Constructing a Ladder for Growth: Innovation and Competition in China

Loren Brandt
University of Toronto
brandt@chass.utoronto.ca

and

Eric Thun
University of Oxford
eric.thun@sbs.ox.ac.uk

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Abstract

Theories of disruptive innovation predict that new entrants should have an advantage over incumbents in market segments that demand products with different attributes than established markets. Such differences are common in emerging markets, yet the success of EMFs varies widely. The purpose of this paper is to construct a framework that allows us to explain this variation. We focus on how the availability of successive segments of a quality ladder for a product shapes firm capabilities over time. The structure of a quality ladder influences capability building through two dynamics. The *incubation effect* is shaped by the length of the ladder. Longer ladders enable indigenous firms to cultivate their capabilities in a low-end segment that offers "natural" protection from foreign firms selling at the high end. The *competition effect* is influenced by the relative size of each market segment on the ladder. When all segments are growing, firms competing at both ends of the ladder have strong incentives to invest in the capabilities that will allow them to fight for the middle segments of the market. This dynamic expands the necessary channels *for capability-building* for local firms on both the demand side and the supply side. In short, each segment serves as a rung on the development ladder for indigenous firms. Missing segments at any point can impede movement up the ladder. We illustrate the argument with a comparison of three sectors with divergent outcomes: automotive, construction equipment, and motorcycles.

1. Introduction

Within their home markets, why are emerging market firms (EMFs) able to challenge incumbent firms from developed economies in some industries, but not others?

Theories of disruptive innovation predict that new entrants should have an advantage over incumbents in market segments that demand products with different attributes than established markets (Christensen 1997; Adner 2002; Christensen and Raynor 2003). The new entrants produce products that have lower performance on the attributes demanded by established markets, but the performance meets the demands of the new markets (and the price is lower). Because these low-end segments have lower margins than high-end segments, they are ignored by incumbent firms. This enables new entrants to build their businesses, improve performance, and eventually "disrupt" established markets. Similar arguments have been widely used to explain innovation in emerging markets, where lower per capita incomes lead consumers to demand more "value for money" than in developed economies (Hart and Christensen 2002; Williamson 2010; Wooldridge 2010; Petrick and Juntiwasarakij 2011; Radjou et al. 2012).

This literature has difficulty explaining variations in outcomes, however. Although the focus in the literature is on cases of success, the empirical reality is that there is tremendous heterogeneity in outcomes, even when the presence of a large and under-served low-end segment provides the potential for disruption. In Brandt and Thun (2010), we assess the relative market share of domestic firms, foreign firms, and imports between 1995 and 2004 in China's domestic market on the basis of data from China's industrial census and trade statistics. The sectors Chinese firms were able to expand their market share were concentrated in labor-intensive sectors, while foreign firms were most successful in sectors that were more capital and/or knowledge/technology intensive, but there was also a great deal of variation. Why?

In Christensen's original conception, the theory of disruptive innovation has difficulty explaining this variation for two reasons. First, the core challenge for an EMF is not finding an opportunity for disruptive innovation—the opportunities are everywhere—but engaging in the sustained process of capability building, which Christensen simply assumes occurs. Second, although existing theories argue incumbent firms cede the low-end to new entrants and retreat to more profitable high-end segments, in an emerging market the incumbents often stay and fight.

Due to the high volumes and rapid growth in the middle segments of these markets, incumbent firms believe that they cannot afford to ignore lower-end segments. A theory of disruption in emerging markets must factor in the competition that ensues.

The purpose of this paper is to construct a framework that allows us to explain why EMFs are able to innovate and build capabilities in some sectors but not others. As a starting point, we borrow the concept of quality ladders from the economics literature. In this setting, firms from developing and developed economies target distinct market segments along the ladder that develop different product attributes. 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 producing lower quality versions of the same products.

We then focus on how the availability of successive segments of the quality ladder shapes the development of firm capabilities over time. The structure of a quality ladder influences capability building through two dynamics. The *incubation effect* is shaped by the length of the ladder, which reflects the scope for product differentiation. When ladders are longer, indigenous firms are able to cultivate their capabilities and gain scale in a low-end segment that offers "natural" protection from foreign firms that have higher cost structures. The *competition effect* is influenced by the relative size of each market segment on the ladder. When growth in demand occurs throughout the ladder, firms competing at either end have strong incentives to invest in the capabilities that will allow them to fight for the middle segments of the market, where we expect demand to be growing most rapidly in emerging economies. This expands the *channels of capability-building* on both the demand side (i.e. knowledge of consumer preferences as well as higher demand) and the supply side (i.e. the availability of new skills and knowledge that are a product of localization efforts of foreign firms). In short, each segment serves as a crucial rung on the development ladder for indigenous firms. Missing segments at any point can impede movement up the ladder.

We illustrate this argument by taking advantage of a "treatment" effect of government policy in China on the trajectory of three industrial sectors--construction equipment, automobiles, and motorcycle--in which there was no *prima facie* reason for believing that domestic Chinese firms would enjoy greater success in capturing domestic market share over foreign firms than in the others. As a result of government policy however, these sectors differed

in the extent to which various market segments were present locally: in heavy construction, there was the full range of segments (and hence a strong incubation effect and competition effect); in the auto sector the low-end segment was constricted (and hence a weak incubation effect); and in motorcycles the high-end segment was missing (and hence a weak competition effect). We track the growth of Chinese and foreign firms in each market segment over the course of two decades utilizing data from industrial yearbooks, and then use data from over 200 firm interviews conducted over the course of six years to analyze how the segmentation of the market shaped firm capability-building.

2. Innovation in Emerging Markets

As a starting point, it is worth asking whether innovation is the right frame for understanding the dynamics of competition between EMFs and global firms. A common assumption in the international trade literature is that innovation occurs in developed economies, which are highly endowed with skilled labor and sophisticated equipment, and then is imitated by entrepreneurs in developing economies that have advantageous factor costs (Krugman 1979; Grossman and Helpman 1991). This mistakes the essence of innovation.

Innovation is combination and re-combination.[1] It is the process by which existing knowledge (e.g. of materials, production processes, markets) is combined in new ways, in contrast to invention, which is the generation of new knowledge (Fagerberg 2005: 5). This process of re-combination can lead to radical innovation, which represents a fundamental change in the path that is being followed. More often, it will be incremental and entail relatively minor changes to an existing product or process, although cumulatively and over time, these incremental changes can have as important an impact as a single radical change (Dosi 1982; Henderson and Clark 1990; Christensen and Rosenbloom 1995; Geroski 2003). It is not the rate of innovation that is critical, but the fact that the process of innovation is ubiquitous and continual Lundvall (1992).

Innovation in emerging markets can take different forms. While radical innovation may allow developing countries to leapfrog earlier developers (Soete 1985; Perez 1988; Lee and Lim

[1] As Lundvall (1992: 9) notes, Shumpeter used “innovations” and “new combinations” as synonyms. Our focus in this paper is on commercial innovation.

2001; Mu and Lee 2005), in countries where GDP per capita is a fraction of advanced economies, economic activity is typically dominated by relatively mature industries in which the process of capability building is predominantly one of learning from earlier developers and making incremental changes and improvements to existing technologies (Gerschenkron 1962; Amsden 1989; Wade 1990; Womack et al. 1990; Hobday et al. 2004; Breznitz and Murphree 2011).

The existing literature provides strong evidence of the importance of incremental innovation in the development process, but does not provide a good framework for understanding the heterogeneity in outcomes. A key problem is that success in incremental innovation and capability-building requires essential inputs on both the demand and the supply side, and the existing literature has typically favored one side or the other. Moreover, in this process the interactions between individual market segments also play an important role.

2.1 Supply-Side Explanations

The development literature has focused largely on supply-side challenges. In the developmental state literature, the focus is on how the state mobilizes resources on the supply side, lowers the risk of investment, and selectively allocates resources to domestic firms that meet performance targets, usually in export markets (Amsden 1989; Wade 1990; Woo-Cumings 1999; Amsden 2001). As Wong (2011: 28) argues, the market demand that East Asian states were targeting was relatively clear, and demand was proven in sectors such as autos, electronic components, and semiconductors.

In the global value chain literature, the focus is similarly on the production side, and the challenges of development are defined by export markets in developed economies. The lead firms in these chains are typically firms from developed economies that have the resources to meet the technological demands of these markets and the understanding of market demand. Although insertion in these chains offers opportunities for EMFs to build capabilities, the extent of the opportunity is determined by the structure of the chain and the strategy of lead firms (Gereffi 1999; Humphrey and Schmitz 2002; Gereffi et al. 2005; Schmitz 2007). Studies of technological change in these East Asian countries, building on the “technology push” side of the innovation literature, have also focused on the supply side, both in terms of the development of

the local knowledge base and the assimilation and adaptation of foreign technology (Hobday 1995; Lee and Lim 2001; Hobday et al. 2004).[2]

In the context of export-led growth, a focus on the supply side made sense: the gap between EMF capabilities and the demands of export markets was so great that firms had to push capability development on the supply side before they worried too much about responding to the nuances of market demand. The "pull" of export demand was assumed and the challenge was to "push" the development of new capabilities.

2.2 Demand-Side Explanations

In contrast to the development literature, the innovation literature has long emphasized the importance of the role of both supply and demand-side forces (Mowery and Rosenber 1979; Adner and Levinthal 2001; Di Stefano et al. 2012). Innovation 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 and Rosenberg 1986: 275). "Successful innovation requires a design that balances the requirements of the new product and its manufacturing processes, the market needs, and the need to maintain an organization that can continue to support all these activities effectively (Kline and Rosenberg 1986: 277)."

Christensen's original concept of disruptive innovation builds on this sense of innovation as adapting a technology to the needs of a market. The powerful impact of the concept was in large part a result of the idea that new entrants could challenge powerful incumbents with *inferior* technology (Christensen and Rosenbloom 1995; Christensen 1997; Christensen and Raynor 2003). As Adner (2002) points out, the dominant viewpoint had been the opposite: whether an S-curve (Foster 1986), a technology trajectory (Dosi 1982), or punctuated equilibria (Tushman and Anderson 1986), the focus of technology strategy was how new entrants could deliver superior performance that could not be matched by incumbents.

A disruptive innovation may take different forms (Danneels 2004)—the literature has identified low-end disruption (Christensen 1997), new-market disruption (Christensen and Raynor 2003), business model innovation (Markides 2006), and radical product innovation

[2] A recent exception to this focus on the supply-side is Whang and Hobday (2011).

