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Constructing a Ladder for Growth: Policy, Markets, and Industrial Upgrading in China

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Summary. — Indigenous firms in developing countries with large domestic markets have unique advantages: the low end provides "natural" protection from foreign competition, while higher-end segments provide incentives for foreign firms to localize activities and develop channels for future capability building. Paradoxically, in their eagerness to support development efforts of local firms, states often nullify these advantages and limit the opportunities and capabilities that local firms can leverage in the upgrading process. Using the case studies of three large industrial sectors in China that faced similar prospects but had widely different outcomes, this paper develops a framework for understanding how policy shapes the growth and segmentation of markets, and thus the opportunity for industrial upgrading of indigenous firms. The cases show how restrictive demand- and supply-side policies often inadvertently limited the opportunities for upgrading through their effect on the availability of know-how, inputs, and resources required for industrial upgrading (the supply side), and through their effect on the incentives for upgrading (the demand side). Given that each segment is a crucial rung on the development ladder, industrial upgrading efforts stall when state policy inadvertently knocks out rungs on the development ladder.

Key words — indigenous innovation, industrial upgrading, technology transfer, quality ladders, emerging markets, China

1. INTRODUCTION

Understanding the relationship between foreign and indigenous innovation in developing countries has long been a central focus of the development literature. The relationship is often portrayed as treacherous: states seek to draw on the knowledge and skills that can be gained from foreign firms, while at the same time aiming to avoid becoming overly dependent on them. [1] This has been particularly true in the context of export-led growth where foreign firms with advanced technologies have obvious advantages in selling to developed markets.

In recent years, scholars have asked whether emerging economies with large domestic markets might have special advantages in navigating the relationship with foreign firms because they are not as dependent on export markets (Brandt & Thun, 2010; Fu & Gong, 2011; Zhou, 2008). Within their home market, indigenous firms have more appropriate technology, products, and knowledge for the more price-sensitive low-end segments of the market, while foreign firms have an advantage in the high-end segments. Over time, the large and rapidly growing middle segments of the market provide incentives for both sets of firms to depart from their competitive strengths and to invest in the capabilities required to "fight for the middle" segments of the market (Brandt & Thun, 2010; see also Herrigel, Wittke, & Voskamp, 2013). Competing at home may offer opportunities that global markets do not.

Although a large domestic market provides potential opportunity for indigenous firms, there are no guarantees. China, for instance, has enjoyed productivity growth in manufacturing over the last 15 years that has been as high if not higher than rates observed in Japan, Taiwan, or Korea over similar periods in their development (Brandt, Von Biesebroeck, & Zhang, 2012); however, the role of indigenous Chinese firms within sectors varies widely. In some sectors domestic firms are rapidly becoming globally competitive and gaining market share while in others they continue to be dominated by foreign firms (Brandt & Thun, 2010). Similarly, in the case of Brazil, there are sectors where indigenous firms have benefited from the large domestic market (e.g., furniture and footwear, see Navas-Alemán, 2011) but there are also sectors where they have failed to do so (e.g., machine tools, see Alcorta, 2000).

In order to understand the dynamics of the increasing number of emerging economies that have both large-scale and rapid growth (Nadvi, 2014; Sinkovics, Yamin, Nadvi, & Zhang, 2014), it is necessary to shift attention from the traditional supply-side focus of an export-led growth model toward an understanding of how domestic demand in conjunction with local supply factors shapes the opportunities for indigenous firms. Just as a basketball team with several seven-footers is likely to employ different tactics than a team of more modestly sized players, a large emerging market has a range of policy options that smaller markets do not.

In this paper, we compare three Chinese manufacturing sectors—autos, heavy construction equipment, and motorcycles—that in principle offered similar opportunities for domestic firms to advance because technologies were relatively mature and domestic markets were huge and rapidly growing, but in only one of which have domestic firms succeeded. While Chinese construction equipment firms have rapidly narrowed the gap with multinationals in key market segments, huge differences persist in autos and motorcycles, and appear to be widening.

We argue that these outcomes are largely a product of differences in how state policy shapes the "fight for the middle"

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dynamic articulated in Brandt and Thun (2010). In a large emerging market, government policy influences the opportunities for upgrading not only through their effect on the availability of know-how, inputs, and resources required for industrial upgrading (the supply side) but also through their effect on the incentives for upgrading (the demand side). When growth in a developing country is export-led, the supply side is typically the crucial concern for policymakers, largely because the demand side is determined by global markets rather than national policy. With domestic-led growth, the two sides are equally important and highly complementary; moreover, policy choices made on one side of the equation often have unanticipated consequences on the other side. For example, policies used to mobilize resources on the supply side to help serve certain segments might inadvertently constrain domestic demand in other critical market segments; conversely, policies used to limit/boost demand in key market segments might limit the supply of firms, technology, inputs, and/or skills that are essential for future industrial upgrading.

Governments often take an active role in the development process, and the signs of an activist state can be found in each of our case studies. What is critical here is that policy makers should take care not to nullify the natural advantages that come with a large domestic market. A large, contested low-end segment, for example, can protect domestic firms as effectively as tariff protection and does not carry the difficulty of having to know when the infant industry stage has passed. Related, a large higher-end segment provides incentives for foreign firms to localize activities more effectively than allowed by stringent local content requirements, which are usually all too easily evaded. Given that each segment of the market plays a crucial role in the development process, our analysis suggests that the objective should be to implement "segment-neutral" policies that do not knock rungs out of the developmental ladder.

In the next section of the paper we use the concept of quality ladders to refine our view of how domestic Chinese and foreign firms compete, link this to the innovation and upgrading literature, and explain the relationship to policy. The third section is an explanation of our methodology. In each subsequent section, we show how policy influences the structure of the quality ladders in each sector, and how this related to the opportunities and/or constraints indigenous firms faced during the development process. As might be expected in sectors in which the upgrading process is largely incremental and unfolds over the course of decades, history matters: the roots of the differences between sectors lie in important policy choices in the 1980s and 1990s, the full consequences of which we see clearly today. A penultimate section extends the argument to cases of telecommunications and wind turbines. In the conclusion we return to the implications for policy.

2. CONSTRUCTING A LADDER

Our starting point is an examination of how firms from developing and developed economies compete. Differentiation on the basis of product quality plays a central role, a dynamic captured in the economics literature by the notion of quality ladders. [2]

In a product market, firms compete through vertical product differentiation, with each firm deciding the level of quality to supply on the basis of their own capability, input costs, and the price consumers are willing to pay for each level of quality (performance). [3] In this setting a ladder in quality emerges—higher rungs, higher quality, and higher prices—with firms producing the highest quality typically enjoying the highest profits. Because of better access to human resources, capital, and technology, richer countries have an advantage in producing higher-quality products, while lower labor costs provide poorer countries a competitive advantage in manufacturing lower-quality, less expensive versions of the same products. The length of the ladder in a product market will depend on the premium that consumers put on quality (Khandewal, 2010).

Our focus is on the ability of firms to produce and capture market share in successively more demanding and higher-quality product segments within a sector. Over time, movement up the quality ladder is critical for firms in developing countries in order to escape the intense competition characteristic of low-end markets where barriers to entry are low. [4] These pressures are compounded by the fact that success in lower-end product segments eventually leads to rising wages for firms, while rising incomes gradually reduce the demand for low-end products. In endogenous models of economic growth (Grossman & Helpman, 1991), firms with market power invest in R&D and innovative activity in order to move up the quality ladder and thereby escape the impact of competition lower down the ladder on firm profits.

Although there are instances when firms in a developing country might "leapfrog" those that came before, the development literature has long emphasized the importance of learning from earlier developers and making incremental changes and improvements to existing technologies in the context of relatively mature industries (Amsden, 1989; Amsden & Chu, 2003; Bernard & Ravenhill, 1995; Gerschenkron, 1962; Wade, 1990; Woo-Cumings, 1999). Innovation in this tradition is not the radical type that leads to new-to-the-world products, but is a process of gradual and relatively minor changes that cumulatively become important (Christensen & Rosenbloom, 1995; Dosi, 1982; Geroski, 2003; Henderson & Clark, 1990). This was the process by which firms in Japan (Womack, Jones, & Roos, 1990), Taiwan (Chen, 2009), and Korea (Amsden, 1989) moved into higher-value-added activities, and it has been identified as the dominant form of innovation in China (Breznitz & Murphree, 2011).

(a) *Export-led growth*

The starting point for much of the literature seeking to explain the successful cases of "catch-up" growth in East Asia is twofold: first, there is a large technological gap between local firms and global leaders; second, there is a gap in the knowledge local firms have about the export markets that they are targeting (Cimoli, Dosi, Nelson, & Stiglitz, 2006; Hobday, 1995; Schmitz, 2007).

In the developmental state literature, the primary focus is on how state policy enables firms to overcome constraints on the supply side. The state mobilizes resources, lowers the risk of investment, and selectively allocates resources to domestic firms that meet performance targets, usually in export markets (Amsden, 1989, 2001; Wade, 1990; Woo-Cumings, 1999). Promotion of licensing deals with foreign firms, public research institutes, and broader S&T policies open up channels of learning within the domestic economy. A core objective of this literature is to provide an explanation of why some states are able to develop the institutions that are able to take on an effective coordination role and others are not (Evans, 1995; Haggard, 2004; Kohli, 2004).

In the global value chain and innovation literature, multinational firms play a more prominent role in transmitting knowledge on the supply side—through joint ventures (JVs), supply chains, and original equipment manufacturing (OEM) sourcing arrangements—but there is also an emphasis on learning from buyers. In Korea, Hobday argues, "buyers provided local companies with blueprints and specifications, information on competing goods, production techniques as well as feedback on design, quality and performance." The early experience as OEMs and original design manufacturer (ODM) suppliers allowed these firms to improve process skills, acquire the scale that made investments in new technology possible, and gain new design skills (Hobday 1995, pp. 1177–1178). The form of insertion in a global value chain and the type of value chain can be key determinants of the breadth of opportunity for learning (Gereffi, 1994; Gereffi, Humphrey, & Sturgeon, 2005; Schmitz & Knorringa, 1999).

In the economics literature, a major focal point has been measuring the contribution of learning-through-exporting to the improvement of firm productivity and upgrading. Considerable empirical support exists for the role of this channel for firms from developing countries (Du, Harrison, & Jefferson, 2012; Harrison & Rodriquez-Clare, 2010), but the exact size as well as the mechanisms through which learning and upgrading occurs remain a black box. Issues of selection of better firms into exporting as well as simultaneous changes in firm product mix, markups, and input costs complicate estimation (Atkin, Khandelwal, & Osman, 2014).

