



THE PROCESS OF CHINESE MANUFACTURING UPGRADING: TRANSITIONING FROM *UNILATERAL* TO *RECURSIVE MUTUAL LEARNING* RELATIONS

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This article argues that upgrading in China has been a historical success, that upgrading must be seen as a learning process, and that current Chinese upgrading involves a transformation in industrial learning dynamics. During China's initial export-oriented industrialization strategy, indigenous producers successfully upgraded by apprenticing themselves to their foreign customers, and they learned through integration in transnational communities of practice. The success of those initial unilateral learning relations enhanced the sophistication of the Chinese market, both as a community of producers and as a market for manufactured goods. This has generated a new phase of learning-driven upgrading in which Chinese producers and MNC manufacturers both seek to make their Chinese operations more sophisticated. In this new context, apprenticeship disappears and Chinese and foreign players learn from one another. A core claim about the new mutual learning is that it is facilitated by the globalization of formal learning systems, such as corporate production systems (CPSs). Copyright © 2013 Strategic Management Society.

INTRODUCTION

In its initial post-1992 industrialization push, Chinese manufacturing excelled in global markets as a platform for high volume, low cost, export-oriented production. (Steinfeld 2010; Lemoine, 2000). Since China's accession to the World Trade Organization in 2001, however, successful industrialization has created the home market conditions for very different manufacturing strategies. In particular, more sophisticated domestic demand for manufactured goods is shifting Chinese manufacturers' strategic focus toward more advanced production. They

are leveraging their volume production expertise (which involves remarkable manufacturing flexibility) to move up the value chain into designing and developing their own (ever more sophisticated) products (Brandt and Thun, 2010; Shafaeddin and Pizzarro, 2010).

Developed country multinational corporations (MNCs) from Asia, Europe, and the United States are responding to the same emerging market possibilities by deepening and enhancing their commitments in China (Brandt and Thun, 2010; Marsh, 2004, 2005a, 2005b, 2005c, 2007, 2008, 2009, 2010a, 2010b, 2011a, 2011b). Most significantly, they are upgrading local Chinese production, engineering, and design capabilities, as well as training and supply chain infrastructures, to adapt their products to the specific technical, regulatory, and cultural characteristics of the Chinese market. Crucially, these MNC projects do not involve unidirectional

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flows: adapting/developing products for competitive production in China involves at least as much learning by MNCs from their local Chinese interlocutors as the other way around.

This article argues that upgrading in China has been a historical success, that upgrading must be seen as a learning process, and that current Chinese upgrading involves a transformation in industrial learning dynamics.¹ During the initial export-oriented industrialization strategy, Chinese producers successfully upgraded by apprenticing themselves to their foreign customers and learned through integration in transnational communities of practice (Brown and Duguid, 1991). The success of those initial unilateral learning relations enhanced the sophistication of the Chinese market, both as a community of producers and as a market for manufactured goods. This has generated a new phase of learning-driven upgrading in which indigenous Chinese producers and MNC manufacturers both seek to make their Chinese operations more sophisticated. In this new context, apprenticeship disappears and Chinese and foreign players learn from one another.

A core claim we make about the new mutual learning is that it is facilitated by the globalization of formal learning systems, such as corporate production systems (CPSs). Originally developed to facilitate innovation and continuous optimization in MNC operations within competitive developed markets, CPS principles have diffused into China via transnational supply chains and intra-MNC governance processes (Sabel, 2005; Spear, 2009). Global CPSs are governance architectures that generate joint reflection, deliberation, and experimentation. When successful, this produces multidirectional (recursive) learning among all participants.

Ultimately, we make three major points: (1) manufacturing upgrading has taken place in China over the last two decades; (2) initially, upgrading in China occurred through predominantly unidirectional learning relations. Chinese producers were integrated into transnational communities of manufacturing practice in which they *learned from* foreign interlocutors; (3) in the last decade, as domestic manufacturing demand sophistication grew, Chinese upgrading processes transitioned from unilateral learning within stable communities of practice to

mutual learning among interlocutors in MNCs, markets, and supply chains. In the new context, formally organized joint inquiry and experimentation processes embedded in, among other things, CPSs, generate recursive learning by continually disrupting and fostering creative recombination of practice communities.