(Govindarajan and Kopalle 2006; Markides 2006)—but our primary focus is low-end disruptions, those that are a product of low-cost businesses that initially focus on the low-margin segments that are over-served by the performance of existing products.[3]

In Christiansen`s original conception (1997), there are three crucial conditions which make a disruptive innovation possible. First, there must be niche markets that value different product attributes than the mainstream market. While incumbent firms deliver superior performance on the product attributes that are most important to the mainstream segment, the new entrants are able to introduce a product that performs well on product attributes that are only valued by new or niche segments. Typically, these "are simpler, more convenient, and less expensive products that appeal to new or less-demanding customers (Christensen and Raynor 2003: 34)." Second, over time, product development efforts of incumbents remain skewed to up-market segments where margins are higher (Adner 2002; Christensen and Raynor 2003). Moreover, even if an incumbent sought to compete in lower-end segments they would not likely have the cost structure or the knowledge base that would allow it to succeed. Third, growth in the demand for the attributes of mainstream product lags the rate of improvement in the products of either the incumbent or new entrant, which Christiansen assumes to be the same. As a result, new entrants are eventually able to satisfy the performance requirements of mainstream customers, and hence disrupt the primary market of the incumbent.

Hart and Christiansen (2002) label developing countries as "ideal target markets" for disruptive innovation because these are economies where low per capita incomes leads consumers to value a different set of product attributes than in developed markets, and there are vast needs that remain unmet. But several ingredients may be missing. First, it cannot be assumed that new entrants will immediately embark on a process of sustaining innovation, with product improvement proceeding at rate equal to the incumbents. Some firms succeed in this process and others fail. Second, it cannot be assumed that the incumbent firms will remain focused on the upper tail of the quality distribution, where margins are greater. The size and growth of the middle segments of the market may provide incentives for incumbents to direct some of their energies to capturing customers in this segment. When they do so, they begin to interact with the value chains of the new entrants.

[3] The lack of precision in both the definition of disruptive innovation and its scopes is a common complaint in the literature. On this point see Danneels (2004) and Govindarajan and Kopalle (2006).

2.3 Quality Ladders and Emerging Markets

We draw on the concept of quality ladders, which figures prominently in the economic literature to help illustrate the nature of product market segmentation between firms in advanced and developing countries, and the role of the interaction of demand and supply across market segments in the upgrading process. Movement up a quality ladder has immediate parallels with the process of incremental innovation, which figures prominently in narratives on the success of manufacturing firms in Japan, Korea and Taiwan. Quality ladders are also important in models of "learning by exporting" (Bernard et al. 2003; Khandelwal 2010), in which the activity of exporting provides firms new information on market demand as well as access to new inputs and know-how, both of which are critical to quality upgrading and the ability of these firms to capture market share from incumbents in established markets in advanced countries.

A quality ladder focuses attention on two product attributes: quality and price. Quality—much like Christiansen's notion of performance—is simply a short hand for product (or service) attributes that consumers value and are willing to pay more for, with differences among consumers in the value they put on these attributes. Examples might include durability, reliability, speed, and so on. Higher quality is also costly for firms to produce, requiring some combination of better designs, superior intermediate inputs, and improved manufacturing processes. These costs will depend on a firm's capabilities, which reflect the know-how collectively held by groups of individuals within the firm. Firms compete through vertical product differentiation, with each firm deciding the level of quality to supply to the market on the basis of their individual capability, and the price consumers are willing to pay for quality (performance). In this setting a ladder in quality emerges—higher rungs, higher quality, and higher prices—with firms producing the highest quality also enjoying the highest profits.

This trade-off between quality and price roughly reflects the initial sorting of EMFs and global firms in the international market, with the former specializing in low quality/low price goods and the latter specializing in high quality/high price goods (Grossman and Helpman 1991; Fajgelbaum et al. 2011). The competitive threat posed by imports to advanced countries from developing countries will generally depend on the length of the quality of ladder, which represents the difference between the highest and lowest quality supplied. All else equal, longer

quality ladders and greater room for vertical product differentiation allow advanced country firms to insulate themselves from cheaper imports because they can specialize in the segments of the quality ladder in which their superior skills, capital, and/or technology give them an advantage (Khandelwal 2010).

Over time, movement up the quality ladder is critical. In endogenous models of economic growth, firms with market power invest in R&D in order to move up and escape the impact of competition from imitators on firm profits.[4] These models have been extended to allow for differences across industries (see Taylor, 1993), and thus better accommodate observed differences in R&D intensities arising from both "demand pull" and "technology push factors" (Cohen and Levin, 1989; Kamien and Schwarz, 1982). They also admit roles for both product (quality) and process (cost) innovation, but the exact mechanisms of upgrading are not clear.

The rapid growth of emerging market economies over the last two decades identifies a shortcoming in the dynamic outlined above, a shortcoming also shared by models of disruptive innovation. Current estimates suggest that growth in demand in China is in upwards of a quarter of the growth in global demand. With per capita incomes in China only a quarter of those in advanced countries, medium quality market segments are likely to offer some of the largest opportunities for firms in advanced countries in these markets. Rather than always moving up market, firms from advanced countries might actually want to move down market at the same time that firms from developing countries are trying to move up market. But serving this market is not costless, and the benefits and costs of doing so need to be laid out. Moreover, serving this market may require these firms to set up manufacturing operations in the emerging market.

As in the disruptive innovation literature, the quality ladder literature does not explain how firms actually move up ladders, and upgrading remains a black box. Theoretically, firms are assumed to differ in their capabilities, with movement up the ladder tied to investments in R&D. For emerging market firms, exporting to advanced countries is assumed to offer the opportunity for new learning and upgrading, but the exact channels through which this occurs are rarely spelled out. From the perspective of firms in newly industrialized countries such as China which

[4] In these models, firms are assumed to have monopoly market power. More recently, Boldrin and Levine (2009) have developed models of quality ladders and endogenous growth in the context of "competitive innovation" in which firms do not have market power and diminishing returns to existing ideas figures prominently.

also enjoy rapidly growing domestic markets, movement up a quality ladder is the key challenge and it is crucial to understand how this upgrading occurs.[5]

3. A Heuristic Framework

Globally, industries will typically have distinct market segments related to "quality", where quality refers here to features or attributes of a product (or service) that bear on its ability to satisfy needs of the user. The market for bicycles, for example, will include models for recreational use, the serious amateur, and the professional. The actual size of these market segments as well as the prices consumers are going to pay for each "quality" level depends on the interaction between consumer preferences (demand) and capabilities and costs of firms (supply) in each of these segments. We begin by sketching this out in the context of markets in more developed countries. We then examine the kind of segmentation that may occur as an economy such as China's opens itself up.

3.1 Quality Ladders: The Interaction of Demand and Supply

Consider the case in which there are "n" potential quality levels of a product. For every consumer, there is a family of demand curves expressing their demand for a product of quality i, $q_{i,}$ as a function of the price of that quality, the price of all other quality levels, the prices of all other goods, their income and preferences. For any given quality level, demand is downward sloping, or decreasing in price. For every quality level, there will also be a reservation price, i.e. a maximum price that the consumer will be willing to pay for a product of quality q_i, all else equal, e.g. $R^D_{q1,}$ R^D_{q2}. Reservation prices will be increasing in quality levels, implying that individuals are willing to pay more for higher quality products. Because of heterogeneity in preferences, these reservation prices will differ among consumers. Aggregating over all consumers, we obtain a set of market demand curves linking demand at each quality level to the price of that quality, prices of other quality levels, incomes and preferences. Aggregate demand

[5] There are multiple strategies a firm may pursue to obtain competitive advantage that do not involve movement along a quality ladder (e.g. horizontal differentiation), but over time, improvements in quality are a fundamental part of the upgrading process.

will be increasing in quality: all else equal, consumers are willing to pay more for a higher quality product; moreover, at any given price, quantity demanded is greater for higher quality products. In Figure 1a, D_{q1}, D_{q2}, and D_{q3} are the market demand curves for quality levels q_1, q_2 and q_3, and $R^D_{q1,}$ R^D_{q2}, and R^D_{q3} are the reservation demand prices for these same levels of quality.

There is a related supply side that is equally important. For every firm, there will be a family of supply curves linking supply of a product of quality i, q_i, to the price of that quality, holding fixed the prices of all other quality levels in the market, input prices, technology, and a firm's capabilities. At any given quality level, supply is upward sloping. For every quality level, there will also be a reservation price, i.e. the minimum price at which the firm would be willing to supply a product of quality q_i, all else equal. These reservation prices will be increasing in quality levels, reflecting the higher costs associated with producing higher quality products. Because of heterogeneity in underlying capabilities of firms, these reservation prices will also differ. All else equal, more capable firms will have lower reservation prices at each quality level.[6] S_{qi} and R^S_{qi} in Figure 1a are the counterparts on the supply side to D_{qi} and R^D_{qi} on the demand side.

The result of the interactions between demand and supply in quality levels is a set of prices and quantities transacted at each quality level (see Figure 1b). Associated with this equilibrium is a locus of price-quality pairs, i.e. a price for each quality level of the product sold, that is increasing in quality; in other words, higher quality products are more expensive. The positive relationship between price and quality in the quality ladder reflects both the willingness of consumers to pay more for higher quality products, as well as the higher costs of producing them. Moreover, for any industry (set of firms) there will be a lower bound below which quality does not go, as the price consumers are willing to pay for this quality level is insufficient to compensate producers for their costs. There will also be an upper bound. Sectors may differ in terms of the quality levels these loci span, i.e. their length, as well as in their upper and lower bounds. Figure 2 provides several illustrative examples. As noted above, less differentiated, more commodity-like products will have shorter ladders.

[6] It is also likely that higher levels of quality will be unachievable by some firms, reflecting their underlying capabilities. For these firms, the reservation prices of these quality levels are infinity. This is the counterpart on the supply side to Adner and Levinthal's (2001) notion of a functionality threshold on the demand side.

3.2 Quality Ladders in Developing Countries after Liberalization

When a developing country such as China opens up through the liberalization of trade and investment policies, it faces a menu of prices tied to quality levels determined in international markets. For simplicity, we take these prices as given. In the domestic economy, there will also be a set of market demand curves linking demand of consumers at each quality level to prices, incomes and preferences. There will be a similar set of curves on the supply side reflecting domestic firms' underlying capabilities, technology, and local costs.

In any given sector, and assuming no barriers to trade, the division of the domestic market between domestic and foreign firms (either through imports or FDI) will depend on the interaction between international prices at each quality level, domestic demand at each quality level, as well as supply of local firms at each quality level.[7] In principle, there are multiple possible outcomes here. Two obvious extremes are either foreign or domestic firms serving the entire market.[8]

Intermediate cases are more likely. At the outset, lower levels of capability of domestic firms will preclude them from entering and competing in most market segments. However these same firms may enjoy "natural" protection from foreign firms in lower end segments, where we expect much of demand to be initially concentrated in the domestic economy. This natural protection reflects some combination of domestic firms' existing capabilities, lower local manufacturing costs, and the higher cost structure of firms from advanced countries. Existing value networks may limit their ability to lower costs (Christensen 1997). Domestic firms may also benefit from a superior knowledge of local demand and marketing channels. Conversely, higher end market segments will typically be beyond the existing capabilities of domestic firms, with quality levels associated with some segments unachievable at any price.[9] In Figure 3, we super-impose on the quality ladder for the rest of the world the reservation demand and supply

[7] With the opening up, the entire family of domestic demand curves will be affected because consumers will now be facing a new set of prices in quality. The same is true on the supply side for Chinese firms. We make the simplifying assumption here that China is a price taker.

