	Electric measuring instruments	35	10.5	-24.5
	Vacuum tubes	37.4	14.8	-22.6
	Copiers	47.2	7.3	-39.9
Medium: 50-75				
	Transmission Equipment	57.2	39.6	-17.6
	Cosmetics	58.5	40.1	-18.4
	Motor meters and instruments	59.3	41.8	-17.5
	Industrial organic chemicals	61.2	41.9	-19.3
	Vehicles	66.3	38.2	-28.1
	Hydraulic equipment and parts	70.2	48.7	-21.5
High: 75 +				
	Radar and radar parts	76.7	59.4	-17.3
	Internal combustion engines and parts	80	52.1	-27.9
	Smelting	95.3	57.3	-38
	Electronic calculators	100	21	-79
	Computer peripherals	100	7	-93
	Hydraulic turbines	100	53.6	-46.4

Table 4: Role of FIEs in China's Domestic Market

Market Share of FIEs	Percentage of All Sectors	Illustrative Examples
Percent		
0-5	14.5	Chemical fertilizers; optical instruments; metallurgy equipment; lead and zinc smelting; irrigation equipment
5-15	28.1	Spinning and weaving; machine tools; tractors; electric fans; transformers; printing equipment
15-25	22.6	Metal furniture; air compressors; construction equipment; fibreboard; paper products; dyestuff; cement products; optical glass; aluminum products; min--motors
25-50	26.2	Apparel; motorcycles; electronic components; air conditioners; washing machines; metal packing materials and containers; glass for industrial construction
50+	8.6	Vehicles; polyolefin plastics; communication terminal equipment; integrated circuits; television sets

Table 5: Domestic Market Shares

	Year	Total Domestic Sales	Domestic firms	FIEs	Imports
		Billion RMB	%	%	%
Construction Equipment	1995	11.33	75.2	4.4	19.8
	2004	59.71	63.5	20.8	15.8
Vehicles	1995	106.95	66.3	29.5	4.2
	2004	526.60	38.2	57.5	4.3
Machine Tool	1995	10.45	40.0	1.5	58.5
	2004	36.63	41.6	5.8	52.7

Table 6: Wheel Loader Market in China

Year	Total Sales by Firms Mfg in China	Domestic Demand	Imports	Exports	JV-WOS % of Domestic Market	Imports % of Domestic Market
1997	17,404	15,704	1,164	2,863		7.41
1998	17,254	17,296	431	389		2.49
1999	18,819	18,991	438	266		2.31
2000	20,857	20,748	297	406		1.43
2001	26,352	26,076	217	493		0.83
2002	43,348	42,693	287	942		0.67
2003	69,666	69,723	441	384		0.63
2004	91,334	90,985	568	917		0.62
2005	107,354	103,620	396	4,130		0.38
2006	129,834	120,946	469	9,357	14.25	0.39

Source : 1997-2006: Zhongguo gongcheng jixie gongye nianjian, 2007, pp. 10-12.

Table 7: Top 10 Wheel Loader Manufacturers in China, 2006

Rank	Firm Name	Firm Type	Total Sales 2006
1	Liugong	Domestic	20,193
2	Longgong	Domestic	20,016
3	Xiamen gongcheng jixie	Domestic	16,734
4	Lingong	Domestic	14,273
5	Xuzhou gongcheng jixie	Domestic	9,222
6	Shandong shangong	FIE	8,049
7	Chengdu shengang gongcheng jixie	FIE	7,230
8	Changlin	Domestic	6,374
9	Shandong futian zhonggong	Domestic	5,159
10	Zhongguo yila jituan	Domestic	4,385
All Firms			129,834
Of which:	Foreign		17,235

Note:

1. Total sales refers to both domestic and overseas.
2. Catepillar took a minority position in Shandong shangong in 2005, and then later acquired the rest.