In the export-led model of development, firms largely learn what customers want in overseas markets through the act of exporting. Because the structure of the quality ladder is defined by the export markets however, the demand side remains beyond the scope of local state policy. Aside from a modest informational role, this limits the influence of the state to channeling the resources to the supply side that would allow firms to meet external demand.

(b) *Domestic-led growth*

A defining feature of development in China is that growth is driven by demand in the domestic market: upward of 85% of all manufactured goods produced in China are sold domestically, with the percentage even higher for domestic firms. [5] Moreover, in sectors extending from autos to network equipment to machine tools, China currently represents the largest market in the world in terms of both absolute size and growth. The importance of the domestic market shifts the terms of development.

As we argued in Brandt and Thun (2010), demand generated by a large domestic market has the potential to facilitate the upgrading process because it eases both the technological and marketing gaps that domestic firms face when they export. Not only do the domestic firms have technologies that are better suited to the domestic market, but their understanding of these markets is often superior to that of foreign firms.

Central here is the view that the innovation process within a market segment is shaped by two distinct sets of forces that interact in subtle and unpredictable ways: market forces (e.g., relative incomes, demographics, etc.) on the demand-side and the technological forces on the supply side (Kline & Rosenberg, 1986, p. 275). From this perspective, it is not necessarily the most sophisticated technology that will most effectively satisfy demand; it depends on what product attributes a particular market segment values most highly. A firm must understand the market, develop organizational capabilities that are able to respond to this market, and engage in the process of combining and recombining inputs so as to effectively satisfy market demand (Adner, 2002; Christensen, 1997; Govindarajan & Kopalle, 2006; Zeng & Williamson, 2007). Having a diverse set of building blocks on the supply side allows for more variety and a greater number of combinations to be achieved, any one of which might be the solution that perfectly satisfies market demand in a given segment at a point in time (Fagerberg, 2005; Johnson, 1992).

Each market segment in the domestic market serves as a rung on the developmental ladder. Demand in the low end—the first rung on the quality ladder—is critical to providing domestic firms with "incubation space" in which they can develop capabilities and increase volumes. This market segment must demand product attributes that foreign firms have difficulty satisfying (e.g., low cost) and must be large enough to generate returns to finance the upgrading process of local firms. Timing is important—the incubation period must be long enough for firms to draw on the resources that are necessary for upgrading—but the length of time is difficult to specify *ex ante*, since it will depend on the richness of existing capabilities on the supply side and the difficulty of the upgrading process.

Demand in medium- and higher-end market segments is equally important. It enables domestic firms to learn about consumers' preferences in these segments and to justify the sizable investments in R&D, personnel, and equipment that upgrading entails. The size of these segments also attracts the participation of foreign firms—first through imports and subsequently through foreign direct investment (FDI) in the local economy—who can play a critical role on the supply side through spillovers to local firms. These firms typically enter the local market through higher-end segments that resemble those in advanced countries, but as they localize activities in the "fight for the middle" segments, the foreign firms become conduits of managerial and technological know-how at each step in the quality ladder (i.e., horizontal spillovers). Vertical spillovers are equally, if not more important, as foreign OEMs can be instrumental in building up the local supply chain, either by encouraging their overseas suppliers to locate locally or by working with local suppliers. [6] In the upgrading process, this is complemented by access through imports to higher quality intermediate goods and capital equipment (De Loecker & Warzynski, 2012), which may not be available locally.

Domestic firms are able to move up the quality ladder only if there are the right sets of building blocks on *both* the demand and supply sides. What previous analysis (e.g., Brandt & Thun, 2010) neglected to demonstrate is how easily policy makers, in their eagerness to support development efforts, inadvertently restrict the process of combination and recombination that allows firms to innovate and meet the demands of the market. Demand in segments in which domestic firms have an advantage may be unintentionally restricted; and the supply of firms, technology, inputs, and/or skills which are required to meet different aspects of demand may be unintentionally excluded. Policy may also dampen competitive pressures. Unlike in the export-led growth model, the state must consider how policies affect the demand side as carefully as the supply side.

(c) *Policy restrictions on the demand side*

On the demand side, state policy in the form of regulations and market restrictions affects knowledge flows about consumer demand and the size of market segments. Tariffs and non-tariff barriers raise domestic prices and limit market size. In the context of a sector with distinct product market segments, an *ad valorem* tariff will typically skew demand

(and domestic production) toward the lower end of the market. Tax policy and subsidies may boost demand in targeted market segments while reducing it in others. Lower (higher) environmental regulations with respect to emissions, for example, can expand (contract) the size of the low versus high end of the market. Concerns about the "race to the bottom" are often predicated on lax enforcement of environmental and labor regulations. Product standards can play a similar role. Finally, government procurement policy can discriminate against firms on the basis of ownership or nationality.

(d) *Policy restrictions on the supply side*

On the supply side, state policy shapes the resources and opportunities that are available to firms within the domestic economy, as well as the competitive pressures they face. In China, a key expression of state policy is preferences based on firm ownership: state vs. non-state. The legacy of the planned economy determined where key capabilities initially resided (i.e., in firms and research institutes), an influence that endured long after the start of reforms. In the reform era, policies on both the demand and the supply sides were often coordinated to give maximum support to targeted state firms. Non-state firms have been systematically discriminated against in matters relating to finance (Brandt & Li, 2003), access to technology, and M&A activity, and have sometimes simply not been allowed to enter a sector (Huang, 2008). State firms, on the other hand, enjoy an equal measure of policy support. While the overall trend during the reform era has been toward a more level playing field between state and non-state firms (Lardy, 2014), the pace and extent of market liberalization differs widely between sectors (Brandt, Rawski, & Sutton, 2008). This can affect firms' upgrading incentives through their ability to attract new resources, such as skilled personnel or capital, and their ability to sell locally.

Policy also mediates the flow of global resources into the domestic economy, both by affecting the form of technology transfer and entry by multinational firms. Foreign firms have the option of multiple modes of entry (e.g., imports, licensing, and/or FDI) and a primary determinant of the mode of entry is the level of control that is required. Wholly-owned foreign enterprises (WOFEs) are more likely to be established for newer products and the most sophisticated technologies when concerns about intellectual property (IP) are paramount and the desire to increase the returns from firm-specific advantage are high, while licensing arrangements will suffice when IP concerns are low and products are more mature. (Dunning, 1988; Dunning & Rugman, 1985; Hymer, 1976).[7] Each form of technology transfer will influence the "supply" of inputs to the domestic economy slightly differently, and at different points in time. Licensing is likely associated with earlier vintage technologies, and thus for products serving the lower end of the market. Although the technology may be "old" from the perspective of the multinational, the fit with existing local capabilities of domestic firms may be good, with licensing offering the prospect of new knowledge spanning the entire product. JVs offer the prospect of managerial and technical spillovers to the domestic partner, and indirectly through the development of a local supply chain.[8] WOFEs also offer indirect benefit for domestic firms; however, these benefits may only be realized over a longer period of time as a result of the sizable technological gap in the market segments these firms initially serve.[9]

Restrictions on modes of entry will be reinforced by tariffs on intermediate goods and capital equipment, which increase firm costs on the supply side. This impact is likely to be larger in higher quality market segments where the role of imported intermediates and capital machinery is more important, especially early on when there are few domestic substitutes. Over an extended period of time, tariffs, and non-tariff barriers on both final goods and intermediates will reduce the size of market segments for higher quality goods, possibly discouraging entry by foreign firms into these segments and minimizing foreign spillovers. Higher tariffs also effectively lower the capability threshold that local firms need to achieve to sell locally, which can have negative selection effects on market dynamics.

In short, both sides of the coin are equally important. An ability to upgrade without the incentives to upgrade will thwart the process. Similarly, the incentives to upgrade, that is, willingness of consumers to pay a premium for higher quality products but limited channels through which firms can obtain the information, know-how, and inputs required to upgrade will have the same result. Constraints on the size and growth of higher-end markets can do the same. A low end by itself will also not do the trick. Over time, there needs to be the right combination of competitive pressures at the bottom, a growing middle, and channels that make it attractive for firms to invest in quality upgrading. The different market segments within China's domestic market are each associated with unique information/knowledge flows, and thus opportunities for upgrading. Each value chain represents a rung on the upgrading ladder.

3. DATA AND METHODOLOGY

Our analysis uses data from three industrial sectors in China: automotive, construction equipment, and motorcycles. Industrial yearbooks and industry reports are the primary source of data on market growth and segmentation. Extensive field research allowed us to identify the key upgrading challenges in each sector, assess the extent of capability building within firms and sectors, and evaluate the role of policy in shaping these outcomes. In each sector, interviews were conducted at leading firms and their key suppliers in the sector.[10]

(a) *Case selection*

Our objective was to understand how the structure of a quality ladder in a sector shapes the opportunity for upgrading. As a result, we sought sectors that *ex ante* appeared to have similar opportunities for growth and upgrading, but which had quality ladders that varied in structure as a result of differences in government policy.

The opportunity for upgrading in these three sectors was similar in three respects. First, in all three, the length of the quality ladder, which measures the extent of vertical product differentiation within a sector and thus the potential for upgrading, was similar. Recent work by Khandewal (2010) suggests that globally all three sectors—motorcycles, construction, and autos—have quality ladders of greater than average length, with the ladder for autos the longest, followed by construction equipment and then motorcycles. Moreover, segments along the quality ladder can be identified and measured. Second, all three sectors are in a relatively mature stage of technological development. In each, there is a dominant product design; innovation generally consists of incremental changes to this design and process improvements; and the value chains typically consist of large lead original equipment manufacturers (OEMs) and extensive outsourcing to suppliers. Third, each of these sectors was successfully developed by

China's neighbors in East Asia, and there was no *prima facie* reason to believe that China would not have similar success. [11]

While the opportunities for upgrading were similar, variation in state policy led to very different outcomes in each sector. We argued in Section 2 that opportunities in the low-, medium-, and high-end segments are critical to fostering upgrading of domestic firms. Early on, a low end is essential, but opportunities in the other two must also be present. In a rapidly growing economy such as China's with rising incomes, we would expect this to happen as a natural matter of course. In two out of three sectors we examined, however, key market segments were often missing or limited in size at critical times as a result of government policy. Key policies on the demand- and supply sides in each sector are summarized in Figure 1, with those that restricted certain segments of the quality ladder (i.e., those that were not segment neutral) shaded.

In construction equipment, a relatively liberal policy environment with respect to both the demand and the supply sides helped to ensure the required array of market segments and opportunities. Relatively low tariffs on imports of final goods and intermediate inputs helped to keep prices low for end users. There were also few impediments to foreign participation and technology transfer through either licensing, JVs, or WOFEs. Barriers on entry by private firms were also relatively low. In short, the policy environment helped to ensure opportunities throughout the ladder and access to the know-how required to serve these market segments.