[8] With these two extremes, the quality segments that are served may differ. Domestic (foreign) firms may capture the entire local market, but the market may only be in lower (higher) end goods.

[9] In terms of the price-quality locus, this implies that at some quality level, the reservation price effectively becomes infinity.

prices in quality levels (R_q^D, R_q^S, respectively) in the domestic market to represent an intermediate case in which local (foreign) firms capture the low (high) end in the domestic economy, but the middle is not served.

3.3 A Dynamic Approach to Quality Ladders

We define successful upgrading as the ability to compete and capture market share in successively more demanding (higher quality) market segments. What is required for successful domestic firms to emerge in these kinds of industries?

The incubation effect depends on the length of the quality ladder. Longer quality ladders are associated with greater vertical product differentiation, and allow domestic and foreign firms to focus on either end of the ladder. The low-end provides domestic firms "natural" protection from higher-cost foreign firms, and the space to develop capabilities and increase volumes.[10] This market segment must be large enough to generate returns sufficient to fuel the upgrading process. This is the first rung on the ladder.

The size and growth of various market segments shapes the incentive of firms at both ends of the quality ladder to undertake the investments in capability building that allow them to compete in new market segments. In terms of Figure 3, huge opportunities in the middle can make it profitable for firms from advanced countries to move into lower quality segments.[11] Over time, we also expect an upward shift in R^D_q as a result of rising incomes in the domestic economy, with much larger effects observed in market segments with higher quality. The growth in demand provides domestic firms an incentive to move into higher quality products, and makes the lower quality market segments even more appealing to foreign firms.

The interactions between firms across market segments are critical. Firms competing in the low end are generally eager to escape intense competition and low margins, but are unlikely to invest in innovation and capability-building if demand in middle- and high-end segments is limited. When demand is present, the most capable domestic firms will be in a position to cover the costs associated with quality improvement and upgrading. At the high-end, existing theories

[10] Domestic firms may be able to undercut foreign firms in low-end product markets because of lower input costs. They may also be able to extend the quality ladder to even lower quality levels.

[11] In terms of Figure 1, this can be seen in terms of outward shifts in the demand for products of quality, Q_0, which originally were not produced by these firms.

of disruptive innovation and quality ladders assume that incumbent foreign firms remain focused on more demanding market segments when faced with competition from new entrants. At some point, however, the size and growth of middle market segments are able to compensate for lower margins and the added costs associated with developing a product that better meets the needs of consumers in these less demanding market segments. Typically, this involves substituting the lower-cost capabilities available within an emerging market. There are opportunities for cost-savings at each part of the value chain: R&D, the supply network, manufacturing, downstream sales/distribution/service.

These investments, which effectively shift the quality ladder of these firms (ROW) upwards and to the left, also impact the supply locus of domestic firms. Insofar as domestic firms are able to tap into the deeper sets of capability fostered by the behavior of foreign firms in the domestic economy, their reservation supply curves will shift further to the right, thereby intensifying the competition between domestic and foreign firms. Graphically, this can be captured by the outward shift in the reservation supply of domestic firms.

4. Data and Methodology

Our data consist of three industrial sectors in China: construction equipment, automotive, and motorcycles. We combine data from annual yearbooks for each sector in China (used primarily to document the segmentation of the market) and industry reports with extensive field research. In each sector, interviews were conducted at leading firms in the sector and their key suppliers (approximately 200 firms over 6 years).[12] The interviews allowed us to identify the key upgrading challenges, assess the extent of capability-building within firms and sectors, and the channels through which these capabilities were acquired.

We document movement along the quality ladder in each sector by tracking the relative market share of indigenous Chinese and foreign-invested firms in different market segments over time. In each case study, we break the overall sector into segments using proxy measures of product quality. In the case of construction equipment, we use the wheel loader as a proxy for the low-end end segment and the excavator as a proxy for the high-end. On the demand side,

[12] Interview data is cited in the text by a number in parentheses. The number corresponds to the date of the interview in month, day, year format (and a letter is added when there are multiple interviews in a single day).

these two products are substitutes for each other, albeit imperfect: 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.[13] In the case of autos and motorcycles, engine size correlates reasonably well with product quality and sophistication. For autos, we classify as low-end vehicles with displacement of 1.6 litre or less; mid-range is 1.6-2.5, and high-end is more than 2.5 litres. For motorcycles, we divide the market into 100 cc and smaller, 110-125cc, and 150 cc and larger.

4.1 Case Selection

Since our intent was to understand how missing market segments can impede upgrading along a single quality ladder, we chose sectors that *ex ante* appeared to have similar opportunities for growth and upgrading. The length of the quality ladder, which is a measure of the degree of vertical product differentiation in a sector, nicely captures the potential for upgrading. Recent work by Khandewal (2010) suggests that globally all three sectors, motorcycles, construction and autos have quality ladders of greater than average length, with that for autos the longest, followed by construction equipment and then motorcycles.

Second, we selected cases in which the challenge of technology upgrading is broadly similar. These three industries are in relatively mature stages of 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. Each of these sectors had also been successfully developed by China's neighbors in East Asia, suggesting there was no reason to believe that China would not have similar success.

And third, the shared domestic setting allows us to hold constant key aspects of the national system of innovation.[14] While there can be crucial differences between sectors within a

[13] For each of these pieces of equipment, there are also distinct market segments.
[14] Regional difference in innovation systems may also be important, but given that we are looking at outcomes at the national level, it is not necessary to explicitly focus on why one region might be more successful in developing a particular sector.

nation, the three sectors that we are focused on have much in common: each has solid roots in the planned economy, each has key state-sponsored research institutes, and each has a mix of state and private firms.

Despite very similar potential opportunities for upgrading in the three sectors, the policy environment shaped the composition of rungs of the quality ladders (i.e. market segments) in distinctly different ways. In construction equipment, the policy environment was quite liberal (e.g. low tariffs, few restrictions on technology transfer and foreign entry, multiple forms of domestic ownership and permissive M&A policy), and the growth in demand was strong and roughly balanced in all segments of the quality ladder. Demand in the low-end segment initially exceeded that in the high-end, but all segments exhibited robust growth over time, with sales in the high-end eventually surpassing the low-end in absolute terms. In the motorcycle sector, the high-end of the quality ladder was constricted by a ban on motorcycle usage in most major cities (where incomes were highest) and highways that was imposed at the end of the 1990s. When combined with persistently high tariffs in the sector, the result was a rapid drop in overall growth rates in the domestic market, a convergence on a standard low-end model, and an increasing reliance on undemanding export markets. In the automotive sector, a variety of regulatory constraints on firm entry, ownership, technology transfer, and tariff and non-tariff barriers restricted growth in the low-end of the quality ladder prior to China's accession to the WTO. Demand was primarily institutional (i.e. state-owned firms and governmental units) and private demand was limited during this period. Table 1 summarizes how state policy shaped the segmentation of markets in each sector.

4.2 Variation in Outcomes

In each of the case studies that follow we document movement along the quality ladder within a sector by tracking the relative market share of indigenous Chinese and foreign-invested firms in distinct market segments over time. In construction equipment, Chinese firms dominated the low-end wheel loader segment in the early period of growth, while FIEs and imports almost exclusively served the high-end excavator segment, but over time the strongest Chinese firms were able to move aggressively into the excavator segment (of which they now control 40 percent). In motorcycles, domestic firms control 70% of the market, but they have

been unable to move into higher-end segments of the market, and growth on the margin through exports has also been at the low-end of the market. In autos, the market share of domestic firms has plateaued at 30%, and these firms have shown limited ability to compete in higher-end segments. Market share data is supplemented with concentration ratios in each sector, and only in construction equipment is growing concentration among domestic firms an important trend.

5. A Ladder with a Full Complement of Rungs: Construction Equipment

In the Chinese construction equipment sector, domestic firms have steadily moved up the quality ladder over the last three decades. The wheel loader segment has always been dominated by domestic firms (see Figure 4). There are two clear indications of growing capabilities among Chinese firms. First, within the wheel loader segment, the most capable firms gained market share (e.g. the four-firm concentration ratio increased from 43.5% in 1997 to 62.2% in 2010), and began to produce larger machines that they sold at a premium.[15] Second, the strongest domestic firms began to penetrate the high-end excavator segment that previously had been almost exclusively controlled by foreign firms. By 2010, domestic firms succeeded in capturing nearly 30% of the rapidly expanding domestic market and industry analysts expect this figure to rise to 50% by 2015. Figure 4 captures the market share of foreign and domestic firms in wheel loaders and excavators in 1999 and 2010.

5.1 Incubation Effect

During the first two decades of development, the Chinese market for construction equipment was dominated by low-end products. As Table 3 indicates, in 1997 the number of wheel loaders sold in China was almost six times the number of excavators (17,404 units compared to 3,293). Within the wheel loader segment, the demand for quality also varied widely, and the bulk of demand was for machines that were towards the lower end of the quality ladder (see Figure 5). Quality is a bundle of attributes, but one measure that is typical within the construction equipment sector is the average number hours of use until a major overhaul was

[15] 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).

required. An average for a domestic machine was 3,000 hours, compared to 20,000 for a foreign machine. These machines were put to different uses: the domestic machine might be used for utility purposes around a factory (and a breakdown was not costly) while the foreign machine might be used in ports and mines, operating 24 hours a day with different shifts of operator (and a breakdown would bring the entire operation to a halt). Systematic price information is not available in the sector, but firm interviews consistently report that foreign products were at least three times as expensive as domestic (122107, 121907).

The dominance of Chinese firms in the low-end derived from a combination of capabilities and cost structure that was better able to meet the demand requirements in this segment than foreign firms. As a starting point, it is important to recognize that Chinese firms were not starting from scratch at the start of the reform period. Basic capabilities were cultivated during the era of the planned economy, when the Ministry of Machinery Industry (MMI) in Beijing coordinated the flow of technology, personnel, and other resources between key firms and research institutes. In the mid-1980s, after the start of reforms, MMI coordinated the licensing of technology from leading firms such as Caterpillar and Komatsu for a line of key products and components and distributed the technology to leading SOEs.