Table 8: Excavator Market in China

Year	Total Sales by Firms Mfg in China	Domestic Demand	Imports	Exports	JV-WOS % of Domestic Market	Imports % of Domestic Market
1997	3293	9202	6623	714		71.97
1998	4238	8753	4728	213		54.02
1999	5988	7434	1602	156		21.55
2000	7926	9034	1333	225		14.76
2001	12397	13451	1624	50		12.07
2002	19710	22259	2886	337		12.97
2003	33982	61392	28200	790		45.93
2004	33614	48848	18673	2874		38.23
2005	33862	48040	18017	3839		37.50
2006	49625	70018	28397	8004	54.42	40.56

Source : 1997-2006: Zhongguo gongcheng jixie gongye nianjian, 2007, pp. 10-12.

Table 9: Top 10 Excavator Manufacturers in China, 2006

Rank	Firm Name	Firm Type	Total Sales 2006
1	Sumitomo	FIE	8,354
2	Komatsu	FIE	6,891
3	Hitachi	FIE	4,955
4	Cat	FIE	4,477
5	Hyundai	FIE	3,440
6	Hyundai	FIE	3,155
7	Guangxi wanglin	Domestic	3,426
8	Chengdu shengang	Domestic	2,923
9	Shandong fulin	Domestic	2,107
10	Zhongguo yila jituan	Domestic	1,734
All Firms			49,625
Of which: Foreign			38,102

Table 10: Production, Consumption, Trade and Pricing of Metal Cutting Machine tools, 1997-2006

	1997	2000	2003	2006
Number of domestic producers	NA	NA	391	451
Employment	NA	208,634	177,118	168,800
PHYSICAL UNITS				
Production	186,500	176,598	306,848	562,134
of which CNC	9,051	14,053	36,813	85,756
Consumption	147,200	158,417	282,989	NA
of which CNC	15,200	23,480	52,383	107,482
Imports	43,900	63,444	75,338	NA
of which CNC	6,200	11,155	23,320	33,693
Exports	83,200	81,625	99,197	NA
of which CNC	965	1,728	2,840	11,967
VALUE TOTALS (US$ Billion)				
Sales of Domestic Producers	1.38	1.56	2.30	7.00
of which CNC	0.22	0.49	0.74	2.74
% CNC	15.87	31.36	32.40	39.10
Consumption	2.06	2.57	4.89	12.9
of which CNC	0.74	1.27	2.87	7.00
% CNC	35.87	49.42	58.70	54.26
Imports	0.91	1.25	2.91	5.48
of which CNC	0.54	0.81	2.18	4.47
% CNC	59.76	65.00	74.97	81.57
Exports	0.23	0.25	0.32	1.16
of which CNC	0.02	0.03	0.06	0.28
% CNC	9.69	13.88	17.30	23.79
Import Share in Absorption by Value (%)	44.03	48.73	59.47	42.48
Import Share in CNC Absorption by Value	73.34	64.09	75.95	63.86
Import Share in CNC Absorption by Quantity	40.79	47.51	44.52	31.35
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 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