Our argument proceeds in five steps. First, we briefly discuss the empirical basis upon which our argument rests, and we outline, broadly, the research program out of which the current material has been taken. Second, we describe the pragmatism-informed theoretical perspective that drives our rendering of the Chinese upgrading dynamic. Step three outlines the initial industrial upgrading period in which learning was unilateral and shows that, ultimately, this apprenticeship learning encountered limits. Chinese producers developed capabilities within transnational practice communities but foreign customers were either unwilling or unable to take advantage of them. This gave rise to a turn toward the domestic Chinese market. Step four then describes the emergent Chinese market contours and the strategies that both indigenous and foreign MNC producers are pursuing to gain positions within it. In the final step, we show how these strategic efforts are transforming the learning dynamics within the community of competitors.

Empirical basis of our upgrading argument

Our argument is about manufacturing upgrading as a learning process. We draw broadly from the secondary empirical literature on manufacturing experience in China, especially in the electronics, automobile, and complex machinery sectors (including their supply chains). More fundamentally, our argument draws on nearly a decade's worth of primary research in Germany, the United States, Central Eastern Europe, and China on automobile and complex machinery industry production strategy and supply chain recombination. In these projects, our focus has been on understanding how changing customer firm product and production strategies involve learning in cooperative and competitive supply chain relations. Under this rubric, in China alone we have conducted nearly 100 face-to-face interviews with managers in indigenous Chinese, foreign MNC foreign direct investment (FDI) and joint venture (JV) facilities. These China interviews are complemented by extensive interviews with German and U.S. managers in home country locations across the

¹ For other perspectives on upgrading as learning, see Mudambi, 2008; Kumaraswamy *et al.*, 2012.

supply chains in both the automobile and machinery sectors.² Although we make an effort to contextualize our observations in the relevant findings available in the secondary literature, most of the empirical assertions and specific illustrations we adduce below are drawn from this (ongoing) interview-based research.

Theoretical framework: sociological approaches to upgrading and pragmatic approaches to organizational learning

Our approach in this article builds on the advances that sociological approaches to upgrading, especially relational- and networked-based work, have made to our understanding of processes of industrial upgrading in developing countries. This literature moves beyond alternative efforts to root upgrading processes in either traditional incentive alignment and market forces-based arguments (e.g., Moran *et al.*, 2005) or technologically determinist arguments about how the modular characteristics of contemporary manufacturing technologies limit possibilities for supplier and emergent producer firm upgrading (Sturgeon, 2002; Lüthje, Schumm, and Sproll, 2002; Gereffi, Humphrey, and Sturgeon, 2005; Sturgeon and Florida, 2005; Giuliani, Pietrobelli, and Rabelotti, 2005; Humphrey and Memedovic, 2003; Breznitz and Murphree, 2011). The virtue of the sociological accounts is that they identify specific relations (especially interactive, non-arm's-length relations in supply chains) and environmental conditions (interconnected clusters of normally region based producers and supporting educational and policy institutions and associations) as preconditions for successful upgrading that the nonsociological perspectives tend to ignore or underestimate (Gulati, Nohria, and Zaheer, 2000; McEvily and Marcus, 2005; Uzzi and Lancaster, 2003; Lorenzen and Mudambi, forthcoming; Blalock and Gertler, 2005; Lin, 2001; see McDermott and Corredoira, 2010, for an overview).

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This sociological literature is limited, however, because it reduces learning to the transfer of technological know-how or knowledge about technologies or even specific products. Moreover, even though they emphasize the role MNCs play in upgrading processes, the literature focuses primarily on one-way flows from MNCs to the upgrading producers in the emerging economy. As a consequence, they leave the possibility that emerging economies have something to teach developed country players relatively undertheorized.

We believe the practice-based organizational learning literature (e.g., Brown and Duguid, 1991; Blackler and McDonald, 2000) better addresses the learning processes observed in China by shifting attention from the discrete nuggets of knowledge or technology that firms 'learn about' to the formal and tacit interactive practices—communities of practice—that firms become involved in. In the next step, we show that gradual Chinese producer integration into transnational communities of practice with foreign customers taught them how to be reliable and competent manufacturing exporters. Foreign customers apprenticed their Chinese suppliers by showing them how to meet ever more exacting manufacturing and commercial standards. This was done iteratively over time, through myriad contracts, audits, supplier quality assurance encounters, comparisons with competitors, and conferences over detected errors and possible process improvements (Lui, forthcoming; Ivarsson and Alvstam, 2010).

The main point of these interactions was not so much the specific substance or content of any given technological or knowledge exchange as it was the development of the Chinese firm's capacity to learn how to identify the changing production quality and cost needs of their foreign customer. Mistakes could be tolerated if prompt moves were made to correct their source. For customers, goodwill and demonstrable learning trumped technological backwardness or a lack of specific know-how. Competency and learning, however, could not be imposed. They had to develop through the practice of the relationship itself (cf. Dyer and Chu, 2011; Lui, forthcoming; Ivarsson and Alvstam, 2010; Brown and Duguid, 1991).