The barriers to entry towards the bottom of the quality ladder were low for domestic firms. From a policy perspective, there were few restrictions on entry, and private firms entered the sector in large numbers. From a technology perspective, the designs of the basic wheel loader were well-known (and IP protection weak) and components could easily be sourced from outside firms. In Fujian, for instance, the leading wheel-loader producer was an SOE that was among the original licensees of CAT technology in the 1980s. As the market expanded in the 1990s, the firm increased its out-sourcing so that it could increase capacity, but several of these suppliers eventually moved into the production of wheel loaders (073008). This experience was replicated elsewhere, and before long once dominant SOEs found they were competing with twenty or so small private firms. As a result of intense price wars, the price of a basic 5-ton wheel loader produced by a Chinese firm may have fallen by as much as a third or a half in the latter half of the 1990s (072908, 073008, 073108).

The intensity of competition within the sector not only squeezed the profits of Chinese firms, it further reduced the competitiveness of foreign firms (both for imports, which fell from 4,224 units in 1993 to 438 in 1999 and for those produced by FIEs in China). First, rapidly

falling prices for Chinese-made wheel-loaders reduced local demand for higher quality (and more expensive) products of the multinationals. Second, on the supply side, foreign producers could not match the low-cost manufacturing capabilities of Chinese firms.

The competitive strength of Chinese firms in the low-end segment was the result of incremental innovations that enabled them to match the product requirements to market demand. Although the Chinese firms started with foreign-licensed design in the 1980s, incremental changes resulted in a product design that was uniquely suited to a price-sensitive Chinese market: the performance-price ratio of the product was extremely high, it was relatively easy to produce, and inexpensive to repair.

Innovation at the product level did not occur in isolation from other parts of the value chain. Upstream, the components were designed with an eye to taking advantage of locally manufactured (and less expensive) capital equipment. The standardization of components throughout the industry allowed the supply network to achieve scale economies, leading to a lower sales price and less expensive aftermarket prices (112408a and 092512). The depth of the distribution network and the ability of dealers to arrange financing for customers allowed the leading Chinese firms to serve customers that foreign firms could not.[16] The dealer network also channelled customer feedback back to the design teams allowing the designers crucial information to more effectively balance trade-offs between performance, quality and costs than foreign firms.

Although competition was intense among domestic firms in the low-end segment, these firms were not threatened by the dominant global players. A leading North American firm conducted three studies on the feasibility of competing in the Chinese wheel loader market between 1995 and 2003, but each time decided that it would not be profitable. One problem was that there global designs had too many features for the Chinese market, and the global design team "did not have much of an appetite for de-featuring" a model (122107).[17] The cost of design was also high. Another problem was that the core competency of the firm was in the fabrication of major structures of the machine, and the designs required expensive and sophisticated

[16] Leading domestic firms typically had hundreds of dealers, and the network reached far into lower tier cities in China. As a comparison, a leading North American firm had 4 dealers (each of which had sub dealers) and a leading European firm had 20 (081007, 050709).

[17] There is also reason to believe that the firm was not very good at "de-featuring" a model. In 1998-1999, the firm introduced a "de-featured" excavator but customers thought that it looked "cheap" and it did not sell well. Interview 122107.

machinery that required significant capabilities to use—this limited the extent to which they could outsource (122107). As a manager succinctly explained, "[Our] value proposition does not fit the Chinese buyer" (050709).

Domestic firms during this early stage of growth found it difficult to expand their sales in the high-end excavator market, however. As a result of the much higher design and manufacturing requirements of the excavator (e.g. the complex integration of the hydraulics, engine, and electronics) Chinese OEMs were much more dependent on parts and components that were either imported, or that could be sourced from multinational suppliers producing locally. These requirements effectively raised the minimum price that these firms needed to sell at in order to break even.[18] Much larger gaps in product quality relative to those manufactured by the multinationals undermined the kind of competitive advantages domestic firms enjoyed in the case of the wheel-loader.

5.2 Competition Effect

The expectation of both the disruptive innovation literature and the quality ladder literature is that global incumbents, when threatened in the low-end, should retreat up the quality ladder where margins are higher. This certainly should have made sense in the Chinese construction equipment sector. The wheel loader segment was high volume and low margin compared to the global industry: in 2006, Chinese wheel loader sales represented two-thirds of global sales by unit, but only one-third by sales value (050709). In the excavator segment, firms reported that profit margins in China were higher than global margins, which in 2007 were between 10 and 20% in 2007 (081007). Even more importantly, the upper ends of the quality ladder (both for high-end wheel loaders and excavators) required genuine aftermarket parts, the sales of which were crucial to the bottom lines of the foreign firms. For a foreign firm, the sale of aftermarket parts and service contracts were typically 40-50% of revenue; in China, where a wheel loader customer would choose a counterfeit or commodity replacement part that was 1/5 the price of an original (even if it would not last as long), the OEM could seldom count on aftermarket business contributing much more than 1% of revenue (122107 and 092512).

[18] The price of an excavator produced by a Chinese firm was on the order of 80 percent or so of the price of an excavator manufactured by a foreign firm. By comparison, the price of a domestic wheel-loader was only a third.

The low margins in the lower segments of the quality ladder were balanced by high volumes and growth, however. As Figure 6 indicates, in 2007 and 2008, the Chinese market for construction equipment eclipsed North America and Europe, and by 2012, it was larger than the rest of the world combined. Although the high-end was expanding even more quickly than the low-end, the growth of the low-end remained healthy (see Table 3A). As the manager of a leading North American firm remarked in 2009, his firm's original view was that the Chinese customer would migrate to the higher quality products (which were the firm's strength), but this had not happened as quickly as they expected (050709). Moreover, the OEMs competed for the most effective dealers, and dealers put strong pressure on them to provide a full product range because they could not survive unless they provided "one-stop shopping" for customers (112108).

5.3 Channels of Capability Building

Competition between foreign and domestic firms for the high volume middle segments of the Chinese market deepened the upgrading channels.

Foreign firms, in order to cut costs and move beyond the high-end, were forced to aggressively localize their operations. First, the foreign firms continued to develop OEM assembly capabilities in China. In wholly-owned facilities, steady improvements in productivity resulted from training programs for workers and managers, but given that labor cost was a relatively small percentage of overall cost, these continued to be high-cost operations. Another approach was to purchase a stake in a Chinese competitor that had low-costs, and then gradually introduce processes (e.g. introducing failure analysis processes, introducing metrics to measure performance, rationalizing the layout of the assembly line, etc.) that would improve quality without adding costs (112408). Second, and particularly important given that 70% of the total cost of a product was typically in components and materials, the foreign firms established supplier development programs. The example of a leading Western producer of excavators that established a JV with a Chinese firm in the mid-1990s is illustrative. By 2003, the domestic content (by value) of its products was still only 20 to 25%. By 2008, this figure rose to 50% and the goal was to achieve 60-70% domestic content (081007). Other leading foreign excavator firms producing in China report similar peak rates of localization. These rates can only be

achieved if foreign firms can identify capable Chinese suppliers and provide them with the engineering resources that are required to increase their manufacturing capabilities.[19] Third, the foreign firms set up R&D centres in China that allowed them to both design new products for the Chinese market and provide the engineering teams that worked with key domestic supply firms.

As leading domestic firms developed higher quality products, there was a common progression in sourcing strategy for core components: initially rely on a foreign supplier, but then develop internal capabilities (sometimes through JVs with foreign firms) that would allow them to differentiate their product. The leading domestic wheel loader producer, for example, produced a basic wheel loader, the 50c series that sold for approximately RMB 350,000 and a higher quality wheel loader, the 856 series, which sold for about RMB 450,000. The engine of the 50c was sourced from Weichai, the leading domestic engine firm, while the engine of the 856 was being developed in a JV with Cummings (a leading global firm). The transmission of the 50c was produced internally, while the transmission of the 856 was produced in a JV with ZF (a leading global firm). The master control valve for the 50c was produced internally, while the master control valve for the 856 was outsourced to a JV, and there were plans to bring this in-house (102611). The pre-existing capabilities in this sector were solid, and firms were able to take advantage of the channels of capability building that were being extended by foreign firms.

6. Missing High-End: Motorcycles

The motorcycle sector provides a valuable comparison to construction equipment. Based on the experience of Japan and Taiwan, it is a sector in which Chinese firms should have done extremely well. On the supply side, the capabilities and requirements are lower than those in heavy construction. It is also more labor intensive. On the demand side, with a population of over a billion and the motorcycle a natural substitute for the bicycle as household incomes rose, the domestic market was huge. In principle, a market this size could have supported ten or more world-class firms each producing in upwards of a million units.

[19] Evidence of the improvements can be found in defect rates. The leading Western firm referred to above reported that in the previous two years the defect rate for its first tier suppliers in China had improved from 380 ppm to 74 ppm. The current rate was among the lowest it had achieved anywhere in the world (081007).

Although the motorcycle sector has shown enjoyed robust growth and domestic firms have done well vis-à-vis foreign firms (see Table 4), domestic firms have been unable to move up the quality ladder. Evidence of this failure can be found in the dominant domestic market share of the standard low-end model, the 125 cc motorcycle, which increased from 23.6% of total volume in 2003 to 57.5% in 2010. As a result of new firm entry into the sector, the market share of highly cost-competitive private firms increased to more than 40%, but overall fragmentation in the sector also increased with the four-firm concentration ratio decreasing from 40.3% in 1997 to 30.0% in 2010. The sector was characterized by intense competition between firms that were essentially producing a low-end commodity product.

Similar difficulties are seen in exports. After 1997, with growth in the domestic market languishing, nearly two-thirds of the growth in sales by domestic firms was tied to exports, which grew from less than 100,000 units in 1997 to 11.4 million in 2010, an annual increase of 35.5%.[20] When Chinese firms went abroad they were forced to seek export markets that demanded products at the same or lower level 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 especially 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 declines markedly.[21] By 2010, exports of Chinese firms were also beginning to lose out in markets such as Vietnam to local JVs.

6.1 Incubation Effect

[20] Over the same period, exports go from representing only 1% of total motorcycle sales to 34.2%, and in 2011, rose further to 42.3%. Conversely, domestic sales of firms producing in China fell from 99% to 57.7% of their total production.

[21] For 125 cc bikes, the average price falls from 4557 RMB to 3236, a fall of nearly thirty percent. 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.

The development of the Chinese motorcycle up through the mid-to-late 1990s has some obvious parallels with the construction equipment sector: the sector was initially dominated by state firms who licensed technology from foreign firms, but then 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.