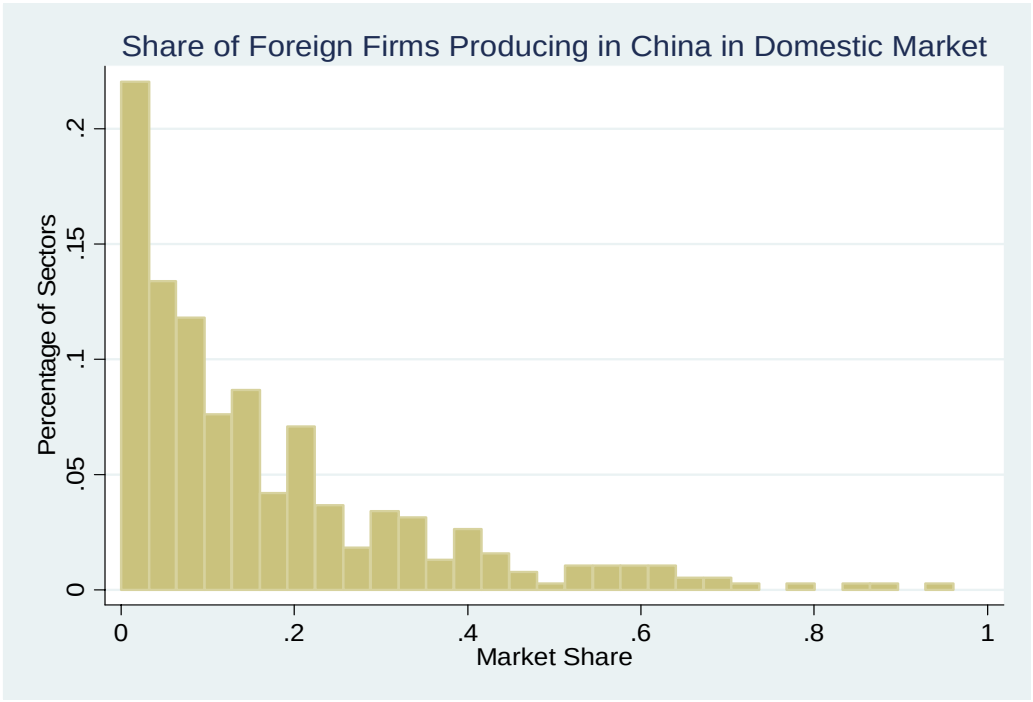
Sources: Machine Tool Yearbook, various years

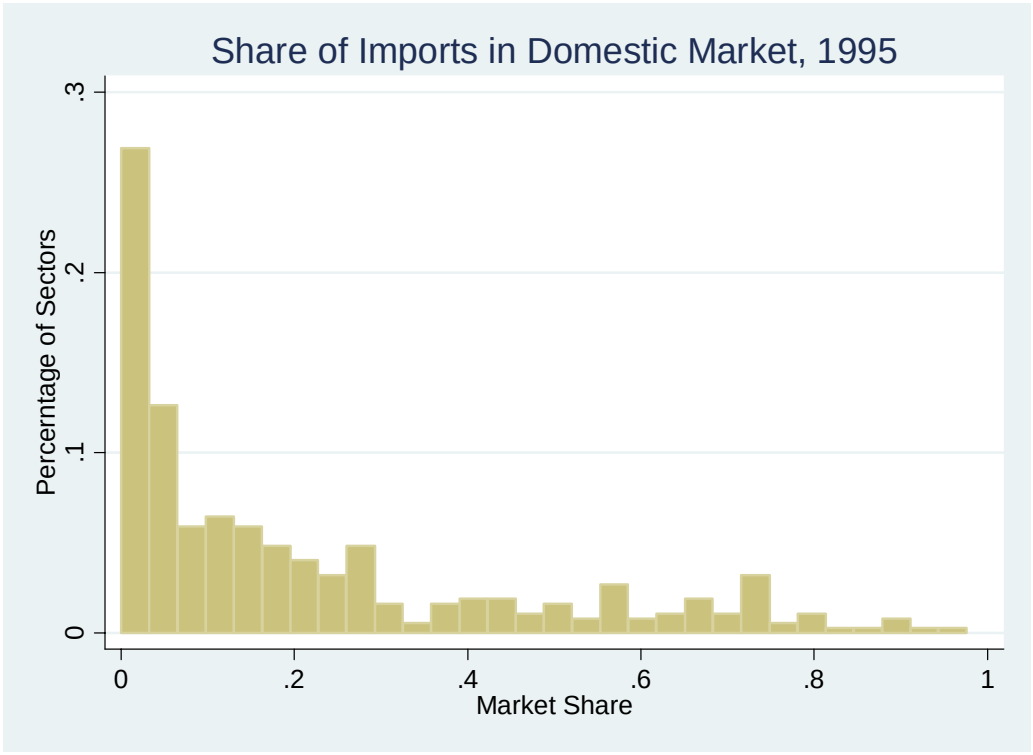
Table 11: Domestic Consumption of Machining Centers, 2005