Although these practice-based organizational learning theories are especially helpful in explaining the first phase of Chinese manufacturing upgrading (described in step three), they are less helpful in accounting for the upgrading dynamics we describe in steps four and five. Community of practice

arguments tend, on the whole, to focus on routine practices and the way in which apprenticeship relations (what Lave and Wenger, 1991, call *legitimate peripheral participation*) unfold within stable sets of practices—such as the asymmetric ties between Chinese exporters and their foreign customers (see also Blackler and McDonald, 2000).

We will show, however, that the gradual routinized apprenticed learning process ran up against limits in China, in large part due to its own success. Chinese producers developed competences that exceeded what customers were demanding. Awareness of this mismatch between capability and demand in traditional export supply relations, we show later, ultimately generated a strategic shift on the part of both indigenous producers and MNC manufacturers within the Chinese market. Both want to gain market share in emerging Chinese markets for dynamic ‘middle range’ products. In order to achieve this, however, firms need to disrupt their routines and reflect upon both the formal and the tacit ways in which their practices are organized and their know-how is deployed. Strategic uncertainty, unfamiliarity with new forms of production, and lack of experience with product development and design, moreover, leads producers to both tolerate and even encourage experimentation.

The pragmatism-based organizational learning literature is centrally concerned with these dynamics. It focuses on collective reflection (inquiry) and experimentation processes within organizations that occur when routine practices are disrupted (cf. Elkjaer, 2003, 2004.; Elkjaer and Simpson, 2006; Simpson, 2010; Sabel, 2005). Reflection and experimentation can be (and surely were) randomly provoked during the first phase as relations between Chinese and foreign customers experienced temporary crises or interruptions. This is how the community of practice literature understands how upgrading occurs through apprenticeship relations. Our claim, however, is that in the new situation, there has been a concerted shift toward the *systematic provocation* of reflection and experimentation in order to generate recursive learning processes. The mechanisms for the inducement of reflection and experimentation in learning have been a central preoccupation, in particular of Sabel’s (1994, 2005) work.

In this second upgrading phase, reflection and experimentation-based learning processes grow out of foreign MNC awareness of the limits of their centralized, home country-developed knowledge, products, and practices. They must rely on local

competence and discretion to adapt and develop successful products in China. Moreover, since the situation is so dynamic, firms rapidly and systematically induce local reflection on the limits of central knowledge to facilitate competitive adaptation of home country products and practices to Chinese conditions.

We argue that MNCs accomplish this by deploying formal systems designed to combine joint general goal setting with local discretion. Although there are many variants, we will highlight the way in which CPSs accomplish this. As multidimensional and recursive ‘constitutional processes’ (Ansell, 2010), CPSs create cycles of learning and recomposition within MNCs and between MNCs and their suppliers. The cycle starts when relevant stakeholder teams (involving central and local players) establish provisional and revisable central metrics, standards, and product designs with the expectation that local players will use discretion in implementing and adapting them to their circumstances. Local experimental efforts interrogate and unpack home country products and production practices to make them work in the Chinese context. Recursivity from the local back to the center is generated as home country teams monitoring and assisting local Chinese experimentation processes are induced through the monitoring itself to reflect on the adequacy and optimality of their own routines both at home and in other global locations. As Sabel (1994, 2005) points out, these serially deconstructive and reflective actions make the tacit routines within communities of practice explicit to all the players and, thereby, systematically encourage stakeholders to alter, optimize, and recompose their practices through experimentation—all of which can stimulate creativity and generate new practice and product ideas (Elkjaer, 2003, 2004; Elkjaer and Simpson, 2006; Simpson, 2010; see also Romme, 1996, 1997). We will later outline these recursive learning dynamics and the various constitutional organization and governance mechanisms they entail.

There are similarities in these practices to the dynamics described in traditional organization theory’s understanding of ‘exploration’ (March, 1991) and to what strategy theorists try to capture with the notion of ‘replication’ (Winter and Szulanski, 2001). The China dynamics differ from exploration and replication, however, in two ways. First, both of the latter approaches are equilibrium approaches where disruptive periods of exploration are replaced by new and stable periods of routinized exploitation. The

Chinese MNC learning processes, however, involve ongoing mixtures of exploration and exploitation. Second, both March's (1991) notion of exploration and exploitation and Winter and Szulanski's (2001) closely related understanding of replication are focused on asymmetric learning dynamics: firms transfer models and seek to exploit gains from the new location, but they do not seek systematically to learn from those locations in ways that will recursively induce experimentation and change in the sending location. The latter, however, is precisely what we will later show to be occurring in the new phase of mutual learning in China.