In the early 1980s, there was a series of technology licensing agreements between leading Japanese firms (e.g. Suzuki, Honda, Yamaha) and upwards of 20 state-owned firms, most of which were defense-related. These firms possessed engineers, skilled technicians, and machining know-how, and the technology transfer agreements were part of efforts to convert these firms from military to civilian production. Through the 1980s, and under a very high tariff umbrella, growth was cyclical in the sector and production grew only modestly, with an annual growth rate of only 4.1% between 1985 and 1991.[22]

In the 1990s, growth in domestic demand accelerated, spurred on by the kick start to economic growth coming from Deng's southern tour in 1991 and a reduction in tariffs on motorcycles of nearly a half. This was met by an expansion in production by existing players and new entry. 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: 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 (Automotive Industry of China, 2002), production grew eight fold from 1.2 million units to 9.6 million. In 1997, production was dominated by state firms, who held two-thirds of the market, but there were also private and collective firms (21.5%) and FIEs (12.7%).[23] Market concentration was relatively low, with the top 4 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

[22] 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 (Automotive Industry of China, 2002).

[23] 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.

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: 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: 58 and 60). The market 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 33.2%, with most of this growth in the very low-end segments of 100 cc and smaller. In 1997, 96.5 percent of domestic sales were for motorcycles 125 cc or below (see Table 4).

6.2 Weak Competition Effect

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. Internally, 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. Between 1990 and 2010, China's urban population doubled from 300 to 600 million, with more than half of the urban population living in the 40 largest cities (McKinsey 2009), but the bulk of demand for motorcycles came from rural areas and lower-tier cities in China. Externally, tariffs on motorcycles remained high in China after accession to the WTO, while tariffs on automobiles were reduced. 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. [24] More recently, demanding environmental requirements have been issued, which has increased the costs 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 five percent per annum between 1997 and 2010, and growth in higher-end segments was severely restricted.[25]

[24] Small cars have also benefited from government subsidy programs durng the last decade.

[25] 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 percent between 1991 and 2010; and third, what we would predict on the basis of estimates of the income elasticity of demand (~1.75) for motorcycles

6.3 Shallow Channels of Capability Building

The lack of demand for higher quality bikes weakened the incentive 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 tend to purchase standard products, and valued ease of repair and low price rather than high-quality (Interview 040812a; Ohara 2006: 33). When both internal and external barriers constrained the growth 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.[26]

Honda, for instance, after watching its market share for in-house bikes decrease from 24% in 1995 to 3% in 2000, formed a series of JVs with Chinese "imitators," and began to adapt 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: 42-43). At a second JV, Wuyang Honda, the sales price for the 125 cc model was RMB 4,729 in 2004, halting a sharp decline in the JVs sales volumes (Abo 2011: 43). As in the case of the foreign firms that acquired stakes in Chinese wheel loader firms, the Japanese focused 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 re-enforcing 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 the 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

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and per capita income growth in China (8 percent). 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 percent.

[26] In contrast to autos, Japanese motorcycle OEM's typically sourced through local domestic suppliers when they invested overseas rather than through Japanese suppliers that set up local production facilities.

compared to RMB 80,000 for a comparable European, but sales were disappointing. As one manager explained, investments in high-end products rarely could be justified in economic terms (040812b). Even when firms did seek to upgrade, they had fewer resources to draw on. The 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.[27] 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 to these manufacturers 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 create 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

[27] In 2001 and 2002, the profit rates of Chinese firms were below zero, and R&D expenditures for the industry were declining (Ohara 2006: 105).

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.

7. Missing Low-End: Automotive

Based on the successful experience of both Japan and Korea, the automotive industry is also a sector in which Chinese firms might reasonably be expected to do well. Over the last two decades, the domestic market has grown by 23.4% per annum, with annual sales increasing from 134,000 units in 1991 to 11.8 million in 2011. This huge increase in domestic demand has been met almost entirely by domestic production, but as in the case of motorcycles, domestic firms have been unable to leverage the benefits of this growth.

The market share of domestic firms increased during the last decade, but this increase belied underlying weakness: there is a high level of fragmentation in the sector amongst domestic firms and increasing market share was often achieved through a proliferation of models rather than the development of high volume models. Reflective of this behavior, in 2010, median sales per model by a Chinese SOE (private) OEM were one-sixth (one-third) of a foreign OEM (Warburton et al. 2013). The market share of domestic firms plateaued at 30% and leading domestic firms have shown limited ability to compete in higher-end segments.[28]

7.1 Weak Incubation Effect

In contrast to the construction equipment and motorcycles sectors, the incubation period for the Chinese auto sector was not conducive to incremental innovation in a broad spectrum of firms.

The structure of the automotive sector at the start of the reform period was not all that different than construction equipment or motorcycles—the industry was small and fragmented, largely state-owned, and technology was badly dated—but the central government exerted

[28] The domestic OEMs share of revenue in the domestic auto market was only half of their market share, reflecting the lower price point of the cars (Warburton et al. 2013).

significantly more influence over the sector, and tightly restricted participation in the sector. First, in the 1980s the state designated six domestic firms ("three big and three small"), all of which were state firms, as the chosen firms in the industry, and declared that no others could be established.[29] The number of centrally-authorized 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 JV subsidiaries as late as 2002 (Thun 2006: 61). Second, the central government tightly controlled foreign participation in the sector. FDI was only allowed in the form of JVs, and foreign firms were prohibited from having a majority stake. Prior to WTO accession, tariffs were high.

The result of high barriers to entry and high levels of protectionism was an increase in prices and a market that skewed away from the low-end segment. This is captured in the top two panels of Figure 7 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, larger sales.) The average price of a vehicle in the mid-1990s, for example, was RMB 130,000, or forty time per capita incomes. 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: 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.[30] As late as 2000, the low-end auto segment accounted for only 20% of total sales, and the majority of these were from a single firm (see Table 6).

On the supply side, the JVs between the Chinese state-owned firms and foreign firms were a valuable means of 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

[29] Although these restrictions were often ignored at the local level, they prevented the expansion of locally-supported firms beyond their home jurisdiction.

[30] In 1996, less than 20% of auto sales went to individuals (McKinsey 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 ten (five) percent of the distribution was more than 10,000 (20,000) RMB.

allowed for a greater transfer of certain kinds of 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. In the context of a JV with state-owned partners who were possible future competitors, however, foreign firms were less inclined to transfer technologies and knowhow that were considered to be core capabilities, particularly those involving vehicles design (Nam and Li 2012). The foreign firms conducted the design and development of vehicles outside of China, and until competitive pressures (and growing market demand) provided incentives to shift R&D to China, they sought to use the JVs as contract manufacturing firms. As a result, through the 1990s the Chinese partners had fewer opportunities to acquire systems-wide knowledge of the sort Chinese wheel loader manufacturers were acquiring during the same period.

There was a single domestic firm that licensed technology during this period, Tianjin Auto, and it dominated the sub-compact market segment in the 1990s. In principle, this should have provided an excellent platform for the same kind of incremental innovation that was common in the construction equipment sector, but it did not. In the absence of significant competitive pressure from other firms in the low end, and little pressure from buyers, minimal effort was made to update the design and sales dropped when the market shifted at the end of the 1990s (080109).

7.2 Delayed Competition Effect

The competition effect in the auto sector must be considered both before and after China's accession to the WTO. Prior to WTO accession, the demand in the low-end market was weak and the foreign partners at the JVs had little incentive to incur the R&D expenses that adapting products to the global market would require (and simply introduced old technology instead). Because profits were high and competition was severely limited, the Chinese partners at the JVs had little incentive to push either for incremental innovations or to aggressively push for a larger role in product design and development at the JV.

As China prepared to enter the WTO at the end of the 1990s, however, there was a rapid increase in competition in the auto sector. First, the central government began issuing licenses for new OEM JVs, and allowed capacity expansion amongst existing OEMs. It also became possible for independent Chinese firms, including private sector firms, to enter the sector.

Second, the terms of China's accession to the WTO mandated that tariffs fall from 80 to 100% to 25%. The sharp increase in competition in the sector, when combined with rapidly rising incomes, led to a dramatic increase in demand among first-time car buyers who were far more price-conscious than institutional buyers. Car prices (unadjusted for quality) fell almost exactly in line with the sharp drop in tariffs, and the share of individual purchases increased from under 20% in 1996 to over 60% in 2006. Between 2000 and 2010, the low-end share of the market increased from 47.7% to 58.9% (see Table 5).

Although the timing was a decade later, the auto sector after WTO accession began to resemble the construction equipment sector in several key respects: there was a growing low-end segment served primarily by independent Chinese firms, there was a high-end segment that was served primarily by the JVs, and the fight for the rapidly growing middle segments of the market was leading to the rapid development of capabilities in the supply chain (Brandt and Thun 2010). The bottom panel of Figure 7 reflects these changes. As Table 3b indicates, there was also tremendous overall growth in the Chinese domestic market, and this meant that the Chinese sales was becoming more important to global OEMs relative to global sales. By 2012, China was the largest market in the world for VW, GM, Nissan, Audi, Hyundai, and BMW (Warburton et al. 2013: 16). Global firms that did not have the capabilities to compete in all of the major segments in China faced increasing pressure to acquire these capabilities.

7.3 Channels of Capability Building

The combination of rapidly falling prices in China (that resulted from increasing competition) and rapidly rising dependence on the Chinese market created an urgent need for global firms to lower their cost structures in China. The approach that they adapted was very similar to the efforts of leading construction equipment firms: they focused on improving the efficiency of their OEM production facilities and in some cases took stakes in low-cost Chinese operations (e.g. GM's investment in Wuling), they aggressively sought to localize their supply chains, and they created R&D centers in China that would could both support the localization efforts and enable them to more effectively respond to the Chinese market.[31]

[31] When Volkswagen's market share in China fell from 56% in 1996 to 16% in 2005, for example, the company announced a restructuring program that sought to reduce costs by 40% through an aggressive localization program

The problem in the automotive sector was that Chinese firms had difficulty taking advantage of the capabilities that foreign firms were nurturing and developing. First, the domestic auto OEMs that entered the low-end segment were new (often private) firms rather than the leading SOEs from the early period of growth. They did not have the benefit of a deeper set of capabilities developed during the initial stage of growth. As a result, and much like entrants in other sectors had done much earlier, they either copied designs or outsourced design work to foreign firms in order to catch the wave of rapidly rising demand. 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.[32] The consequence of this approach, and a potential long-run disadvantage, 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.

A second difference with construction equipment was that the "natural" protection offered by the low-end segment of the quality ladder was threatened from multiple directions. First, the strength of the competition effect was leading foreign firms to aggressively strip down low-end models from other markets and re-design them for China.[33] Second, the used car market began to expand, and provide competition for firms that sought to compete at the lower end of the quality ladder. Third, increasingly sophisticated consumers were willing to pay a slight premium for a car that was believed to be of higher quality. In short, the "incubation effect" that was available to domestic firm's at the low-end was eroding quickly.

8. Conclusion

Emerging markets are rife with opportunities for disruptive innovation. In new markets, where incomes are far lower than established markets, products of incumbent firms often

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("Volkswagen Group in China: Automaker bolsters localization of key components in China," *Fourin China Auto Weekly*, January 7, 2008, p. 3). In Brandt and Thun 2010 we give more details on these efforts.