In contrast, in autos, there were a variety of regulatory constraints on entry, ownership, technology transfer, and tariff and non-tariff barriers. Tariffs of 80–100% made cars too expensive for all but the richest of households. Entry by private firms was nearly impossible. Licensing of technology, often a preferred form for entry to the low end, was limited to a single case, with JVs between state-owned enterprises (SOEs) and multinational corporations (MNCs) the preferred organizational form. WOFEs were prohibited. More generally, competition among firms was leisurely up until China's decision to enter the World Trade Organization (WTO).

Motorcycles represent an intermediate case. The level of tariffs that were imposed on motorcycle imports was between those in heavy construction and autos, and barriers to entry were much lower than in autos. However, in the late 1990s, restrictions were imposed on the use of motorcycles on highways and in China's rapidly expanding cities, where incomes were higher. With entry into WTO, tariffs on motorcycles also remained high relative to autos. These restrictions had the unintended effect of limiting demand in more demanding market segments.

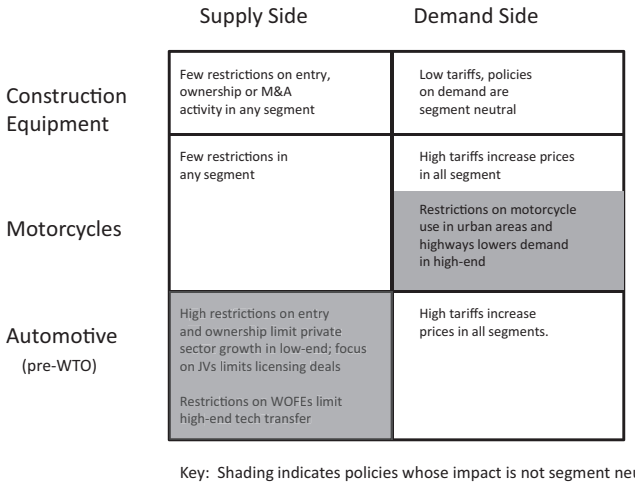


Figure 1. *Variation in policy across sectors.*

A final advantage of these three cases is that reverse causality seems unlikely. The concern here is that rather than state policy shaping the structure of the quality ladder in each sector and thus upgrading prospects, a larger low end in sectors such as construction equipment might have obviated the need for state intervention. Divergence in state policy, however, occurred well before there was any substantial difference in the structure of the quality ladders. Table 2 shows that tariff rates for construction equipment in 1992 were already much lower than the other sectors. Moreover, Table 1 clearly indicates that all three sectors were in their infancy at this time, suggesting that policy makers had little reason to believe at this point in time that indigenous firms would enjoy greater success in wheel-loaders than in low-end cars or motorcycles. [12] As we will explain in more detail, it was the high initial tariffs on autos—in the vicinity of 100%—that reduced the size of the low end of the auto market. The adverse effects of these policies were reinforced by other policies that restricted entry into the sector, and the form of technology transfer. [13]

In each case study below, we break the overall sector into segments using familiar measures of product quality. For construction equipment, we use the wheel loader as a proxy for the low-end segment and the excavator for the high end. On the demand side, these two products are substitutes for each other, albeit imperfect ones: the excavator can do more, and do things faster. On the supply side, for reasons relating to design and manufacturing, especially of the hydraulic system, the capabilities and expense required to produce an excavator are significantly higher. Reflecting these differences, the price of an excavator is generally two to three times the price of a wheel loader. [14] In the case of autos and motorcycles, engine size correlates reasonably well with product quality and sophistication in the Chinese market. For autos, we classify as low-end, vehicles with displacement of 1.6 L or less; mid-range is 1.6–2.5, and high-end is more than 2.5 L. For motorcycles, we divide the market into 100 cc and smaller, 110–125 cc, and 150 cc and larger. Figure 2 summarizes the segmentation in each sector and indicates the segments that were restricted as a result of state policy.

(b) *Variation in outcomes*

We define movement up the quality ladder as the ability of domestic firms to capture market share relative to foreign-invested firms in successively more demanding and higher quality product segments within a sector. Only in one of the three sectors we examine—heavy construction equipment—have Chinese firms been able to narrow the gap with multinationals, while gaining market share.

Table 1 shows estimates for each of the three sectors for select years of several key variables: total sales volume by firms producing in China, total domestic market sales, exports, and imports. [15] For heavy construction, sales are for wheel loaders and excavators combined; for autos and motorcycles, sales are in all size classes of vehicles. Growth in the heavy construction and auto sectors has been fairly similar, with sales by firms in China growing at impressive annual rates in excess of 25%. These sales have been largely directed to the domestic market, with exports modest. Although imports played an important role in serving domestic demand relatively early on, these have also been relatively minor. In contrast, sales growth in the motorcycle sector since the mid-1990s has lagged considerably behind that in the other two sectors—sales were only a third of

Table 1. *Sales, market demand, exports and imports*

	Total sales by firms in China			Domestic market demand			Exports			Imports		
	HC	M	A	HC	M	A	HC	M	A	HC	M	A
1985		979,307			979,307							
1991		1,250,396	81,044		1,250,396	134,264			789			54,009
1997	20,697	9,242,825	487,995	24,906	9,150,887	518,941	3,577	91,938	1,073	7,787		32,019
2003	103,648	14,754,513	2,037,865	131,115	11,732,824	2,138,033	1,174	3,021,689	2,849	28,641		103,017
2010	407,515	26,591,387	11,278,887	419,801	17,553,628	11,654,987	30,162	9,040,525	282,900	42,448	2,766	650,000
					Annual growth rates							
1985–91	4.2%			4.2%								
1991–97	39.6%	34.9%		39.3%	25.3%			5.3%				
1997–2003	30.8%	8.1%	26.9%	31.9%	4.2%	26.6%	−16.9%	79.0%	17.7%	24.2%		21.5%
2003–10	21.6%	8.7%	27.7%	18.1%	5.8%	27.4%	59.0%	16.9%	92.9%	5.8%		30.1%
1997–2010	25.8%	8.4%	27.3%	24.3%	5.0%	26.1%	17.8%	42.3%	53.5%	13.9%		26.1%

Note: HC is heavy construction, M is motorcycle, and A is automotive.

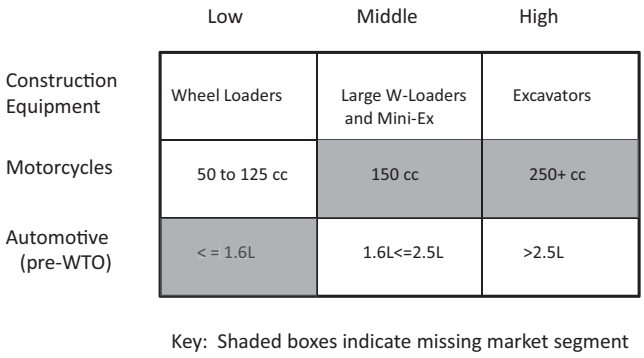
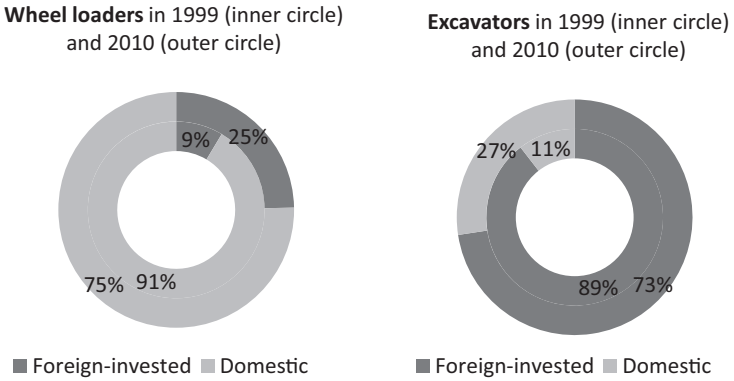


Figure 2. *Proxy measures of segmentation within sectors.*

that in autos or heavy construction—with exports becoming increasingly important. By 2010, a third of all motorcycles produced in China were exported.

In Figure 3 we report a breakdown of sales in 1999 and 2010 of wheel loaders and heavy construction among domestic and foreign firms manufacturing in China. From the perspective of the 1990s, there is clear segmentation in the market: Chinese firms dominate the low-end wheel loader segment, while foreign firms capture much of the market for higher-end excavators through local production and imports. In volume terms, the market for wheel loaders is also larger. Over time, there are two clear indications of successful upgrading on the part of Chinese firms. First, leading firms in wheel loaders were able to gain market share, and during 1997–2010 the four-form concentration ratio increased from 43.5% to 62.2%. They also moved into larger machines that they were able to sell at a premium.[16] Second, they succeeded in penetrating the demanding market for excavators, and over the same period increased their market share from only 10.8% to 27.4%. By 2011, the market share of domestic firms in the excavator segment was in upward of 50% (CLSA, 2013, p. 9). Over the same period, foreign firms made inroads into the highly competitive wheel loader market.

Although Chinese excavators typically sold at a 10–30% price discount to foreign competitors (and were often able to arrange more favorable financing terms), the quality of machines was comparable to the foreign products. In 2013, the investment advisory CLSA, commissioned a comparative test of the 13 leading excavator brands in China and measured the machines according to productivity, fuel economy, and durability over 185 working hours during a two-week period. In the medium class segment (20–24.9 tons), which is the largest segment in the Chinese market, Caterpillar was the leader in



Note: The Foreign-invested expansion in market share in wheel loaders is largely a result of acquisitions of Chinese firms.
Source: China Construction Equipment Yearbooks.

Figure 3. *Market share in construction equipment.*

work cycle, productivity, and durability, and was followed by Sany, a Chinese firm in each case. Sany was the leader in fuel efficiency (CLSA, 2013, p. 33). Overall, the study found that "technology gaps are non-existent between top-tier Chinese and international companies because both source critical components, such as engines and hydraulic systems, directly from global suppliers" (CLSA, 2013, p. 23).

The automotive sector has also enjoyed rapid growth, with sales of cars in China rising more than twentyfold from 0.52 million units in 1997 to 11.6 million in 2010. Most of the increase in demand has been met by rapid expansion of output from OEMs manufacturing in China, with imports remaining relatively unimportant except at the very high end of the market. Much is often made of the near doubling of the market share in volume terms of Chinese OEMs to more than 30%, but this is misleading in several respects. First, their share of the market in value or monetary terms is only half that in quantity terms (Warburton, Zhu, Wen, & Quettawala, 2013), implying that they are heavily concentrated in the low end. Second, this increase has been largely achieved through an increase in the number of Chinese OEMs, and a proliferation of models among them rather than sales per model: in 2010, median sales per model by a Chinese SOE (private) OEM were one-sixth (one-third) of a foreign OEM (author's calculations based on CATARC, 2011).