	Quantity			% imported	Value (Billion $US)			% imported	Average Price		
Type	Total	Imported	Domestic		Total	Imported	Domestic		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	

Figure 1

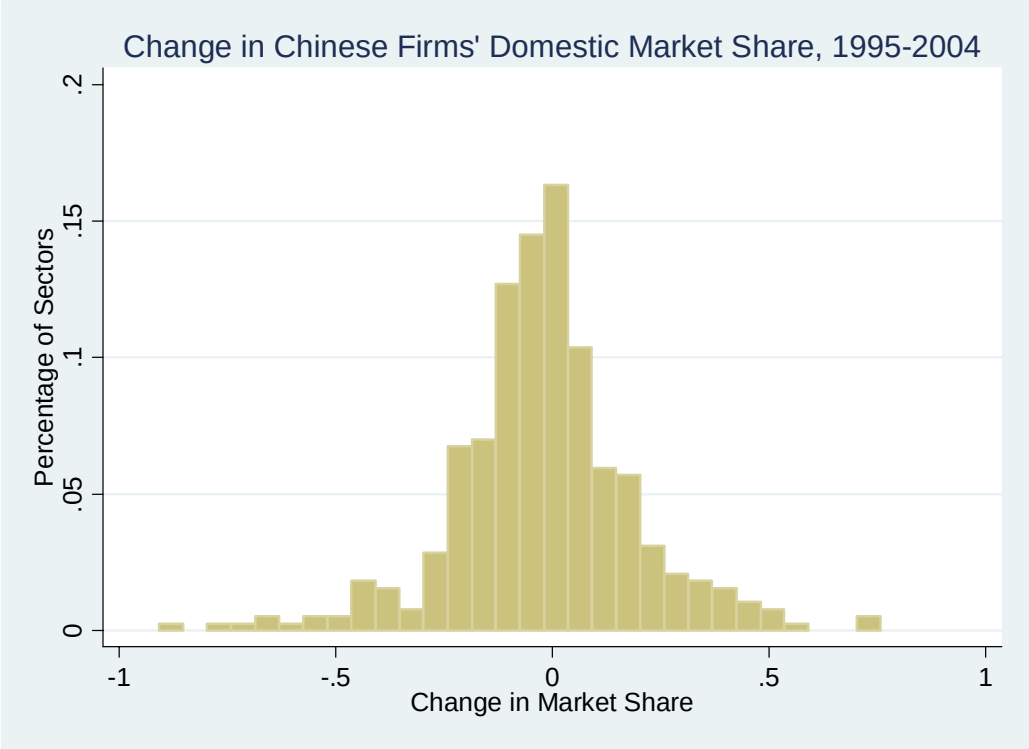

Share of Chinese Firms in Domestic Market, 1995
Percentage of Sectors
0
.02
.04
.06
.08
0
.2
.4
.6
.8
1
Market Share


Share of Foreign Firms Producing in China in Domestic Market
Percentage of Sectors
0
.05
.1
.15
.2
0
.2
.4
.6
.8
1
Market Share



Source: See text.

Figure 2



Source: See text.