[32] Geely, for instance, was estimated to have spent approximately $250 per unit on R&D compared to approximately $1500 at Volkswagen and Toyota. 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. (Warburton et al. 2013: 61).

[33] Shanghai General Motors (SGM), for example, took a Daewoo design and used its Shanghai design center to further simplify the model, e.g. a very simple dashboard, cheaper materials, and minor changes to the chassis. It launched this model in 2010 with a price of RMB 58,000, which was only RMB10,000 or so more expensive than many of the competing Chinese models in this segment. By 2012, the Sail was the best-selling subcompact in China. It was also the country's leading auto export (Automotive News China, September 9, 2012).

oversupply performance, and fail to meet the needs of a majority of customers. Although the opportunities for new entrants are widespread, they are not always realized.

In order for sustained capability-building by domestic firms, we argue that the full array of market segments must be present, each of which plays an important role. The lower-end of the market provides new entrants natural protection from incumbents, while competition for the middle and high-end segments of the market ensures incentives for capability-building. Without a low-end segment, the new entrants are not able to acquire the basic capabilities that allow them to start the process of incremental innovation. Without a middle segment, the new entrants have little incentive to invest in upgrading while incumbents have little incentive to build the capabilities required to compete in high-volume/lower-margin segments. Without a high-end, the incumbents will find the local market much less appealing, and over time be much less inclined to be the source of the most sophisticated capabilities that the market requires. Innovation and learning occur at every stage of the quality ladder, and successful development requires each rung of the quality ladder.

Interaction is crucial to this argument, driven by the fact that domestic and foreign firms are moving *towards* each other on the quality ladder. Much of the work on upgrading for low-income countries has been in the context of exporting. When the final market is overseas, foreign firms play the dominant role in the global value chain, and typically control what activities are undertaken in the low-income country. There is interaction between foreign and domestic firms and a transfer of know-how, but activity outsourced to the local economy by foreign firms is often limited to either labor-intensive assembly or the manufacture of less-demanding parts and components. When the final market is at home, the competition for the middle segments of the market expands the points of contact between domestic and foreign firms. As foreign firms move down the quality ladder, new capabilities within the local economy are created that are further leveraged by geographic proximity: workers, engineers, and managers that are trained in one set of firms are able to move to others; suppliers that are nurtured by one customer will apply the same lessons to other customers. The competition for the domestic market is a pressure cooker, and the intensity of the interactions is not easily duplicated when a domestic firm is exporting to a distant market.

There are implications for firms and the policy-makers who try to influence them. With respect to firms, new entrants should seek product markets which have a strong incubation effect,

meaning that the quality ladders are long, and demand in the low-end segment is not easily met by incumbent firms. New entrants should also seek markets in which there is a strong foreign presence in the high-end, and the prospect of these same firms competing for large middle segments. This last point is more counterintuitive—why not seek markets with little competition?—but it follows from the type of innovation that allows new entrants to build capabilities: these firms are not engaging in radical innovation, they are combining and re-combining existing knowledge and the foreign firms in the higher end segments contribute to the knowledge pool that fuels this process. A new entrant operating in a market devoid of foreign participation (e.g. due to restrictions on foreign entry) will enjoy rents in the domestic market, but upgrading and competing in global markets will be more difficult.

Incumbent firms must manage the fight for the middle: they must build and utilize local resources in order to lower their cost structures and increase their ability to respond flexibly to market demand, but they must do so in a manner that protects their own key resources. Within the firm, the proper balance must be achieved between the global organization's desire for global standards, and the local organizations desire for flexibility. At the boundaries of the firm, the proper balance must be struck between utilizing low-cost suppliers and retaining key activities in-house.

Policy-makers in states with large domestic markets should seek to maximize the advantages that are inherent in their size. On the demand side, there must be an awareness of how state policy affects the size of different market segments. Although policy-makers in developing countries tend to focus on the need to push the development of capabilities on the supply side (e.g. the need to channel resources at targeted programs, the need to lure human capital from abroad, the need to trade market access for technology), the demand side is equally important. Policy should be segment neutral, meaning that it should not curtail the size of any particular market segment. Rather than a flat fee for an automobile license, for example, the cost of which is likely to deter the growth of the low-end segment, a municipality might devise a licensing approach that allocates an equal number to each market segment. When the state limits demand in a particular segment, it inadvertently knocks out a rung of the development ladder by eliminating incentives to upgrade, as well as the channels of upgrading that are created by other firms trying to serve these same segments.

On the supply side, the key implication is that the state does not have to aggressively skew the playing field in favor of domestic firms when the segmentation of the quality ladder provides sufficient space for incubating domestic capabilities and incentives for foreign firms to localize activities. Policy-makers should also be aware that policy may impact the place on the quality ladder that foreign firms choose to enter, and the approach to capability-building adapted by both foreign and domestic firms. Weak intellectual property protection, for example, may discourage foreign firms from entering at the high-end and all firms will avoid investing in capabilities that cannot easily be protected. The objective should be to provide incentives for firms to develop capabilities at every rung of the quality ladder.

References

Abo, T. (2011). The competition strategies of Japanese manufacturing firms in China, 1990s-2000s: The positioning problems in the competitive advantages through transfer of the production systems. In T. Abo (Eds.), *Competing Chinese and Foreign Firms in Swelling Chinese Economy: Competition Strategies for Japanese, Western and Asian Firms*.(pp.). Munster, Germany: Lit Verlag.

Adner, R. (2002). When are technologies disruptive? A demand-based view of the emergence of competition. *Strategic Management Journal* 23, 667-688.

Adner, R. and Levinthal, D. (2001). Demand heterogeneity and technology evolution: Implications for product and process innovation. *Management Science* 47(5), 611-628.

Amsden, A. H. (1989). *Asia's next giant: South Korea and late industrialization*. New York and Oxford: Oxford University Press.

Amsden, A. H. (2001). *The rise of "the rest": Challenges to the west from late-industrializing economies*. Oxford: Oxford University Press.

Bernard, A. B., Eaton, J., et al. (2003). Plants and Productivity in International Trade. *American Economic Review* 93(4), 1268-1290.

Brandt, L. and Thun, E. (2010). The fight for the middle: Upgrading, competition, and industrial development in China," *World Development* 38(11), 1555-1574.

Breznitz, D. and Murphree, M. (2011). *Run of the red queen: Government, innovation, globalization, and economic growth in China*. New Haven and London: Yale Univeristy Press.

Christensen, C. M. (1997). *The Innovator's Dilemma*. Boston: Harvard Business School Press.

Christensen, C. M. and Raynor, M. E. (2003). *The Innovator's Solution: Creating and Sustaining Successful Growth*. Boston: Harvard Business School Press.

Christensen, C. M. and Rosenbloom, R. S. (1995). Explaining the attacker's advantage: technological paradigms, organizational dynamics, and the value network. *Research Policy* 24, 233-257.

Danneels, E. (2004). Disruptive technology Reconsidered: A critique and research agenda. *The Journal of Product Innovation Management* 21, 246-258.

Di Stefano, G., Gambardella, A., et al. (2012). Technology push and demand pull perspective in innovation studies: Current findings and future research directions. *Research Policy* 41, 1283-1295.

Dosi, G. (1982). Technological paradigms and technological trajectories. *Research Policy* 11, 147-162.

Fagerberg, J. (2005). Innovation: A guide to the literature. In J. Fagerberg, D. C. Mowery and R. R. Nelson (Eds.), *The Oxford Handbook of Innovation*.(pp. 1-26). Oxford: Oxford University Press.

Fajgelbaum, P., Grossman, G. M., et al. (2011). Income distribution, product quality, and international trade. *Journal of Political Economy* 119(4), 721-765.

Foster, R. J. (1986). *Innovation: The Attacker's Advantage*. New York: Summit Books.

Gereffi, G. (1999). International trade and industrial upgrading in the apparel commodity chain. *Journal of International Economics* 48, 37-70.

Gereffi, G., Humphrey, J., et al. (2005). The governance of global value chains'. *Review of International Political Economy* 12(1), 78-104.

Geroski, P. (2003). *The evolution of new markets*. Oxford: Oxford University Press.

Gerschenkron, A. (1962). *Economic backwardness in historical perspective*. Cambridge: Belknap.

Govindarajan, V. and Kopalle, P. K. (2006). The usefulness of measuring disruptiveness of innovations ex post in making ex ante predictions. *The Journal of Product Innovation Management* 23, 12-18.

Grossman, G. M. and Helpman, E. (1991). Quality Ladders and Product Cycles. *The Quarterly Journal of Economics* 106(2), 557-586.

Hart, S. L. and Christensen, C. M. (2002). The great leap: Driving innovation from the base of the pyramid. , 44(1), 51-56. *MIT Sloan Management Review* 44(1), 51-64.

Henderson, R. M. and Clark, K. B. (1990). Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly* 35, 9-30.

Hobday, M. (1995). East Asian latecomer firms: Learning the technology of electronics. *World Development* 23(7), 1171-1193.

Hobday, M., Rush, H., et al. (2004). Approaching the innovation frontier in Korea: the transition phase to leadership. *Research Policy* 33, 1433-1457.

Humphrey, J. and Schmitz, H. (2002). How does insertion in global value chains affect upgrading in industrial clusters? *Regional Studies* 36(9), 1017-1027.

Khandelwal, A. (2010). The long and short (of) quality ladders. *Review of Economic Studies* 77(4), 1450-1476.

Kline, S. J. and Rosenberg, N. (1986). An overview of innovation. In R. Landau and N. Rosenber (Eds.), *The positive sum strategy: Harnessing technology for economic growth*.(pp. 275-304). Washington, DC: National Academy Press.

Krugman, P. (1979). A model of innvoation, technology transfer, and the world distribution of income. *Journal of Political Economy* 87, 253-266.

Lee, K. and Lim, C. (2001). Technological regimes, catching-up and leapfrogging: findings from the Korean industries. *Research Policy* 20, 459-483.

Lee, K. and Lim, C. (2001). Technological regimes, catching-up and leapfrogging: findings from the Korean industries. *Research Policy* 30, 459-483.

Li, Z. (2009). The role of international technology transfer in the Chinese automotive Industry. *Manufacturing Management Research Center*. Tokyo, Univeristy of Tokyo**,** 1-22.

Lundvall, B.-A. (1992). Introduction. In B.-A. Lundvall (Eds.), *National systems of innovation: Toward a theory of innovation and interactive learning*.(pp. 1-19). London: Pinter.

Markides, C. (2006). Disruptive Innovation: In need of better theory. *The Journal of Product Innovation Management* 23, 19-25.