In general, Chinese automotive firms have shown limited ability to leverage this growth into movement up the quality ladder. A recent report by a third-party investment analyst is informative: "The leading Chinese products now have bodies, safety and suspension hardware that are largely competitive. But they are behind on engine technology and are also let down by assembly standards, material choices, systems integration, refinement, and lack of final development and testing. They are still a long way from being genuinely 'world class'" (Warburton *et al.*, 2013, p. 1). [17]

In the motorcycle sector, domestic firms have long dominated the local market, but upgrading in the sector has been modest, and Chinese firms have shown limited success in moving into higher-end segments of the market. Production remains focused on the low end, and sales of the standard low-end product, the 125 cc motorcycle, increased from 23.6% of total volume in 2003 to 57.5% in 2010. Fragmentation in the industry has also increased, with the four-firm concentration ratio decreasing from 40.3% in 1997 to 30.0% in 2010.

After 1997, the focus of domestic motorcycle firms shifted to export markets, with nearly two-thirds of subsequent growth in sales by domestic firms tied to exports, but this shift did little to increase the ability of domestic firms to move into higher-end segments. [18] Chinese firms sought export markets that demanded products at the same level (or lower) on the quality ladder as the Chinese market. Aided by VAT rebates and other export subsidies, exports were primarily to lower-income countries in Southeast Asia, Africa, and Latin America, where competition was based primarily on price and not quality. Within these markets, growth was most robust for low-end products, notably 100 cc and 110 cc motorcycles, with this segment representing more than half of the growth in exports between 2004 and 2010 in absolute terms. Indicative of low and falling average export quality, the price of exports during this period declined markedly. [19] By 2010, exports of Chinese firms were also beginning to lose out in markets such as Vietnam to local JVs.

In the case studies that follow, we seek to explain first, how policy shaped the growth and segmentation of these markets; and second, how this segmentation influenced upgrading and innovation in the sectors.

4. CONSTRUCTION EQUIPMENT

The ability of Chinese construction equipment firms to produce and capture market share in successively more demanding product segments was the result of highly complementary factors on the supply and demand sides, both of which were shaped by state policy. We discuss each of them separately, and then briefly their interaction and complementary role.

(a) *The supply side*

The early development of China's construction equipment industry owes much to decisions that were made under state planning. The Ministry of Machinery Industry (MMI) in Beijing directed the flow of technology, personnel, and other resources between key firms and research institutes. Liugong, the leading producer of wheel loaders in 2012, for instance, was originally set up in 1958 by MMI in the interior province of Guangxi. [20] In the mid-1980s, as part of efforts to modernize the heavy construction sector, MMI arranged the licensing of technology from major foreign firms such as Caterpillar and Komatsu for a line of key products and components and distributed the technology to leading SOEs, including Liugong.

Critical here was the decision by MMI to license an older (vintage late 1960s/early 1970s) wheel loader technology, which was a reasonably good fit with the existing capabilities of the SOEs and their suppliers, and as explained more fully below, market demand in China. Through licensing, Chinese firms were able to learn and acquire mastery of all aspects of the new technology from the inside out. Initially, some of the key intermediates were imported from leading Western firms, but over time, 100% local sourcing was achieved. Policy with respect to the wheel loader was complemented by the establishment of several JVs and WOFE that focused on the excavator. The technical requirements for the excavator were higher on multiple levels (design, assembly, key intermediates), which made licensing of even older excavator technology directly to Chinese domestics less feasible at the time. Larger wheel loaders and excavators were imported.

Huang (2008) argues persuasively that in the 1990s, private firms in China often found it very difficult to obtain the licenses required to enter newly emerging sectors. In the heavy construction sector, however, private firms began to enter in growing numbers, with the supply network an important channel of technology transfer to these firms. In Fujian, for example, several local suppliers to a leading SOE that was among the original licensees of CAT wheel loader technology moved downstream into the wheel loader market. Private firm entry was further facilitated by relatively low technical barriers to entry for the low-end wheel loader market, limited IP protection, accumulating human capital in the sector in both SOEs and foreign-invested enterprises (FIEs), and an expanding local supply chain. The relatively low technical barriers to entry and the set of existing capabilities in the wheel loader sector were both heavily influenced by the earlier technology licensing decision.

The state's relatively agnostic view regarding state versus private ownership among domestic firms is reflected in the changing composition of leading wheel loader firms between 1998 and 2010. Both state and private firms have succeeded (and failed) in a highly competitive environment. Two of the

top four firms (Liugong and Xiagong) in 2010 were restructured state firms that were also leading firms in 1998; one was a private firm (Longgong) and a new entrant, and the other was a former state firm (Lingong) that Volvo acquired a majority share (70%) of in 2006. A number of early market leaders were no longer contenders, either because they could not keep up or because they decided to move into less competitive product markets.

State policy toward foreign entry was also relatively liberal. Foreign firms found it very difficult to compete in the highly cost-sensitive low-end segments of the market, but their technical capabilities gave them an advantage at the high end of the quality ladder. In these market segments, the foreign firms had a choice of entry strategies, and choices were determined by the relative need to control technology and manufacturing processes, and market size in China. Machines that were premium global products and demanded in relatively small numbers in China were imported (e.g., large-scale mining equipment). Excavators and high-end wheel loaders were produced in WOFEs or JVs that were majority controlled by the foreign partner and initially used a higher percentage of imported components (particularly for core parts such as hydraulics and engines). Low tariffs on imported intermediates helped to keep costs down. As these parts were localized, sourcing was from foreign-invested suppliers. In order to expand market access in lower-end segments, foreign firms began to experiment with a range of entry strategies, including local M&A. Caterpillar and Volvo, for example, acquired Chinese firms and then sought to improve the quality of the basic wheel loaders that these firms produced. In both cases, this meant pushing their supplier development programs far deeper into the supply chain than was the case for their wholly-owned facilities.

Diversity in the mode of foreign entry (e.g., WOFEs, JVs, technology licensing, and imports) was important because each brought different advantages and know-how to the upgrading process on the supply side. Imports helped to identify new market opportunities for local firms. Licensing transferred technologies that were outdated in advanced markets, but provided Chinese firms with broad product knowledge, including systems integration, and opportunities for learning-by-doing (and a foundation for incremental improvement).[21] Foreign-owned facilities had more advanced technologies, but competitive pressures to "fight for the middle" segments of the Chinese market forced them to aggressively localize their operations, which offered a new range of upgrading opportunities for Chinese supply firms.

This diversity combined with liberal policy with respect to entry, bankruptcy, and exit helped to ensure that the capabilities that were being developed within the sector flowed to those firms that would utilize them most effectively. Sany's highly successful foray into the excavator, for example, drew heavily on the R&D personnel from a failed excavator JV. The two leading manufacturers of cement pumps in China grew out of state-supported research institute in Changsha, Hunan.

The critical point here is not that any single ownership form or foreign entry mode was *a priori* better than the next. They often facilitated serving different market segments. Each however contributed different elements to the ecosystem of the sector, which intense competition forced firms to recombine in new and novel ways on the supply side.

(b) *The demand side*

China's heavy construction sector has been a huge beneficiary of rapid growth in demand that has been largely domestic in nature. Exports have played only a minor role in the sector's expansion. The unusual feature of demand in this sector, relative to motorcycles and automobiles, is twofold: first, from the outset, demand spanned all market segments from low to high; second, over time, all market segments have enjoyed robust growth, with a shift to higher end segments. More generally, the level of local demand in the heavy construction sector has been supported by very low tariffs compared with those imposed in autos or motorcycles (see Table 2).

In the initial stage of growth there was a large low-end segment that allowed domestic firms to "incubate" capabilities. During the 1990s, domestic demand in China for wheel loaders outstripped that for excavators, often by a two-to-one margin. This ratio, which was the reverse of that found in developed markets, reflected several features of local demand. At China's level of per capita GDP throughout much of this period, the higher price of the excavator (and difficulties in accessing finance) put it out of limits for many customers. In addition, with low labor costs, the higher productivity of the excavator was less important.[22] The demand for the wheel loader was dominated by individual contractors and small-to-medium non-state firms in the construction industry, who demanded a very high price-performance ratio.[23] By contrast, the high end of the wheel loader market, machines used in ports and coal mines, was often occupied by state-owned firms. Similarly, much of the demand for excavators was coming from larger state-owned construction companies. The demands of these users were more similar to those found in global markets.

The higher-end segments, while always present, expanded rapidly over the course of development. Up through 2005, domestic sales of the two products grew in tandem, at an annual rate of 30%, but after 2005 growth in demand of excavators was double that of wheel loaders (30% vs. 15%). By 2010, domestic sales of the excavator (by unit) surpassed those of the wheel loader. Given the price differences, excavator sales by value were 2.5–3 times that of wheel loader sales. This growth provided strong incentives for domestic firms to

Table 2. *Sector tariff rates*

	Motorcycles		Construction equipment		Vehicles	
	Output tariff	ERP	Output tariff	ERP	Output tariff	ERP
1992	120	570	17	5	132	568
2000	59	227	14	30	62	261
2007	43	175	7	10	21	69

Note: ERP is the effective rate of protection and is equal to: $(t_i - at_j)/(1 - a)$, where t_i and t_j are the nominal tariffs on the final good and intermediate inputs, and a is the value of intermediates as a share of the value of the final good at international prices.

develop the capabilities required to shift into higher-end segments.

(c) *The interactions*

Growth (or expectations of growth) throughout all market segments was extremely important to the positive dynamics on the supply side we observed, as were policies that did not overtly discriminate against multinationals or private firms, or particular market segments. At the outset, this encouraged multinationals to enter and invest in developing capabilities in China in expectation of serving a rapidly expanding local market. Similar expectations fueled investments by Chinese firms in deepening capabilities that would enable them not only to capture more of the lower end wheel loader market, but also to move into larger wheel loaders, and the excavator.

Thus, even in the face of intense competition and falling prices for both wheel loaders and excavators, we did not observe a race to the bottom. Rather, upgrading and market consolidation dominated these sectors as "better" firms won out. Firms had both the incentives and access to the know-how required to upgrade to escape the low-end competition, and a growing pool of domestic customers willing to pay premiums. Distribution and marketing channels that these same firms were heavily investing in were also providing the information on those product features customers were most willing to pay for.