Figure 3: Market Segments in the Construction Equipment Sector

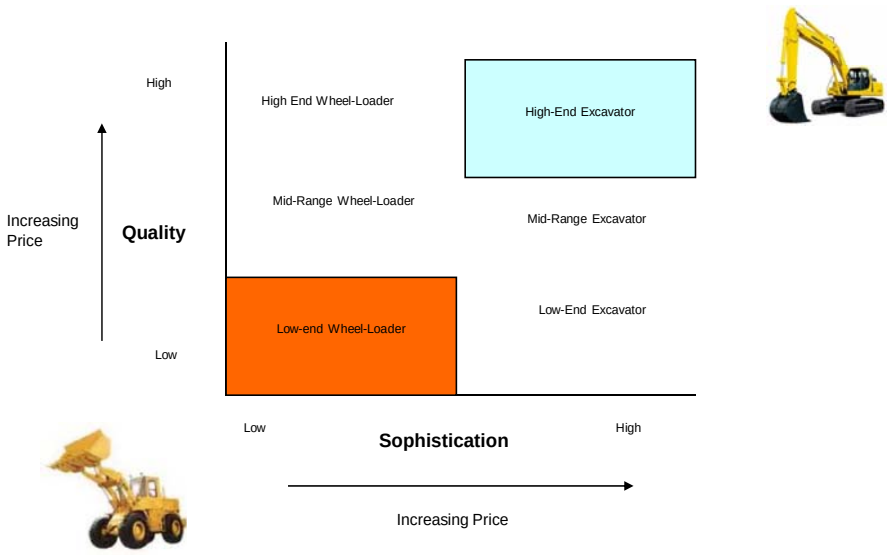


Figure 4

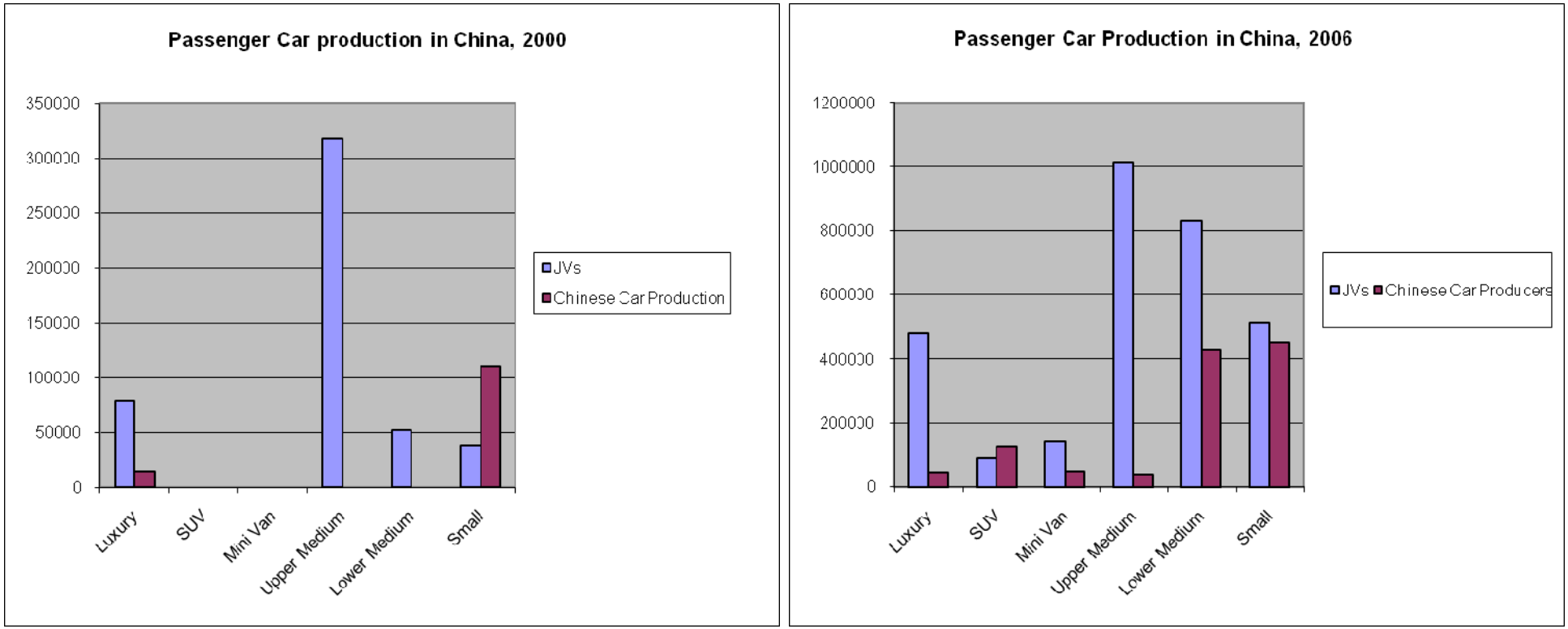

Passenger Car production in China, 2000
350000
300000
250000
200000
150000
100000
50000
0
Luxury
SUV
Mini Van
Upper Medium
Lower Medium
Small
JVs
Chinese Car Production
Passenger Car Production in China, 2006
1200000
1000000
800000
600000
400000
200000
0
Luxury
SUV
Mini Van
Upper Medium
Lower Medium
Small
JVs
Chinese Car Producers