Learning from foreign customers: the fruits of export processing are not more export processing

China's rapid industrialization in the last two decades was driven by its distinctive integration into the global economy. Unlike the other Asian industrializers (Japan, South Korea, and Taiwan) and fellow BRICs (Brazil, India, and Russia), China relied heavily on FDI to industrialize (Steinfeld, 2010; Huang, 2003, 2008; Lemoine, 2000; Qian, 2010; Ljungvall and Tingvall, 2010). By exploiting its labor cost advantages, China lured FDI in a broad array of low-end, high volume manufacturing industries. Foreign producers either constructed pure manufacturing facilities in China or they helped indigenous Chinese do so. The newly created facilities produced components and assembled final products, many of which were ultimately exported out of China for sale in other markets (mainly in the United States, Europe, and Japan). Especially after 1992, this strategy gradually led to the emergence of highly competitive low cost manufacturers across a wide array of industries: automobile and machinery components, product-level electronics, textile and apparel, footwear, and countless other commodity manufactured goods. This business was notoriously low margin, often exceedingly exploitative of workers, and it involved very little knowledge of how to develop or design products (Sturgeon and Lester, 2003; Lüthje *et al.*, 2002; Dedrick, Kramer, and Linden, 2010; Breznitz and Murphree, 2011). But it attracted manufacturing investment and, we claim, gradually integrated many Chinese production facilities into transnational manufacturing communities of practice.

Industrialization and development scholars have been skeptical of this strategy. In particular, many

argue that the export platform strategy is inherently self-limiting. Although it produces remarkable industrial growth and jobs, skeptics maintain that the strategy fails to give Chinese producers access to the tools they need to become truly sovereign players in the global economy because it focuses on a limited area of manufacturing practice at the low end of global value chains and the bottom of technological hierarchies. Specifically, none of the most technologically advanced and highest value functions (engineering and design capability, distribution know-how, branding) are performed in China, and the functions that are performed in China do not enable the Chinese to bootstrap themselves upward into those more sophisticated and valuable areas of value and technology (summary in Steinfeld, 2010; Sturgeon and Lester, 2003; Nam, 2011). To the skeptical eye, China appears to have pursued a strategy that led it to become trapped at the bottom of the U-shaped technology development curve (Steinfeld, 2010; Nolan, Zhang, and Liu, 2007).³

There is no denying that cases of this self-limiting dynamic exist and, moreover, that many Chinese producers follow exploitative low cost strategies with little hope for significant upgrading. Our claim, however, is that by reducing the Chinese industrialization experience to those relations and outcomes, the skeptics underestimate the dynamic learning benefits associated with the Chinese strategy. Power and learning have a dynamic relationship, not an antithetical one.

In any case, *initially* the Chinese industrialization strategy involved no practical exposure to engineering and design know-how. Instead, it emphasized the skill and know-how development needed to manufacture other people's products competitively and in very high volumes. This was a learning strategy. With their customers or foreign employers as teachers, apprenticing Chinese producers became better manufacturers, more and more able to achieve the quality standards their customers demanded (Shafaeddin and Pizzarro, 2010). In particular, through their relations with foreign customers, Chinese producers grew proficient in lean manufacturing principles and the new logic of formal CPSs.⁴

³ Optimists within this framework suggest that China can make a virtue of its backwardness by trying to dominate mid-and low-level technological markets (Breznitz and Murphree, 2011).

⁴ For information on new style corporate production systems, see Spear (2009) and Sabel (2005). For case studies of Chinese manufacturing upgrading, see Hawes and Chew (2011) and

This learning, in turn, impacted the development of Chinese human capital. Skilled worker demand increased, especially in setup and maintenance, but even on the production lines themselves. Manufacturing engineers were needed to implement more complex product designs in Chinese factories. Good Chinese manufacturers came to be admired for their ability to produce high volumes with good quality and significant variety. By the beginning of the twenty-first century, rapid changeover and optimization practices at high volume had become a Chinese comparative advantage.