5. MOTORCYCLES

(a) *The supply side*

The motorcycle sector has early parallels with the construction equipment sector. In the early 1980s, there was a series of technology licensing agreements between leading Japanese firms (e.g., Suzuki, Honda, Yamaha) and upward of 20 state-owned firms, most of which were defense related, to license technology for 100 cc motorcycles. These firms possessed engineers, skilled technicians, and machining know-how, and the technology transfer agreements were part of efforts to convert them from military to civilian production. Initially, SOEs dominated the market, but subsequently entry barriers were lowered and high levels of entry by both foreign and Chinese private firms spawned a large low-end segment that was dominated by domestic firms.

Many of the Japanese firms that had originally licensed technology to China in the 1980s formed JVs, hoping to capitalize on their higher level of quality and capture high-end urban demand (Ohara, 2006, p. 127). Private firms also began to enter in mass, copying the designs of models produced by state firms, and sourcing components from their suppliers. They also hired their managers, engineers, and workers. Between 1991 and 1997, the number of firms in the sector increased from 59 to 143 (CATARC, 2002), and production grew eightfold from 1.2 million units to 9.6 million. In 1997, production was still dominated by state firms, which held two-thirds of the market, but there were also private and collective firms (21.5%) and FIEs (12.7%).[24] Market concentration was relatively low, with the top four firms having 40% of the market.

The domestic market during this period provided an ideal environment for incremental innovation focused on the low-end segment. As Ohara explains, the "base model" for products was derived from the product designs of Japanese firms, but these products were designed for consumers in advanced markets that valued high performance (Ohara, 2006, p. 44). Given the intense competition with the Chinese market, domestic firms made incremental changes that allowed them to alter the cost/quality ratio (e.g., using cheaper raw materials, using steel-stamped parts rather than forged parts, using different processes for quality control etc.; see Ohara (2006, p. 58 and 60)). The market soon coalesced around several base models as new entrants used common suppliers (which lowered cost) and consumers demanded inter-changeable parts (which lowered the cost of repairs). Domestic sales between 1991 and 1997 grew at an annual rate of 39.6%, with most of this growth in the very low-end segments of 100 cc and smaller (see Table 1). In 1997, 95.3% of domestic sales were for motorcycles 125 cc or below (see Table 3).

(b) *The demand side*

The key difference in motorcycles has been the manner in which restrictions on domestic demand have weakened growth in all segments above the low end. Through the 1980s, and under a very high tariff umbrella, production in the sector initially grew only modestly, with an annual growth rate of just 4.1% during 1985–91.[25] Demand-side constraints were relaxed in the 1990s, aided by the reduction in tariffs on motorcycles by nearly a half to slightly more than 50%. As illustrated by Table 1, production expanded rapidly during 1991–97. Subsequently, however, new restrictions on the use of motorcycles in China's 150 largest cities sharply reduced demand from the market segment that was growing most rapidly and had the highest per capita incomes. Tariffs on motorcycles also remained high in China after accession to the WTO, while tariffs on automobiles were reduced (see Table 2). Tariffs affected the demand in all market segments for motorcycles, but the impact may have been most severe in the higher end that competed with cars for customers.[26] A comparison between China and Taiwan with respect to the percentage of households that owned motorcycles is informative. By 1991, 79.2% of all households in Taiwan owned motorcycles. By comparison, in 2000 only 21.9% (18.8%) of rural (urban) households did so. This percentage rose to 62.2% in the countryside by 2012, but in the cities rose only marginally to 20.3%.[27]

More recently, demanding environmental requirements have been issued, which has increased the cost of motorcycles, and in some cases may be exceeding firm capabilities. As a result of these policies, growth in domestic demand for motorcycles slowed to less than 5% per annum during 1997–2010, and growth in higher-end segments was severely restricted.[28]

(a) *The interactions*

Lack of demand for higher quality bikes weakened the incentives of both foreign and domestic firms to invest in the channels of capability building that would allow them to move along the quality ladder. The natural target markets for foreign firms were urban areas, where higher-income consumers typically placed a higher premium on quality than their rural counterparts. Rural consumers tended to purchase standard products, and valued ease of repair and low price rather than high-quality (Interview 040812a; Ohara, 2006, p. 33). With the disappearance of urban markets, foreign firms had limited incentive to deepen investment in the local manufacturing facilities required to serve higher-end segments, and the leading Japanese firms actually shifted strategies and began to focus on the low-end market.[29]

Honda, for instance, after watching its market share for bikes produced through its wholly-owned subsidiary decrease

Table 3. *Motorcycle sales by market segment and ownership*

Displacement: cc	50–125		150		250+		Total	
	Sales	Market share	Sales	Market share	Sales	Market share	Sales	Market share
				1997				
Total	8,738,833		167,646		261,997		9,168,477	
Foreign	1,051,044	12.0%	10,780	6.4%	105,603	40.3%	1,167,427	12.7%
State	5,818,744	66.6%	90,110	53.7%	119,936	45.8%	6,028,788	65.8%
Collective–private	1,869,047	21.4%	66,756	39.8%	36,458	14.0%	1,972,261	21.5%
Collective	754,548	8.6%	47,443	28.3%	4,718	1.8%	806,709	8.8%
Private	1,114,500	12.8%	19,313	11.5%	31,740	12.1%	1,165,553	12.7%
Market share	95.3%		1.8%		2.9%			
				2003				
Total	13,291,574		876,126		88,358		14,256,058	
Foreign	3,578,719	26.9%	157,504	18.0%	6,672	7.6%	3,742,895	26.3%
State	5,092,806	38.3%	103,709	11.8%	9,309	10.5%	5,205,822	36.5%
Private	4,620,052	34.8%	614,914	70.2%	72,377	81.9%	5,307,341	37.2%
Market share	93.2%		6.1%		0.6%			
				2010				
Total	21,953,013		3,960,874		677,500		26,591,387	
Foreign	4,664,982	21.2%	649,288	16.4%	14,247	2.1%	5,328,516	20.0%
State	8,998,617	41.0%	916,230	23.1%	154,403	22.8%	10,069,248	37.9%
Private	8,240,564	37.5%	2,444,211	61.7%	508,851	75.1%	11,193,624	42.1%
Market share	82.6%		14.9%		2.5%			

from 24% in 1995 to 3% in 2000, formed a series of JVs with Chinese "imitators," and began to adopt a Chinese approach to production. Xindazhou Honda was established in 2001, and the 125 cc model was priced at RMB 5,500. This was half the price of a comparable Honda model, but still almost twice the price of a comparable domestic model (Abo, 2011, pp. 42–43). At a second JV, Wuyang Honda, the sales price for the 125 cc model was reduced to RMB 4,729 in 2004, which helped to halt a sharp decline in the JVs' sales volumes (Abo, 2011, p. 43). As in the case of the foreign firms that acquired stakes in Chinese wheel loader firms, the Japanese focus on production processes within these JVs led to improvements in product quality, but unlike in construction equipment, the Japanese were not nurturing capabilities at every step of the quality ladder. The Japanese were abandoning the high end and reinforcing the skill set of Chinese firms at the low end.

Domestic firms similarly had little incentive to invest in the capability building that would allow them to compete in high-end segments given lack of demand in these segments. To give an example, one leading Chinese firm designed a 600 cc motorcycle with an Italian partner (which it later acquired) for sale in the Chinese market. The model sold for RMB 39,000 compared to RMB 80,000 for a comparable European model, but sales were disappointing. As one manager explained, investments in high-end products could rarely be justified in economic terms (040812b). Even when firms did seek to upgrade, they had fewer resources to draw on. Lack of foreign involvement in the high end meant the channels of upgrading were absent; the inability to increase profit margins by differentiating a low-end product reduced the ability of Chinese firm to finance these kinds of investments.[30] All firms—Chinese and FIEs alike—were competing in a segment in which consumers demanded largely undifferentiated products and in which barriers to entry were low.

Why did export markets not allow Chinese firms to move up the quality ladder? The shift to export markets after 1997 appears to mimic the developmental trajectory of Japan's motorcycle industry, but there are critical differences. Most importantly, the Japanese firms began to export *after* leading firms began to improve quality. As Ohara notes, there were more than 100 motorcycle manufacturers competing in the Japanese domestic market in the 1950s, a level of fragmentation similar to China in the 1990s, but this number fell to 7 (and then 4) as growth began to slow in the 1960s. The firms that survived the domestic shake-out were able to compete higher on the quality ladder, as was demanded by foreign consumers, and by the 1980s, 70% of sales were overseas.

In contrast to Japan, the Chinese motorcycle firms began exporting *before* capabilities had seriously deepened and any consolidation occurred within the domestic industry. This lack of consolidation may have been partially attributable to local politics, and in particular local governments that had both the incentive and the means to support local firms, but it was also a result of the homogenous nature of domestic demand in China: without higher-end segments, the more ambitious and capable firms had limited means or incentives to differentiate themselves. With only low-end products, when firms went abroad, they had no choice but to concentrate on markets that mirrored the demand characteristics of China. Export subsidies in the form of VAT rebates to these manufacturers and favorable payment terms for buyers only reinforced this behavior.

Export markets, of course, will have the higher-end demand segments that are missing in China's domestic market, and this could provide the incentive for upgrading. Stitching together a

quality ladder, with the low end in the domestic market and the high end abroad is not the same as having all segments at home, however. The former offers the incentive for domestic firms to upgrade, but because the high-end segments are not within China, there is no competition effect pushing foreign firms to localize and expand channels of capability building within the Chinese economy.

6. AUTOS

Although the auto industry was roughly similar to construction equipment and motorcycles at the start of the reform period—the industry was small and fragmented, largely state-owned, and technology was badly dated—the central government had far greater ambitions than in the other sectors, as evidenced by the publication of three official industrial policy statements (1994, 2004, 2009) for the sector within a fifteen year period (Anderson, 2012).

It is necessary to distinguish between two stages of growth in the auto sector, with China's entry to the WTO as the rough point of demarcation.

(a) *Pre-WTO*

During the first two decades of the reform era, the state tightly regulated both the supply and the demand sides of auto sector development.

On the supply side, the state directly chose the firms that were able to participate in the sector. The central government designated six domestic firms ("three big and three small"), all of which were state firms, as the key firms in the industry, and declared that no others would be given licenses to enter the sector.[31] The number of centrally approved firms grew slightly throughout the 1990s, but the sector remained largely closed to non-state firms, and the three "big" firms—First Auto Works (FAW), Shanghai Auto, and Dongfeng—continued to have a 67% share of the sedan market through their subsidiaries as late as 2002 (Thun, 2006, p. 61). The state also tightly regulated the form of foreign entry and technology transfer: foreign firms were forbidden from owning more than 50% of an assembly operation, and each was partnered with a key state-owned firm in a joint venture.[32] Tianjin Auto, a municipally-owned SOE, was the one firm without a JV partner during this period, and it licensed technology for a small passenger car from Daihatsu. High tariff barriers protected these ventures from external competition as part of a more general policy of "trading technology for market." The tariff on vehicles with engines 3.0 L or larger was 100%, and 80% on those smaller.