Figure 5

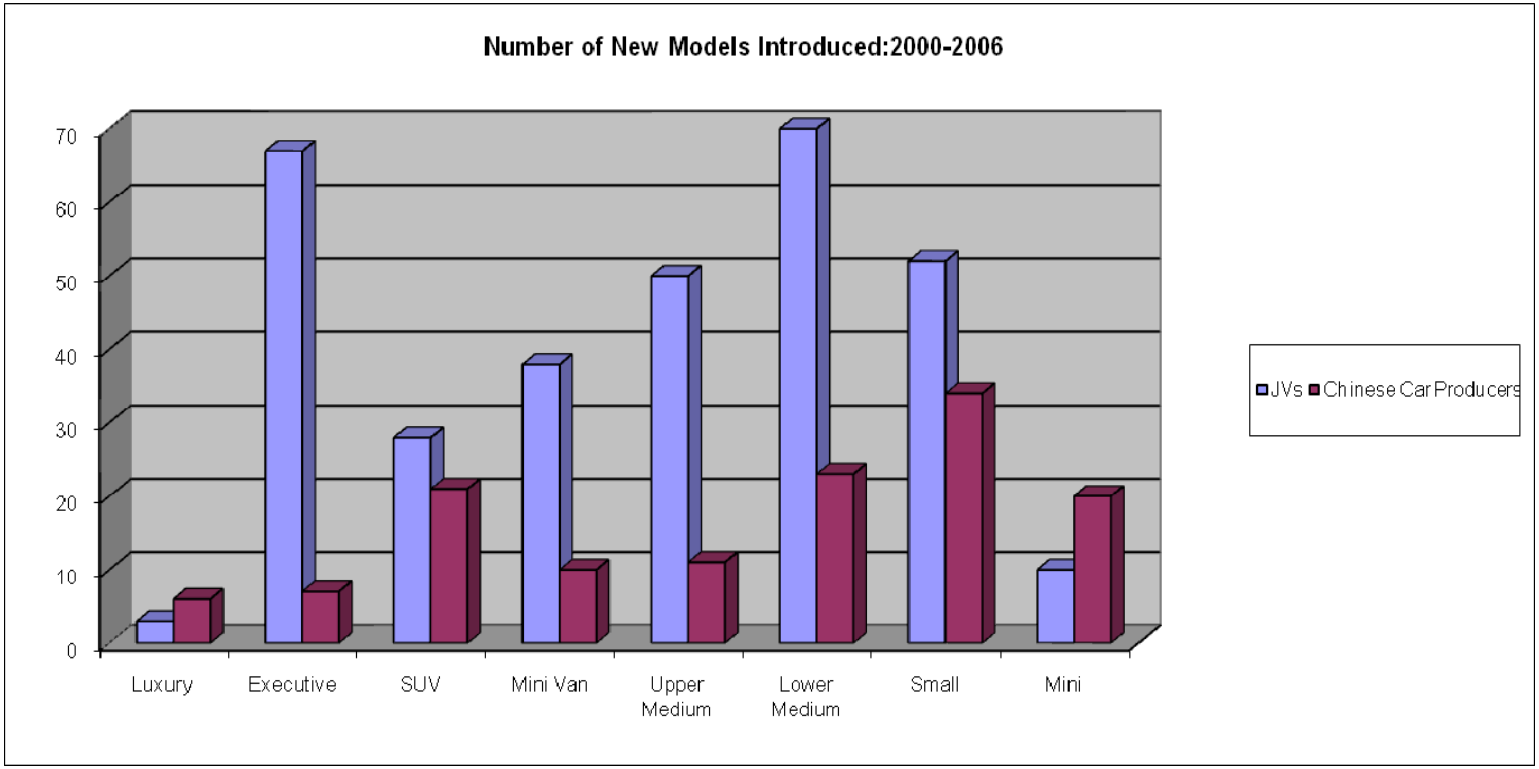