This upgrading through apprenticeship within transnational communities of practice occurred through three distinctive kinds of relations between foreign customers/investors and Chinese producers. The three relations varied by the intensity of integration in foreign communities of manufacturing practices. The stingiest and least integrated relation was the contract-manufacturing model used extensively in many areas of the electronics industry.⁵ This model presupposed a modular product architecture that enabled a clear separation between value-laden product design and development functions and cost-intensive manufacturing functions. Computer and mobile device companies in the U.S. and Europe were the main drivers of this kind of arrangement. They designed notebook computers, mobile phones, PDAs, GPSs, iPads, iPhones, iPods, flat screen TVs, and countless other devices at home and had the hardware produced and (sub-) assembled in China (e.g., Dedrick *et al.*, 2010; Lüthje *et al.*, 2002). Chinese manufacturing in this area was, to a large extent, organized by foreign subcontractors, in particular by very sophisticated contract manufacturing multinationals (e.g., Flextronics, Selectron, Foxconn, Jabil, etc.) with considerable know-how regarding organizing production for exceedingly low margin products in a profitable way. Among such producers, product design and production know-how

was concentrated outside of China, while focus in China was on low cost.⁶

Even in this kind of business, however, low labor cost was not the only element of the story. The ability to achieve lean production flow, use automation to insure quality, and reduce change over time also played an important role. In this event, electronics industry contract manufacturers educated Chinese managers and workers in the principles of modern lean manufacturing practice (Ernst, 2005, 2007; Chesbrough, 2002; Lui, forthcoming; Dedrick *et al.*, 2010; Brown and Linden, 2011; Lüthje *et al.*, 2002; Sturgeon, 2002; Breznitz and Murphree, 2011).

The other two avenues into transnational communities of modern manufacturing practice were in complex engineering sectors (automobiles, machinery), where product architectures were more integrated and the clean separation between value-laden operations and cost-intensive operations was not as clear as it was (alleged to be) in the electronics sectors.⁷ As a result, the intensity of learning inducing (apprentice-like) interaction between Chinese producers and foreign designer-customers was greater.

The second upgrading path grew out of offshore outsourcing relations. During the 1990s and early 2000s, foreign automobile and machinery MNCs—overwhelmingly from North America—targeted indigenous Chinese producers as capacity suppliers and producers of low cost standardized or simple components. The foreign players were typically looking offshore for respite from the high manufacturing costs (in particular high labor costs) in their home markets. In contrast to the contract manufacturers in electronics, foreigners in these complex engineering sectors initially did not directly control production in China. Instead, companies such as John Deere, Caterpillar, and CNH in the agricultural equipment and construction machinery sectors contracted with indigenous Chinese producers and

Lockström *et al.* (2010). This learning seems especially pronounced in the sectors we have studied—automobiles and machinery, see illustratively, Thun (2006). But there is evidence of this kind of upgrading in other sectors as well, cf. Bellandi and Di Tommaso (2005) and, more broadly, Shafaeddin and Pizzaro (2010). The skeptics have concentrated unduly on the electronics sector, where the evidence for upgrading is more ambivalent.

⁵ The model could also be found in other sectors, such as textiles and clothing, where the stinginess toward the upgrading we describe was perhaps even more entrenched.

⁶ There were also less dominant examples of captive electronics production in China; i.e., integrated operations by end producers such as Siemens or Nokia. Chinese subsidiaries, in these cases, functioned as in-house contract manufacturers, with many of the same divisions between design and production, though with slightly greater community of practice integration dynamics. Such captive plants also often shared business from the parent with contract manufacturers.

⁷ For critiques of the ‘clean hand off’ view of modularity, see Chesbrough (2002); Ernst (2005); Fixon and Park (2007); MacDuffie (2007); Sabel and Zeitlin (2004); and Herrigel (2010).

brought them up to speed through their own supplier quality assurance departments. Others, often smaller companies active as suppliers to those large OEMs, enlisted engineering and manufacturing quality consultancies that sprang up in China to teach indigenuous manufacturers to produce to foreign customer quality standards.

For their part, the Chinese producers frequently attracted foreign business by hiring experienced Chinese managers, fluent in Western market and production practices, away from foreign contract producers. Many such managers also established their own businesses and used their proficiency with foreign manufacturing standards as a selling point to garner foreign business. Initial rounds of contracting and offshoring were plagued by the inconsistencies and quality problems associated with novice work. But with time and foreign investment in teaching and Chinese learning, the indigenous producers enhanced their capabilities and improved their production expertise and quality. A genuinely transnational community of continuously improving manufacturing practice emerged.