The JVs as an ownership form had their advantages with respect to technology transfer. The products were sold under the brand of the foreign partner, so the foreign firm took care to control the manufacturing operations of the JV and gradually improve the capabilities of the supply chain (Thun, 2006). The JV structure allowed for a greater transfer of the tacit knowledge than would have been possible in licensing deals, and this played a crucial role in improving the operational skills of the domestic partners.[33] But in the context of a JV with state-owned partners who were likely future competitors, foreign firms were less inclined to transfer the technologies and know-how that were considered to be core capabilities, particularly those involving vehicle design (Nam & Li, 2012). The foreign firms conducted the design and development of vehicles outside of China, and until competitive pressures and an expanded domestic market provided incentives to shift R&D to China, they sought to use the JVs as contract manufacturing firms. Lack of wholly-owned foreign firms contributed to lack of technology depth of the sort that WOFE foreign excavator firms willingly brought to the sector; lack of technology licensing agreements at the vehicle level and independent domestic firms meant that local firms were not acquiring the same type of systems-wide knowledge Chinese wheel loader manufacturers were acquiring, nor were there firms capable of supplying the low end.

On the demand side, the same combination of high barriers to entry and high levels of protectionism increased prices and skewed the market away from the low-end segment. This is captured in the top two panels of Figure 4, which show average vehicle prices for car models by engine size for 1995 and 2001. The size of the "bubble" for each model in the middle panel captures model sales (larger bubble equals larger sales.) The average price of a vehicle in the mid-1990s, for example, was RMB 130,000, or forty times annual per capita incomes, and for the Tianjin Xiali at least half of this. By comparison, the price of a standard vehicle in the initial stages of motorization in early developers (United States in the 1920s, Germany in the 1950s, and Japan in the 1960s) was roughly equal to annual average per capita income (Li, 2009, p. 9). Private demand for autos in China languished, and the market was dominated by less price-sensitive government units, state-owned firms, and taxi companies.[34] As late as 2000, sales of vehicles between 1.1 and 1.6 L were only 200,000; the majority of these were from a single firm—Tianjin Xiali (see Figure 4). Sales of vehicles a liter or less were only 80,000.

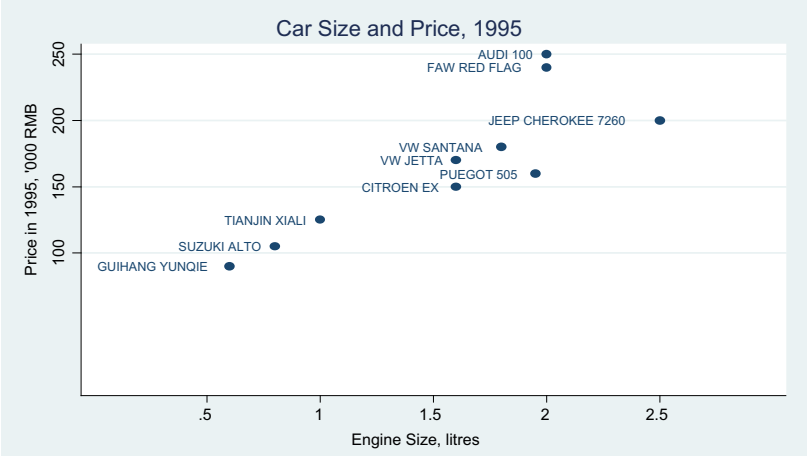
During this early stage of development there was very little movement along the quality ladder in the auto sector. While the state had considerable bargaining power in negotiations over the parameters of technology transfer (e.g., vintage of technology, content to be transferred, localization rates, etc.), these policies were crude instruments that were easily eluded by firms when not in their interests. The firms that the state allowed into the sector were highly profitable due to high levels of protectionism and limited competition in the sector. With the size and growth in demand at other points along the quality ladder limited, there was little incentive for these firms to make additional investments in the market.

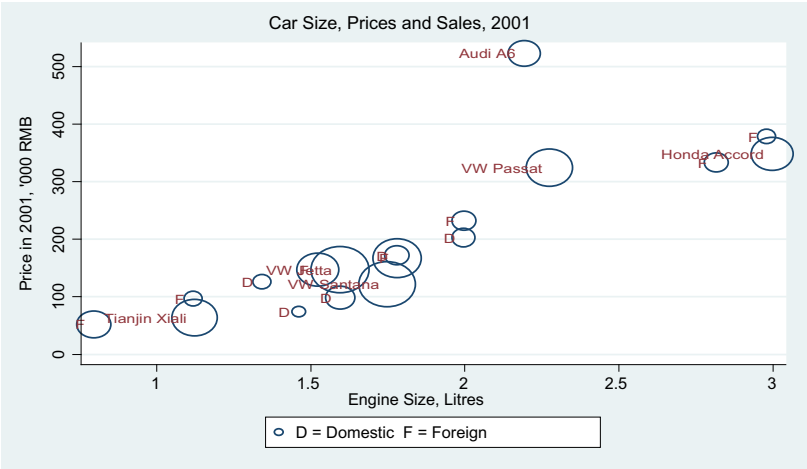
(b) *Post-WTO accession*

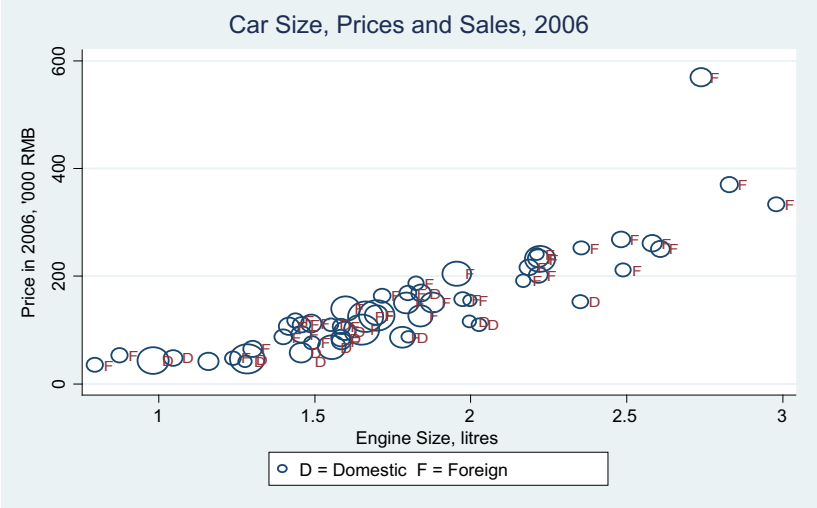
At the end of the 1990s, when it was clear that China would soon be joining the WTO, the balance between state and market within the sector shifted.

On the supply side, the state became more permissive over entry into the sector. The government began issuing licenses for new OEM JVs, and allowed more foreign firms into the market (although WOFE OEMs were still forbidden).[35] At the same time, independent Chinese firms—both state and non-state—were allowed to enter the sector, and diversity on the supply side began to increase. These new entrants continued to face obstacles obtaining production licenses and financing, but these gradually lessened over time and product variety offered on the market increased dramatically. Between 1995 and 2009, for example, the number of models increased from less than 30 in 1995 to 396 in 2009 (Li, Xiao, & Liu, 2015, p. 7).

On the demand side, dramatic tariff reductions—from as high as 100%, they fell to 25% for vehicles and 10% for components—led to lower prices and dramatic growth in the private car market. The share of individual purchases increased from under 20% in 1996 to over 60% in 2006. During 2000–10, the low-end share of the market increased from







Source: Data for 1995 from McKinsey; Data for 2001 and 2006 from CATARC

Figure 4. *Car size, prices, and sales in 1995, 2001, and 2006.*

47.7% to 58.9% and in absolute terms expanded by 3.5 million units (see Table 4).

During the decade that followed China's accession to the WTO, liberalization on the supply- and demand-sides of the Chinese auto industry interacted in a pattern that almost exactly followed the dynamic of construction equipment. First, high rates of entry increased competition and led to lower prices. During 2000–05, prices of existing models fell,

Table 4. *Car sales by market segment and ownership*

Engine size	⩽1.6		1.6 < *L* ⩽ 2.5		>2.5		Total	
	Sales	Market share	Sales	Market share	Sales	Market share	Sales	Market share
				2000				
Total	290,717		288,734		30,543		609,994	
Domestic	90,569	31.2%	13,584	4.7%	0	0.0%	104,153	17.1%
Foreign (JV)	200,148	68.8%	275,150	95.3%	30,543	100.0%	505,841	82.9%
Market share	47.7%		47.3%		5.0%			
				2010				
Total	6,645,875		4,245,745		396,267		11,287,887	
Private	1,818,393	27.4%	508,229	12.0%	30,859	7.8%	2,357,481	20.9%
State	1,011,445	15.2%	483,213	11.4%	7,314	1.8%	1,501,971	13.3%
Foreign	3,816,037	57.4%	3,254,303	76.6%	358,095	90.4%	7,428,435	65.8%
Market share	58.9%		37.6%		3.5%			

closely in line with the reduction in tariff (Brandt & Von Biesebroeck, 2006). After this period, reduction in input tariffs, increased market competition, and falling mark-ups contributed to a further reduction in auto prices (Li *et al.*, 2015). Second, as Figure 4 illustrates, declining prices during this period led to a rapid expansion of all segments of the quality ladder, particularly the highly price-sensitive low end. In 1995, 290,717 cars with an engine size less than 1.6 L were sold in China; in 2010, there were sales of 6,645,875 cars in this segment. Third, rapid expansion of the low end further induced foreign-invested firms to localize activities in order to lower costs (and thereby pushed capabilities into the domestic economy). Finally, intense competition in the low end provided domestic firms incentives for developing the capabilities necessary to move into higher-end segments.

Although the dynamic is very similar to construction equipment, as we explained in Section 3, the result has not been the same: production volumes of Chinese auto firms have grown, but this has been largely through model proliferation, with these same firms showing little capacity for moving into more demanding segments of the quality ladder. The most critical issue is that auto firms missed the almost two-decade incubation period enjoyed by Chinese wheel loader firms, a time when they were able to incrementally improve their capabilities relatively free from foreign competition in the lower end. As major beneficiaries of high profits in the JVs, the dominant state firms had little incentive to push aggressively to develop independent capabilities. The independent auto OEMs that entered the low-end segment after accession to the WTO were new (often private) firms, which did not have the benefit of a strong foundation of capabilities developed during the initial stage of growth.[36] As a result, they either copied designs or outsourced design work to foreign firms in order to catch the wave of rapidly rising demand.[37] The outsourcing of design work, combined with less R&D activity in general resulted in R&D costs per unit that were far below the global norm (Warburton *et al.*, 2013).[38] The consequence of this approach was a relatively shallow depth of design knowledge and less ability to engage in the types of incremental innovation that would enable them to move up the quality ladder and compete with foreign firms.[39] Within a decade of China's accession to the WTO, foreign-invested firms were aggressively entering the low end of the Chinese market and the window of opportunity for domestic firms had slammed shut.