Mowery, D. C. and Rosenber, N. (1979). The influence of market demand upon innovation: a critical review of some recent empirical studies. *Research Policy* 8, 102-153.

Mu, Q. and Lee, K. (2005). Knowledge diffusion, market segmentation and technological catch-up: The case of the telecommunications sector in China. *Research Policy* 34, 759-783.

Nam, K.-M. and Li, X. (2012). Out of passivity: potential role of OFDI in IFDI-based learning trajectory. *Industrial and Corporate Change*.

Ohara, M. (2006). *Interfirm relations under late industrialization in China: The supplier system in the motorcycle industry*. Chiba: Institute of Developing Economies and Japan External Trade Organization.

Perez, C. (1988). New technologies and development. In C. Freeman and B.-A. Lundvall (Eds.), *Small Countries Facing the Technological Revolution*.(pp.). London: Pinter Publishers.

Petrick, I. J. and Juntiwasarakij, S. (2011). The rise of the rest: hotbeds of innovation in emerging markets. *Research-Technology Management*(July-August), 24-29.

Radjou, N., Prabhu, J., et al. (2012). *Jugaad Innovation: Think frugal, be flexible, generate breakthrough growth*. San Francisco: Jossey-Bass.

Schmitz, H. (2007). Reducing complexity in the industrial policy debate. *Development Policy Review* 25(4), 417-428.

Soete, L. (1985). International diffusion of technology, industrial development and technological leapfrogging. *World Development* 13(3), 409-422.

Thun, E. (2006). *Changing lanes in China: Foreign direct investment, local governments, and auto sector development*. New York: Cambridge University Press.

Tushman, M. L. and Anderson, P. (1986). Technological Discontinuities and Organizational Environments. *Administrative Science Quarterly* 31.

Wade, R. (1990). *Governing the market: Economic theory and the role of government in East Asian industrialization*. Princeton: Princeton University Press.

Warburton, M., Zhu, R., et al. (2013). Chinese Autos, Part 1: The quest for global competitiveness--Technology, competence, ambition, and politics. *Bernstein Global View*. BernsteinResearch, BernsteinResearch.

Williamson, P. J. (2010). Cost innovation: Preparing for a "Value-for-Money" Revolution. *Long Range Planning* 43, 343-353.

Womack, J. P., Jones, D. T., et al. (1990). *The Machine that Changed the World*. New York: HarperPerennial.

Wong, J. (2011). *Betting on Biotech: Innovation and the limit's of Asia's developmental state*. Ithaca and London: Cornell University Press.

Woo-Cumings, M., Ed. (1999). *The Developmental State*. Ithaca: Cornell University Press.

Wooldridge, A. (2010). First break all the rules: The charms of frugal innovation *Economist*(April 15).

Table 1. “Treatment” Effect of State Policy

	Low-End	Middle	High-End
Construction Equipment	Basic Wheel-Loader	High-End WL Mini-Excavator	Excavator
Motorcycles	125 cc Bikes and below	Higher-end segments restricted by high tariffs and restrictions on use in urban areas and highways.	
Automotive (pre-WTO)	Lower-end segments restricted by high tariffs, restrictions on private sector entry, and restrictions on foreign participation.	Cars with engine displacement of 1.6 liters and above.	

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: $(t_f - at_i)/(1-a)$, where t_f and t_i are the nominal tariffs on the final good and intermediate inputs, and a is the value of intermediate inputs as a share of the value of the final good at international prices.

Table 3A: Sales, Market Demand, Exports and Imports

	Total Sales by Firms in China				Domestic Market Demand				Exports			
	WL	EX	M	A	WL	EX	M	A	WL	EX	M	A
1985			979,307				979,307					
1991			1,250,396	81,044			1,250,396	134,264				789
1997	17,404	3,293	9,242,825	487,995	15,704	9,202	9,150,887	518,941	2,863	714	91,938	1,073
2003	69,666	33,982	14,754,513	2,037,865	69,723	61,392	11,732,824	2,138,033	384	790	3,021,689	2,849
2010	228,219	179,296	26,591,387	11,278,887	203,905	215,896	17,553,628	11,654,987	24,996	5,166	9,040,525	282,900

Table 3b: Annual Growth Rates

	Total Sales by Firms in China				Domestic Market Demand				Exports			
	WL	EX	M	A	WL	EX	M	A	WL	EX	M	A
1985-1991			4.2%				4.2%					
1991-1997			39.6%	34.9%			39.3%	25.3%				5.3%
1997-2003	26.0%	47.6%	8.1%	26.9%	28.2%	37.2%	4.2%	26.6%	-28.5%	1.7%	79.0%	17.7%
2003-2010	18.5%	26.8%	8.7%	27.7%	16.6%	19.7%	5.8%	27.4%	81.6%	30.8%	16.9%	92.9%
1997-2010	21.9%	36.0%	8.4%	27.3%	21.8%	27.5%	5.0%	26.1%	18.1%	16.4%	42.3%	53.5%

Table 4: 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%	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%			

Table 5: Car Sales by Market Segment and Ownership

Engine Size	< = 1.6		1.6<L<=2.5		> 2.5.		Total	
2000	Sales	Market Share	Sales	Market Share	Sales	Market Share	Sales	Market Share
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%			

Figure 1: Market Equilibrium in Quality

Figure 1a

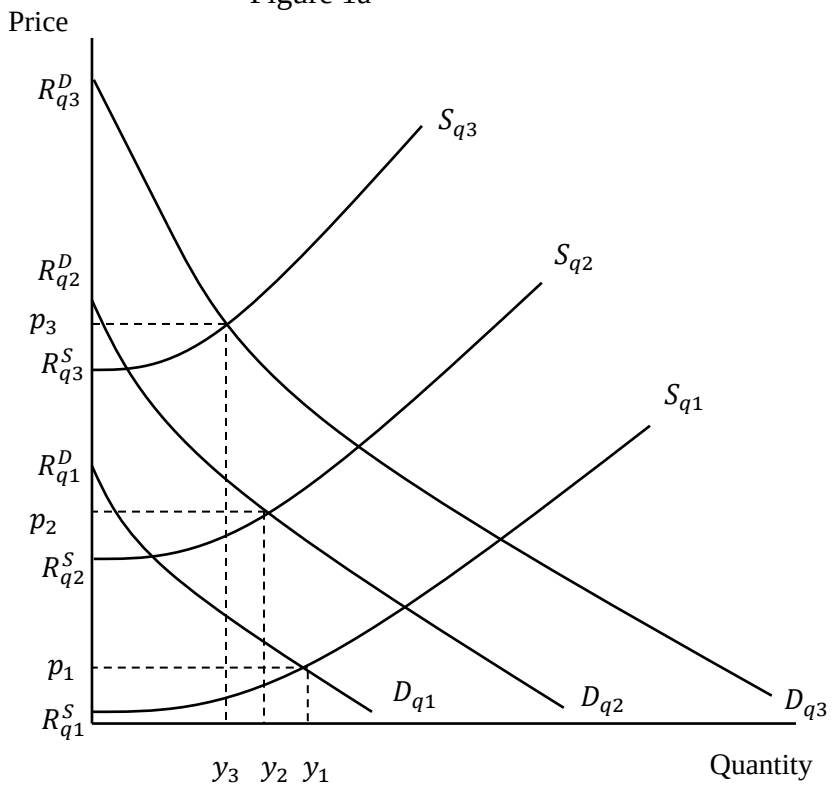
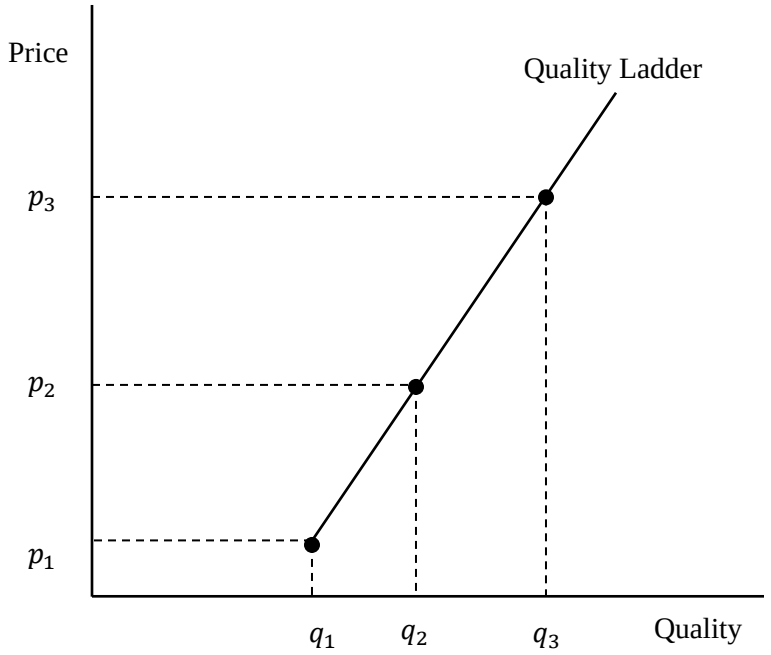


Figure 1b



p_i: Price of quality i;

q_i: Quality i;

y_i: Output of quality i;

R^S_{qi}: Reservation supply price for quality i;

R^D_{qi}: Reservation demand price for quality i.