The third avenue for learning between foreign MNCs and Chinese suppliers was in the early joint ventures in the automobile and machinery industries (including players in supply chains). Here Chinese governments enjoined foreign MNCs both to work with joint venture partners to create assembly operations on Chinese soil and to develop an indigenous supply base for their components (Chu, 2011; Thun, 2006). Once again, these large MNCs, both final assemblers like Volkswagen and component suppliers like Bosch, directed purchasing and manufacturing engineers and supplier quality assurance experts to create an indigenous supply base for their products. The MNCs also worked closely with local governments to upgrade training infrastructures for themselves and suppliers. The products made in the initial automobile and machinery joint ventures were older models (e.g., the VW Santana) that incorporated less competitive technologies and components than were used in the modern products the MNCs were selling in richer developed markets. But the learning that took place in the supply base was real and increasingly sophisticated: Chinese suppliers had to develop the ability to machine to the more stringent MNC tolerances, to produce and deliver their goods in a more unforgiving MNC time frame, to apply themselves to continuous cost reduction, to develop the ability to cooperate with customers, to respond to special requests, and to make suggestions

regarding component engineering when problems in the flow of the supply chain emerged (Thun, 2006; Chu, 2011; Brandt and Thun, 2010; Shafaeddin and Pizzarro, 2010; Lockström *et al.*, 2010; Marsh, 2008; Chang and Xu, 2008).

Each of these avenues into a transnational community of manufacturing practice—contract manufacturing, offshore outsourcing, joint ventures—generated more and less intensive positive learning and upgrading cycles. Interacting actor ambitions expanded as their competences increased. Recognition by the customer of the supplier's ability to learn favorably disposed them to support the supplier's ambitions to learn more. By the same token, an inability to effectively collaborate and learn resulted in exit from the customer's stable of suppliers (Lui, forthcoming; Herrigel, 2010). Learning and success were linked.

All these Chinese upgrading trajectories, however, gradually bumped up against limits. Interestingly, these limits are different than those typically pointed to by the skeptical development literature. There the limit follows from the hierarchical organization of global manufacturing know-how, with high value design and engineering competence located outside China and production know-how inside China. Hierarchy blocks Chinese producers from developing the crucial know-how needed to develop their own products.⁸

Without denying that such hierarchies exist in some product areas or that they are striven for in many others, we claim that the Chinese upgrading strategy actually encountered quite different limitations—and these alternative limitations proved not to be insuperable. The continuous apprenticeship learning-based upgrading process reached limits because while the Chinese developed the perpetual ability to learn and participate in collaborative development projects, their foreign customers, for various reasons, could not utilize or keep up with developing Chinese supplier sophistication.

Take the contract manufacturing and offshore outsourcing arrangements first. The basic limit in these relations is that the more intensively collaboration became a part of the relationship between customer and supplier, the more distance became a prohibitive

⁸ On China, see Breznitz and Murphree (2011). More generally, see also the skeptical argument for upgrading in supply chains presented in Humphrey and Memedovic (2003) and Giuliani *et al.* (2005).

cost. The iterated experimentation that is essential to collaborative product development was cumbersome to organize across long distances; apart from the simple fact that transport costs and time were expensive, there were also many unpredictable hazards—accidents, strikes at ports, weather on the oceans, natural disasters—that could also generate cost. Customers in developed markets, who originally encouraged Chinese efforts to become more sophisticated, became more reluctant to welcome even highly competent Chinese suppliers into the most sensitive and high valued collaborative development projects. As a result, Chinese suppliers (and foreign-owned subsidiaries in China) gradually found that they were participating in supply chains with producers abroad in ways that failed to utilize all of their own capabilities.

There was a comparable limiting dynamic in manufacturing JV supply relations. There the initial MNC strategy was to transfer relatively simple, often frankly outdated, products and technologies into their Chinese JVs (cf. the VW Santana referenced earlier). The terms of the JV agreements, however, required MNC JV partners not only to have local content, but to use and develop local suppliers. As a result, companies like VW encouraged its most trusted European suppliers to invest in China to supply the JV and help develop the local supply base. Together with these suppliers (and with the cooperation of Chinese local governments), foreign MNCs then cultivated indigenous Chinese suppliers able to reliably produce needed parts and components that either could not be supplied from Germany or the U.S., or that were required under the JV agreement (Chu, 2011; Thun, 2006; Brandt and Thun, 2010).

To a point, this proved to be a successful strategy for all the parties involved. Suppliers did develop and they soon became eager to upgrade, expand their customer base, and produce more sophisticated products. For various reasons (many of them having to do with the political embeddedness of the customer JVs in regional Chinese government procurement structures), however, large JVs like VW Shanghai had difficulty altering their technologies and creating the possibility for further supplier upgrading (Sun, Thun, and Mellahi, 2010). In this case, both indigenous suppliers and FDI suppliers began to push against the limits of the original FDI customer strategy for the Chinese market. Producers wanted to be able to do more than the existing market structure permitted.