In contrast to the OEMs, Chinese auto component firms have been able to upgrade their technical capabilities and are among leading exporters in the sector. Policy in the component sector was far less restrictive than in the assembly sector. On the supply side, there was a diversity of ownership forms: foreign firms were allowed to establish wholly-owned enterprises, as well as JVs, and private sector firms were allowed to enter. Initially, the supply chains were dominated by state firms, but competitive pressures gradually led to more diversification. Moreover, unlike some of the SOE Chinese partners in the OEM JVs, many of these suppliers had independent ambitions (and because entry was not restricted, they had a competitive push to achieve these ambitions). On the demand side, there was a fuller complement of market segments. At the low end, component firms could export into the global aftermarket. They could also supply the commercial truck industry, which was dominated by independent domestic firms, mainly SOEs. The older products that were being introduced at the JV OEMs were exactly the stepping stone that the local supply firms required in order to gradually upgrade their manufacturing capabilities. Local content requirements may have aided these efforts.

7. EXTENDING THE ARGUMENT

We have only looked at three sectors in this paper, but there is good reason to believe that the argument has wider applicability. Our expectation is that upgrading will be most pronounced in those sectors in which state policy has not been overly restrictive on the supply side (i.e., through ownership restrictions or regulations on forms and types technology transfer) and in which there has been robust growth in all segments of the quality ladder, albeit not necessarily equal growth at the same time. This would include sectors as diverse as machine tools, white goods, elevators, power tools, and biological enzymes.

Telecom equipment, a sector in which China has had great success in developing globally competitive firms, is like construction equipment in that wide diversity on the supply side was accompanied by multiple demand segments along the quality ladder.[40] On the supply side, despite the fact that telecom was viewed as a strategic sector, the state allowed entry of a diverse set of firms much earlier than in the auto sector. In

the 1980s, as part of a policy of "trading market for technology" the Ministry of Post and Telecommunications (MPT) negotiated JVs between SOEs and leading international telecom companies for digital switches.[41] Several competing state initiatives emerged to "localize" the same technology, the most successful of which was then licensed to half a dozen different firms under MPT. The technology (along with personnel) soon diffused to firms with weaker ties to the state, such as ZTE and Huawei. Unlike in the automotive sector, the competition within the sector was intense, and this drove firms to upgrade their products and lower their costs.[42]

On the demand side, the rapid development of the Chinese telecommunications infrastructure provided strong growth opportunities in multiple market segments. First-tier cities such as Shanghai, Beijing, and Guangzhou originally utilized imports to build their network and were the obvious targets of the JVs. The lower-tier cities were more challenging for JVs because product requirements and cost considerations were very different.[43] Aware of the shortcomings, and aided by highly decentralized procurement decisions under MPT, firms such as Huawei tailored their products to meet these requirements (Brandt & Thun, 2011). Success in these markets provided firms with the revenue needed to fuel growth and an opportunity to learn-by-doing. "We started in the rural market, which was more sensitive to cost and less sensitive to quality," explained a Huawei engineer, "and we moved from the village to the county to the prefecture to the capital cities of provinces (Interview 072312)." In these efforts, they were aided by the ongoing localization efforts of the JVs, and the increased availability of key intermediates and personnel. When operators in first-tier cities continued to discriminate against their new 2G (Second Generation) products, they shifted into global markets, and only later returned to take advantage of the rapid growth in the domestic market.

Wind turbines provide a contrasting example. In the early 2000s, the domestic industry was dominated by the multinationals, largely through JVs. There were a relatively small number of domestic firms, of which Goldwind was the largest, having entered the sector through technology licensing agreements with some of the smaller European manufacturers and design firms. Within five years, and almost exclusively in the context of the rapid growth in the domestic market promoted by government policy, domestic firms came to dominate, and today have approximately 95% of the domestic market. JVs have largely disappeared and MNCs supply the local market largely through a small number of wholly-owned subsidiaries.

On the surface, this looks like a case of success, and there is an extensive literature documenting the rise of Chinese domestic firms and the role of public policy in supporting the development of the domestic sector (Lewis, 2012; Nahm & Steinfeld, 2014). But there may be *less* than meets the eye. The sharp drop in the market share of the MNCs may have as much to do with government procurement policy that discriminated against them, as well as localization requirements that made it harder for them to compete. The industry is increasingly dominated by a handful of firms, largely SOEs. Moreover, a majority of the expansion in wind farms, the customers for wind turbines, has been experienced by subsidiaries of the five big power generating companies, two of which also have acquired domestic wind turbine manufacturers. In both cases, a high percentage of the turbines procured by the wind farms were from the wind turbine subsidiary acquired by the parent group. Vertical integration and the dominance of state firms throughout the value chain has dampened the demand for more efficient wind turbines relative to a sector in which independent power producers facing harder budget constraints were allowed a larger role. Recently, it has been reported that less efficient wind farms with higher costs were receiving higher feed-in-tariffs.

The end result is that Chinese wind turbine firms have been able to increase the size of the wind turbines that they manufacture, but they are not able to compete globally, even in wind turbines between 1.5 and 2 MW that are the "bread and butter" of the sector. Moreover, like their domestic counterparts in the auto sector, they are generally weak in design capabilities and highly dependent on foreign firms for their control systems, two key capabilities critical for long term success.[44]

8. CONCLUSION

In this paper we argue that each segment of a quality ladder plays a critical role in the ability of domestic Chinese firms to compete successfully with firms from advanced countries in increasingly demanding market segments. When state policy restricts demand in one of these segments or limits the availability of inputs that are needed to meet this demand, the (often inadvertent) result is to knock a rung out of the developmental ladder. The low end provides domestic firms with an "incubation space" that is relatively free from foreign competition; the higher-end segments offer incentives for foreign firms to localize activities and domestic firms to upgrade. The result of this process is an intense interaction between foreign and domestic firms that nurtures new capabilities and fosters innovation within the domestic economy.

This is not an argument for every country and every sector. For countries with small domestic markets, the incubation space in the low end will not be large enough for domestic firms to gain scale; similarly, the higher-end segments will be too small to encourage foreign firms to localize their activities. Thus, a policy approach that works in China will not work in Cambodia (although regional cooperation may allow smaller states to enjoy similar advantages). Furthermore, demand characteristics in the domestic market must be significantly different than in developed markets, a characteristic that we have captured in the length of the quality ladder, so as to provide "natural" protection from foreign firms. When quality ladders are relatively short (e.g., commercial aircraft, nuclear reactors), there is much less room at the bottom for domestic firms. These caveats aside, there are over a dozen countries that have domestic markets of a scale that allow for dynamics similar to what we describe in China, and which now play an increasingly important role in the global economy (Sinkovics *et al.*, 2014).[45]

For states that are fortunate to have a large domestic market, the policy objective should be to maximize this natural advantage. Policy should seek to support the growth of the market in a way that is segment-neutral and allow multiple forms of entry and technology transfer to better enable firms to innovate to meet demand in this market. Competition between foreign and domestic firms should not be viewed as zero-sum, with gains for one coming at the expense of the other. Initially, each set of firms has market segments in which they have a competitive advantage.

Policies that dampen the "fight for the middle" dynamics should be avoided. High tariffs may eliminate the natural advantage of domestic firms if they serve to restrict the overall size of the market and decrease the size of the low end (as was the case in autos). Similarly, entry restrictions on foreign firms will inhibit these firms from localizing and building supply chains in the high end that over a slightly longer period can

serve domestic firms. At the same time, policies that favor the low-end segment (e.g., lax regulation of environmental or labor laws, tax policies that support exports at the expense of selling to the domestic market) enable firms at the low end of the quality ladder to remain profitable and discourage upgrading.

Our argument should not be taken to imply that all policy interventions will have an adverse effect on development. Indeed, there is a very wide range of "segment-neutral" policies that in other contexts have been identified to be important. Such policies, for example, may include those that increase the absorptive capacity of firms (Cohen & Levinthal, 1989; Cohen & Levinthal, 1990; Fu, 2008), improve the level of human capital available to firms (Cleeve, Debrah, & Yihevis, 2015; Dunning, 1988), promote public–private partnerships and "knowledge bridges" between different local ecosystems and/or universities (Corredoira & McDermott, 2014; Mathews & Hu, 2007), and/or help coordinate the activities of local actors (Thun, 2006). Examples of each of these can be found in all of the sectors examined in this paper, including the "liberal" case of construction equipment (which had state-organized technology transfer programs in the 1980s, specialized universities to train engineers, state-sponsored R&D units for core components and technologies, etc.).

Although the evidence we present shows that development efforts in China have been most successful when the state has fostered growth in all segments and has not been overly restrictive on the supply side, recent policy initiatives such as the 12th Five-Year Plan for Science and Industry and the Five-Year Plan for National Strategic Emerging Industries demonstrate that China's central government has drawn different lessons. A central component of the recent strategies is a pronounced tilt toward domestic firms, often at the expense of participation of foreign firms, and the aggressive promotion of "indigenous" innovation and national champions in leading sectors. Underlying this shift are views that earlier policies, including a relatively liberal environment with respect to FDI and foreign firms, have not been as successful as desired in enabling local (Chinese) firms to narrow the technological gap and compete with leading multinationals. Our analysis suggests that factors other than foreign participation are keys to explaining these difficulties.

NOTES

1. See, for example, the special section in *World Development* (2011, vol. 39, No. 7) on "The Role of Foreign Technology and Indigenous Innovation in the Emerging Economics" (Fu and Gong, 2011). For a review of the extensive literature on the relationship between multinational firms and host countries see Meyer (2004).

2. Quality here is simply a shorthand for product (or service) attributes that consumers value and are willing to pay more for; consumers also differ in the value they put on these attributes. Higher quality is also costly for firms to produce, requiring some combination of better designs, superior intermediate inputs, and improved manufacturing processes. These costs differ among firms and will depend on each firm's underlying capabilities, which reflect the know-how collectively held by groups of individuals within the firm (Sutton, 1998). Cost innovation, i.e., the ability to produce the same quality at lower cost, is an integral part of the same upgrading process.