Figure 2: Quality Ladders

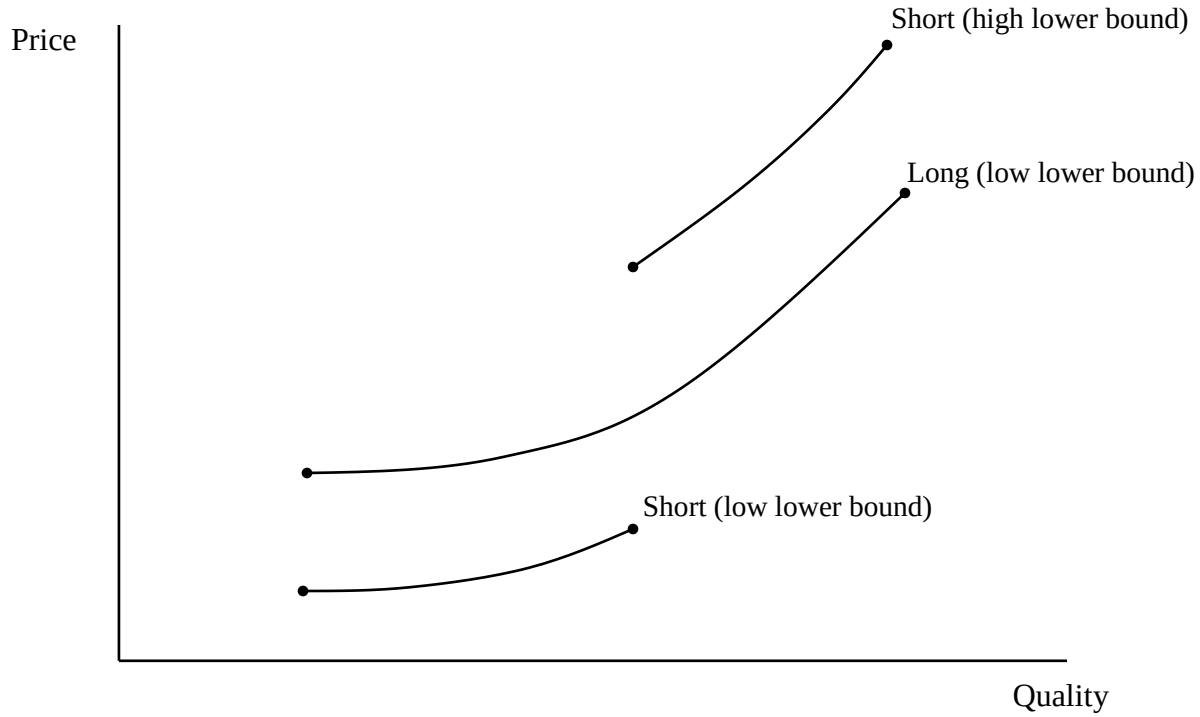


Figure 3: Market Segmentation

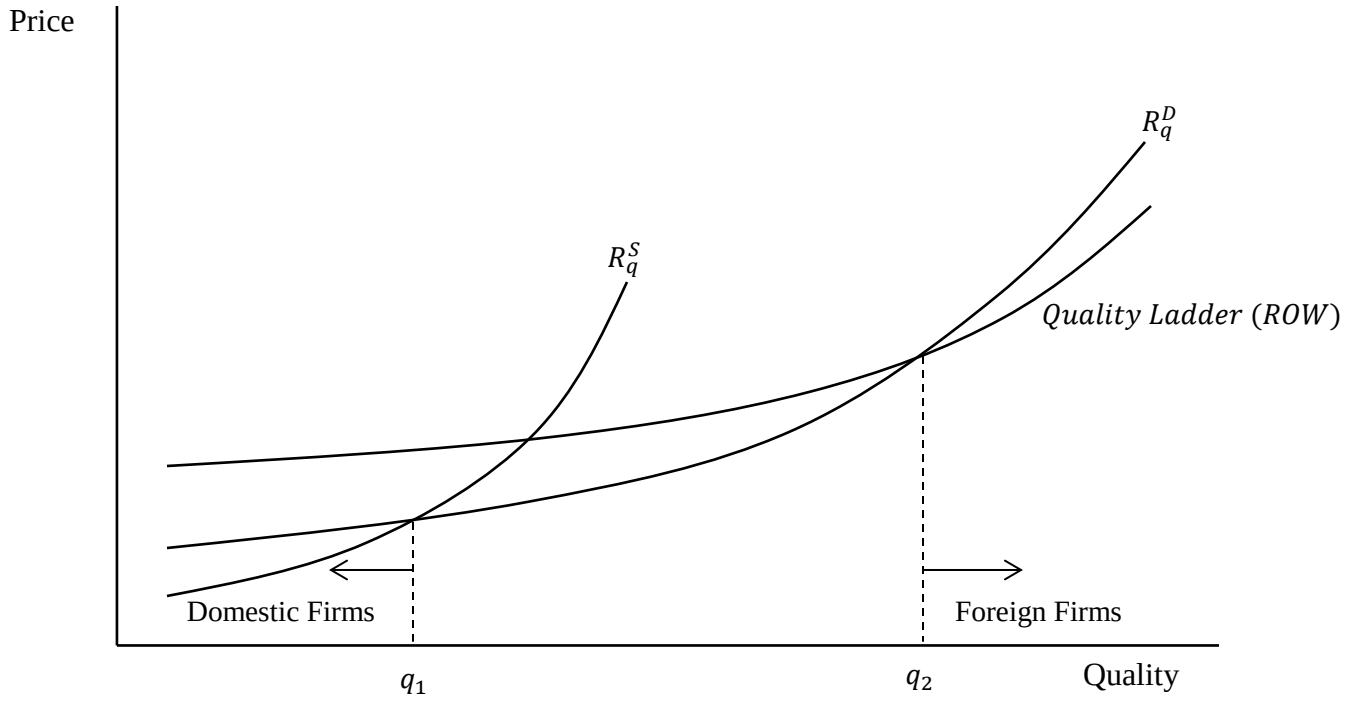
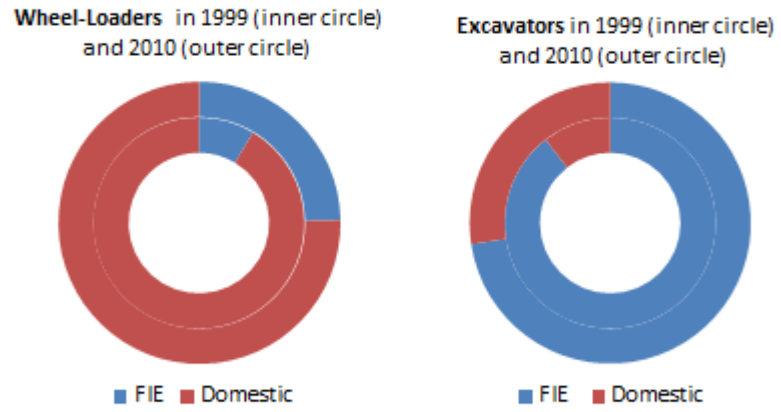
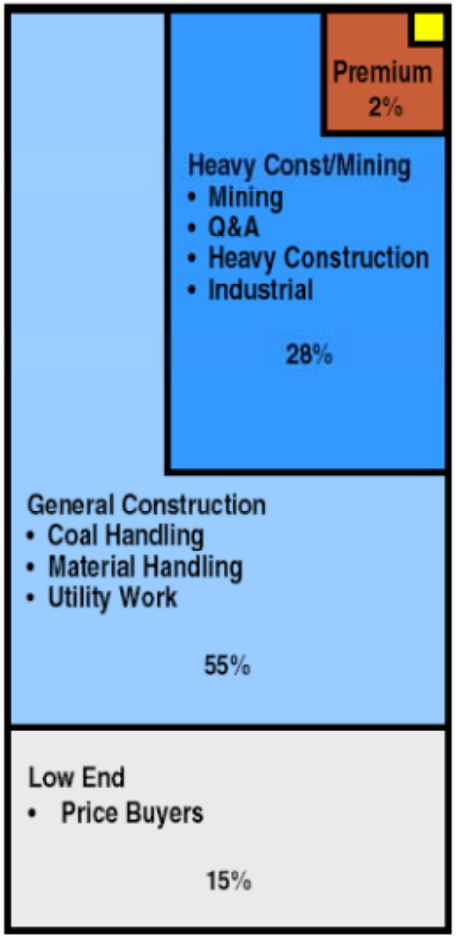


Figure 4 - Market Share in Construction Equipment



Note: The FIE expansion in market share in wheel-loaders is largely a result of acquisitions of Chinese firms.

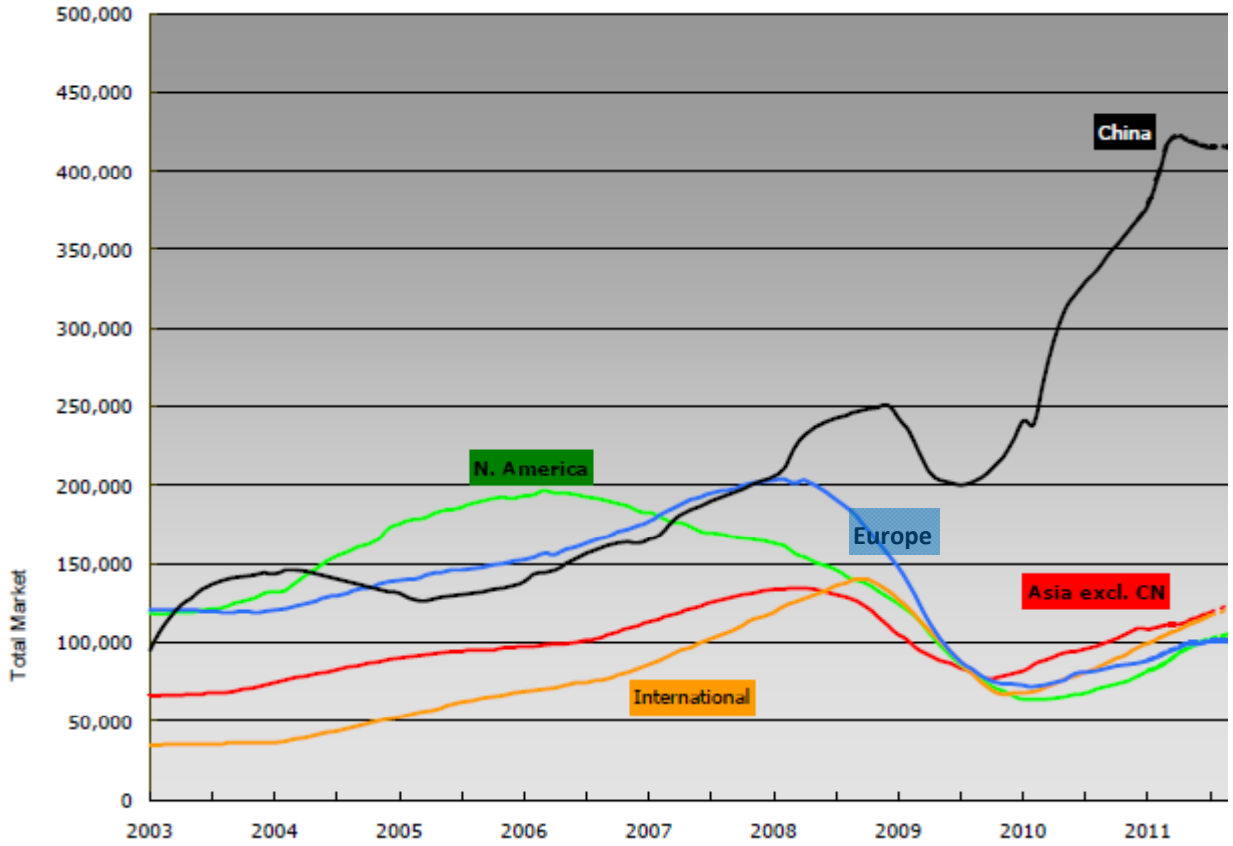
Figure 5: Segmentation of the Chinese Wheel-Loader Market



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

Source: Internal analysis of leading multinational construction equipment firm

Figure 6: Global Sales of Construction Equipment, 2003-2011



Source: Off-Highway Research

Figure 7: Car Size, Prices and Sales in 1995, 2001, and 2006