All these developments make it clear that by the beginning of the new century, Chinese manufactur-

ing capability was like a child who had outgrown the clothes its parent had provided. Fortunately, successful industrialization produced conditions that facilitated new strategic and learning practices. It gradually became clear, for example, that increasingly sophisticated Chinese manufacturers needed ever-more sophisticated capital goods and more elaborate infrastructure. Successful industrialization produced higher income and education levels throughout the most developed Chinese regions. By the beginning of the new century, private consumers, industrial producers, and the Chinese state (through ambitious infrastructure projects) were ratcheting up demand in the domestic market. At the same time, foreign manufacturing MNCs grew eager to expand and upgrade their existing Chinese operations to capture part of this new growth potential. China strategy change became even more urgent for these MNCs as indigenous Chinese end product producers challenged them in the middle-value product ranges in a wide array of sectors, such as automobiles, omnibuses, power drives, turbines, construction machinery, and sophisticated industrial machinery and tooling (Brandt and Thun, 2010).

Ultimately, the dam burst. Old self-limitation dynamics dissolved into new competition and innovation dynamics in China. The current situation pits ambitious and strikingly capable Chinese producers looking to move up and capture more advanced technological business against foreign MNCs seeking to adapt their technological know-how and skills to the local Chinese conditions. Both have advantages and yet both are confronted with obstacles that require cooperation with the other side. We will next describe these new dynamics in greater detail and show how, ultimately, producers have begun to move away from unidirectional *learning from* relations to dynamic *learning with* relations.

Competition between MNCs and indigenous Chinese producers for the ‘middle’ of the market

New foreign MNC Chinese market engagement is shaped not only by the quantity, but also by the changing character, of Chinese demand. Contemporary Chinese customers demand products with distinctive characteristics. They want either product versions that are notably less technologically sophisticated than the variants MNCs sell in richer more developed markets; or they want high-end products like those sold in developed markets, but with

specific modifications to accommodate Chinese preferences, regulations, standards, and resource and material input differences. In the former case, even when products are less sophisticated or involve materials or components not used in home country versions, foreign MNCs can't compete against native Chinese producers by modifying and selling older or outdated versions of their current equipment. Native Chinese producers quickly copy such technologies and underprice the foreign producers in the domestic market (Xi, Lei, and Guisheng, 2009; Li, 2009; Ivarsson and Alvstam, 2010; Breznitz and Murphree, 2011).

In order to take advantage of the emerging Chinese customer sophistication, then, foreign MNC players in the automobile, automobile component, and complex machinery sectors significantly modify and reconceive their current forms of technology or even develop entirely new products adapted to Chinese idiosyncrasies. The aim is to reduce sophistication and narrow product functionality. For German firms, in particular, this means learning how to design less durable products that can be easily maintained and manufacture them with simpler production technologies and less skilled labor. These modifications directly address the needs and usage norms of Chinese consumers and make the product more affordable than the versions sold in MNC home markets. The sweet spot for foreign MNCs is a midrange market above the highest volume, lowest quality commodity segment and yet below the highest quality, most sophisticated technologies typically sold in developed markets. Chinese customer desires for such products exceed native Chinese producers' abilities to produce them, so there is a legitimate market opportunity for foreign firms.

There are countless examples of this sort of mid-market product. Take the case of computer numerical control technology (CNC) for machine tools and other steerable capital goods. Due to insufficient demand, Japanese and German CNC producers cannot widely sell their highly complex highest-end controllers to machine tool and other capital equipment producers in China. Instead, the foreign firms succeed by selling specially designed 'simple' CNC controllers. As a manager at one German firm told us, 'There are millions of conventional machine tools in China that can be easily converted to simple CNC machines if they are provided with the right kind of controller.'

Interestingly, neither the Japanese nor German producers could sell older versions of their entry-

level controllers in China. Knockoffs of older designs already existed in the market at price points the foreign producers could not match. Instead, they developed entirely new 'simple but sophisticated' controllers, designed specifically for the needs of Chinese customers, that integrated new electronics into a simpler delivery unit. Indigenous Chinese producers did not have the electronics know-how to be able to compete with the new products. Crucially, in order to more quickly and efficiently supply demand at a competitive cost level, the MNCs also shifted new controller production to China, using indigenous Chinese designers (who cooperated with designers back in the home location), less complex production technologies, and Chinese suppliers.

Naturally, one could ask why the Japanese or German companies would even bother to invest in this kind of less than cutting-edge business. The answer one gets in interviews with firm representatives is that the companies need to establish their brand positions in the Chinese market so that it will be possible to grow in the market. Foreign producers regard it as inevitable that the current midmarket niche will be overrun by rapidly improving indigenous producers. But the more sophisticated the technology becomes, they believe, the slower the process of indigenous learning will become. If the MNCs can establish their brand position in this emerging market, they're betting that the market will grow toward their strengths.