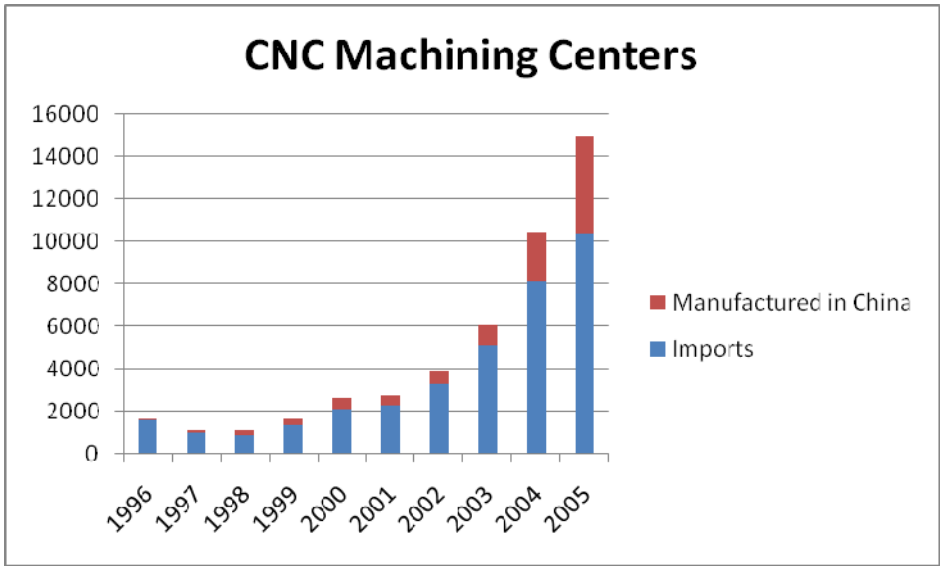
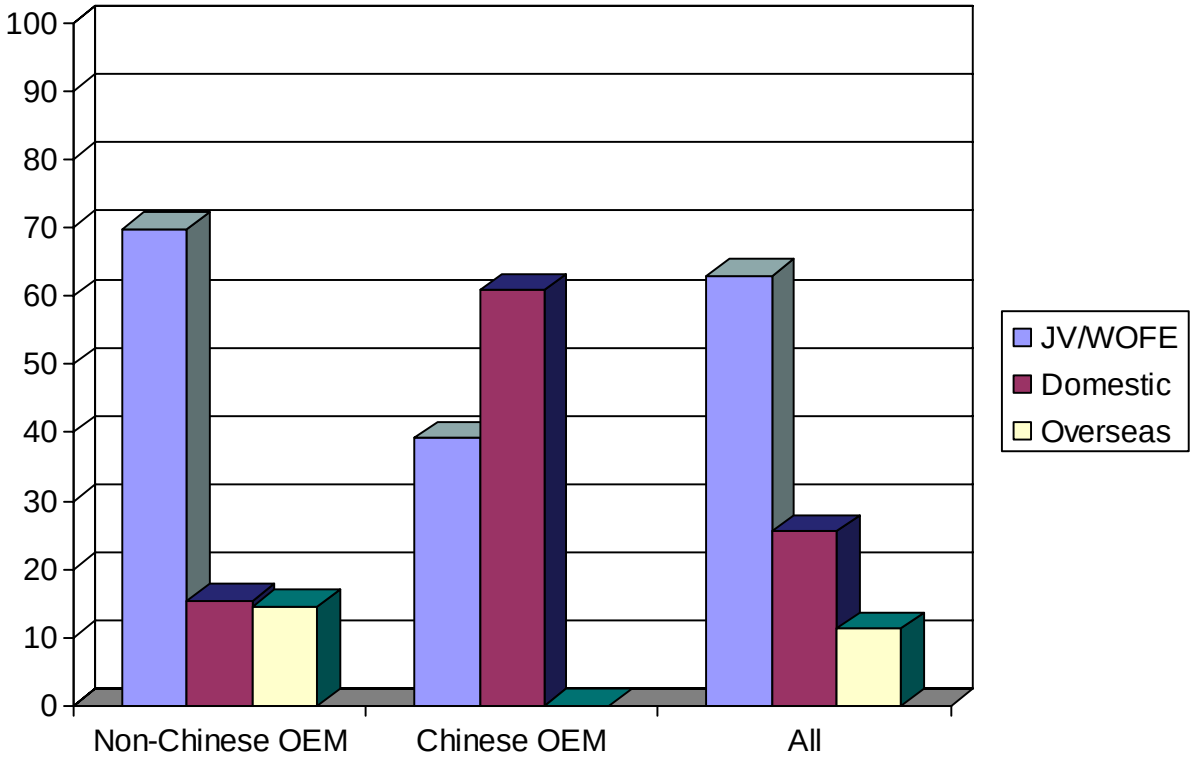