3. We are abstracting here from the role of horizontal product differentiation; however, some of the same forces we describe are also likely important in enabling a firm to differentiate its products from related varieties.

4. For details on these dynamics in the case of China, see "China 2030: Building a Modern, Harmonious, and Creative High-Income Society", a joint report of the World Bank and the Development Research Center of China's State Council.

5. Calculations are based on the Chinese Industrial Census for 1995, 2004, and 2008 and UNCOMTRADE data.

6. There is an extensive empirical literature examining the effect of horizontal and vertical spillovers in industry, of which Gorg and Greenaway (2004) is a good review. In general, the results are mixed. For China, Du *et al.* (2012) find significant vertical linkages through both backward and forward linkages, but no horizontal linkages. A possible shortcoming of the spillover literature is that it ignores the important interactions between FDI, and demand-side factors in the local economy in influencing the sign and size of the spillovers. As we argue in this paper, upgrading by local firms requires that demand and supply conditions be complementary. This is often not the case however, as explained below in autos and motorcycles. In both sectors there has been significant FDI in China, but only modest upgrading by domestic firms.

7. A firm might prefer ownership (i.e., FDI) to market transactions (i.e., licensing) due to structural market imperfections (e.g., the desire to achieve market power through internal economies of scale, knowledge, advantages, etc.) or transaction-cost imperfections (e.g., the difficulty of protecting intellectual property or preventing opportunism).

8. WOFEs likely provide foreign firms the most powerful incentives to transfer knowhow locally, but all within the firm, and not to a Chinese partner, which is what the Chinese government was usually most concerned about.

9. As Ling Chen (2014) argues in the case of Suzhou, when there is excessive policy preference for multinational firms (and hence entry), the technology gap may be too large for local firms to bridge. Again, each rung of the ladder plays a crucial role.

10. During 2007–13, a total of 81 interviews, each lasting roughly 1 h, were conducted in the 3 sectors, including 25 OEM firms, 17 supply firms, and one dealership. In Beijing, interviews also were conducted at the Development Research Council, the State Information Center (under the National Development Research Council), the Ministry of Industry and Information Industry, and the Ministry of Science and Technology.

11. An alternative hypothesis for the variation in outcome in these three sectors is that the structures of the quality ladders differed, and consequently firms in sectors with less favorable opportunities for upgrading lobbied for protection. Khandewal (2010) demonstrates that globally the quality ladders of the three sectors were similar in structure, and there is little reason to believe that this was not the case in China.

12. Table 1 reports total sales in 1991 for motorcycles and autos and in 1997 for construction equipment. Although this latter figure is six years later—the earliest year for which we can obtain data—it is clear that in the early 1990s all three sectors were in their infancy, and market demand small. At this point in time, there was little reason for policymakers to believe that prospects were any brighter for construction equipment firms

than for firms in the other two sectors, particularly given that countries such as Japan and Korea were successful in all three at comparable stages of development.

13. Although explaining the divergence of state policy is beyond the scope of this paper, Brandt *et al.* (2012, revised 2015) looks at the determinants of tariff rates in 1995 in the context of an examination of the effect of tariffs on productivity. They find that on average, tariffs on capital goods (which would include construction equipment) and intermediate goods sectors were 30 percentage points lower than they were on consumer goods (which would include autos and motorcycles). One possible explanation is that customers of imported capital and intermediate goods were state firms, who were able to lobby for tariffs that would lower their purchasing costs (and increase profits). An explanation of this sort, of course, would be exogenous to our argument.

14. For each of these pieces of equipment, there are also distinct market segments.

15. By definition, domestic market sales are equal to total sales by firms in China minus exports plus imports.

16. The sales price of Liugong's premium wheel loader (the 856) was approximately RMB 450,000 in 2011 compared to RMB 350,000 for the basic model (the 5c).

17. The Bernstein report detailed the strengths and weaknesses of Chinese firms: "The Chinese are clearly making substantial progress in a number of areas—some OEMs can engineer bodies, suspension, electronics, and interiors independently. There are now some highly skilled engineers in the Chinese OEMs with specific functional expertise. But almost all of our interviewees cited issues with Chinese OEMs being unable to integrate different components and systems, being unable to calibrate and utilize (expensively acquired) equipment, and being unable—or unwilling—to properly nail down quality. They also highlighted that Chinese OEMs struggle to develop competitive engines" (p. 6).

18. During 1997–2010, exports increased from less than 100,000 units to 11.4 million, an annual increase of 35.5%, and go from representing only 1% of total motorcycle sales to 34.2%. In 2011, exports soared to 42.3% of total sales. Conversely, domestic sales of firms producing in China fell from 99% to 57.7% of their total production.

19. For 125 cc bikes, the average price falls from 4,557 RMB to 3,236, a fall of nearly 30%. The reduction is smaller for the 100–110 cc class, but this is primarily due to the increase in the number of 110 cc motorcycles in the group. The only segment in which we observe an increase in prices is the less-than-50 cc segment, which primarily reflects the increase of exports by Japanese-based JVs to Japan.

20. Personnel and equipment were transferred from existing factories in Shanghai, and to a lesser extent Luoyang.

21. In 2008, 50% of the sales of the leading wheel loader producer in China, Liugong, were based on a model originally derived from CAT designs. Interview 072808.

22. Implicit here is the fact that the costs of operating the machine include both the capital costs of the machine and the costs of the operator.

23. In developed markets, wheel loaders are generally designed for 98% utilization (i.e., the machine will run 22 h a day), but a Chinese private entrepreneur might only demand 30–40% utilization. Global machines typically required servicing to be done by authorized outlets using authorized components, while the Chinese users demanded low-cost commodity components and servicing that could be done anywhere.

24. SOEs produced motorcycles as part of JVs and as independent manufacturers. In some cases, we have not been able to break down the production between the two, which may result in a slight upward (downward) bias in the share of SOEs (FIEs) in 1997 of four to six percentage points.

25. By 1990, there were more than 60 manufacturers in the sector, a majority of them SOEs, but total annual production was still only a million units (CATARC, 2002).

26. Small cars have also benefited from government subsidy programs during the last decade.

27. These estimates are taken from select years of the China Statistical Yearbook.

28. The rates of growth observed in domestic market sales over much of this period are low in several respects: first, by comparison to growth in domestic demand in heavy construction; second, by comparison to sales in related consumer durables such as autos, where domestic demand grew nearly 25% during 1991–2010; and third, what we would predict on the basis of estimates of the income elasticity of demand (~1.75) for motorcycles and per capita income growth in China (8%). A fourth factor is the effect of falling tariffs and prices, which easily should have pushed annual rates of growth in domestic sales to over 20%.

29. In contrast to the practice with autos, Japanese motorcycle OEMs typically sourced through local domestic suppliers when they invested overseas rather than through Japanese suppliers that set up local production facilities.

30. In 2001 and 2002, the profit rates of Chinese firms were negative, and R&D expenditures for the industry were declining (Ohara, 2006, p. 105).

31. The regulations on entry were articulated in the State Council "Notice on the Regulations of Controlling the Number of Passenger Car Manufactures," and repeated in policy documents in 1989 and 1994 (Li, 2009, p. 7). In reality, the central government had difficulty preventing local governments from supporting local firms, and the best it could do was prevent the expansion of small firms beyond their home jurisdiction. It did so by having the security bureau refuse to issue licenses to vehicles that were not from an approved firm (Thun, 2006, p. 59). As a result, there continued to be a large number of firms, but the majority of these were small-scale.

32. In addition to having the say over the foreign partner, the state also tightly oversaw the technology transfer agreements including the car models to be produced, import of capital equipment, and localization requirements.

33. As an engineer in Shanghai Auto explained, when the firm established operations that were independent from its JVs, the processes were largely adapted from the JVs. Interview 040313.

34. In 1996, less than 20% of auto sales went to individuals (Gao, 2003). Weak demand from individuals might have been the result of lower per capita incomes at this stage rather than high prices, but this argument should not be overstated. By the mid-1990s, there were already more than 100 million households living in Chinese cities. Conservatively, per capita incomes for households in the upper 10% (5%) of the distribution was more than 10,000 (20,000) RMB, and total household incomes 3–4 times these levels.

35. During this period, JVs were established by General Motors (1997), Honda (1997), Fiat (1999), Toyota (2002), Hyundai (2002), Nissan (2002), and Ford (2003).

36. There are a few exceptions. Great Wall, a leading maker of SUVs, and one of the most successful of the private OEMs, has been the largest manufacturer of pickups in China the last 14 years. SUVs and pickups share similar platforms.

37. When the first wave of output from these firms hit the market in 2001 and 2002, there were rapid allegations of IP violations. Models of the two leading firms, Chery's QQ and Fengyuan, and Geely's Haoqing and Meerie, appeared to be based on a foreign platform and led to IP dispute. See Fourin China Auto Weekly, "China's Original Passenger Cars: Local Initiative Sees a Flurry of New Models," August 2, 2004.

38. Reasons included the use of older technologies, lower quality standards, the elimination of expensive and non-critical features and functions, and the use of less expensive engineers. Geely, for instance, was estimated to have spent approximately $250 per unit on R&D compared to approximately $1,500 at Volkswagen and Toyota (Warburton *et al.*, 2013, p. 61).

39. Due to the integral nature of the product technology, it has generally been assumed that an OEM must have the design knowledge that will allow it to be a systems integrator. The outsourcing of design in China may be an obstacle to increasing quality, but it might also be an innovation that ultimately leads to much lower design costs than have been achieved in the past (and a source of competitive advantage) with in-house design skills. A potential danger is that the external design houses develop the critical skills within the value chain, and hence have more leverage over the OEMs.

40. As an indication of Chinese success in telecom equipment, Huawei overtook Ericsson to become the world's largest supplier of telecommunications equipment in 2012.

41. A State Council document promulgated in 1989 actually called for limiting the number of foreign firms to only three, but it had little impact. By 1995, there were a total of seven JVs involving leading international telecoms producing in China.

42. By the mid-1990s, localization at Shanghai Bell, for example, was in the vicinity of 70% (Harwitt, 2007).

43. First, with proficiency in English much less common, a machine operator interface with a Chinese language screen menu was essential. Second, the switches that were produced by the JVs were much less robust to problems in transmission lines and transmission quality, which were common in the lower-tier networks. And third, foreign systems were designed around the assumption of low usage of individual lines, which was not the case in China.

44. Goldwind is an exception, and is investing heavily in design as opposed to manufacturing capabilities. In this regard, the head of R&D said they aspire to be like Apple (Interview 102312).

45. In addition to the familiar BRIC countries, this would include Mexico, Indonesia, Nigeria, Turkey (the "MINT" economies), and others.

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