Number of New Models Introduced:2000-2006
70
60
50
40
30
20
10
0
Luxury
Executive
SUV
Mini Van
Upper Medium
Lower Medium
Small
Mini
JVs
Chinese Car Producers

Figure 6



Source: China Machine Tool Yearbook, 2006.

Figure 7: Sourcing by Auto OEMs



Source: Firm Interviews, 2006 and 2007.

Appendix: Taxonomy of Lathes

Economical lathes: Single axis, 4-tool vertical turret and flat horizontal bed configuration. Compared with the conventional non-CNC lathes, the economical lathes provide better machining precision, usability and efficiency. Shortcomings include the small number of tools on the turret, positioning accuracy, and the fact that spindle speed cannot be changed automatically. (Price is ~ typically between $US 12-15,000)

Universal type lathes: More technologically advanced than the economical lathes in a number of dimensions including turning ability, the properties of key functional components, and the NC system. In contrast to the single axis economical lathes, the universal lathe has 2 axes. They come in both horizontal and vertical models. (Price is ~ $US 50,000)

CNC Turning Centers: More complex than the universal lathe because it can achieve 3-axis or more simultaneous machining. It also carries out the turning operations with higher accuracy and faster cycle time. There are a number of different types of turning centers including horizontal turning centers, vertical turning centers, and modular turning centers. The trend in design has also been to develop centers with twin turrets and spindles. The advantage of two spindles (the second spindle is referred to as the sub-spindle) is that it allows secondary operations to be performed without operator intervention. The sub-spindle allows machining on both sides of the part in one operation, thereby improving concentricity, cutting set-up time, and labor costs for loading-unloading of the part. (Price is in upwards of $US 150,000).

CNC Turning/Milling Centers: Most complex of the CNC lathes because it combines a lathe with a machining center in order to harness the turning ability of the lathe and the milling ability of a machining center. Compared to a CNC turning center, the turning/milling center has an additional C-axis. The highest configuration of the CNC turning/milling machine has 5 axis, which allows for simultaneous machining on the X Y Z C and B axis. (Price in upwards of $US 500,000)