Rather than designing a wholly new machine or component for the Chinese market, many firms redesign existing offerings to make them more affordable and appropriate for Chinese needs. Peter Marsh of the *Financial Times* has been following this phenomenon and he quotes a manager at Mindray, a producer of medical devices and patient monitoring systems:

'We look at what parts we can standardise, where we can reduce the level of technical sophistication without comprising quality, and in what instances we can substitute software for electronic components,' says Joyce Hsu, Mindray's chief financial officer. The result, she says, is often a low cost product that may not have so many features as an equivalent piece of equipment made in Western Europe or the U.S. but which satisfies requirements in hospitals—in China and elsewhere—that are trying to cut back on costs' (Marsh, 2008: 4).

A German automobile supplier who has been part of our *Globale Komponenten* study has followed

a similar strategy for the design and delivery of internal frames (front ends, engine cradles, cross car beams) in China. Even when the firm wins a bid on a global component that will be built into the same automobile model in Europe, North America, and China, materials, component designs, and manufacturing procedures still differ in each market. In China, the company does not use the same quality steel or the same sophisticated welding processes that it uses to construct the customer's front ends in Europe. The China product is manufactured in a comparatively primitive fashion and is less complex, less durable, and incapable of the same level of performance as its European counterpart.

We found producers in many different machinery and automobile component sectors undertaking these sorts of quite substantial product and production modifications (reconceptualizations), including firms making power drives, turbines, gear units, transmissions, and woodworking machinery. Crucially, modifications like these are most conveniently done in China, even when there is substantial cooperation with home country designers. Chinese engineers understand the customer requirements, local regulations and standards, and the quirks and quality of local materials. And local production managers have an active sense of labor capabilities and the realistic costs of running complex Western production machinery in the Chinese context.

Such moves on the part of MNC firms, of course, create opportunities for local Chinese suppliers to become integrated into the newly recast production strategies. MNCs need local suppliers because the volumes for castings or stamped metal frames for a controller (or the front end of an automobile or the cab of a construction machine made in China) simply overwhelm the operations of suppliers back in the home market. It is not simply that such distant suppliers are already busy with production slated for home region customers, but also that transportation costs make home country components too difficult to justify. This encourages component-producing MNCs to invest in China to offer their customers a 'global footprint.' But it also provides an opportunity for indigenous Chinese producers to enter into newly emerging and more sophisticated foreign MNC supply chains. In any case, as indicated earlier, many capable Chinese suppliers have emerged who are chafing at the limits of their old export processing routines and are in a position to take advantage of such business (Chu, 2011; Thun, 2006; Xi *et al.*, 2009; Li, 2009). In cases where capable suppliers were difficult to identify immediately, MNC

customers could work with suppliers to improve their production quality.

The VW experience in China illustrates one way in which this interconnected upgrading process takes place.⁹ As we noted earlier, for decades VW produced the modest and outdated Santana only in China, in organizationally and technologically minimalist production locations. But toward the end of the twentieth century, when the company recognized that a market for its luxury brand Audi was emerging with the growth of a wealthy class in China and that demand growth was too robust to service with German exports, the company erected production and assembly facilities in China that mirrored those in Germany. Their aim was to produce a Chinese Audi A6 that was identical in quality to the A6 manufactured in Germany.

While working to achieve this goal, Audi recognized that Chinese customers actually wanted an A6 with particular characteristics unwanted by German (and other European and North American) consumers. For example, Chinese consumers wanted limousine-like sedans with significantly more legroom (30 centimeters) than existed in German versions. Incorporating such design changes within an integral architecture like the A6's entailed corresponding changes in materials quality, component machining, in-house system assembly, and the character of local supplier relations. Audi engineers, planners, and purchasing teams could not manage all of these changes from Germany. Therefore, local Audi engineering, production worker capability, and supplier quality assurance had to be developed and maintained to work together with the home country actors to manage the changes.

New and old orientations to the Chinese market can often be seen together, like geological sedimentations, in German MNC factories in China. At our visit to the VW/Audi/FAW JV in Changchun, for example, alongside the old equipment still in use for the VW Jetta, were brand new assembly lines with flexible automation and materials handling work stations that had been specifically designed for Audi's local Chinese assembly needs. The equipment was highly automated, but distinctive in its ability to handle radical amounts of variety: different versions of the A6, Golf, Jetta, and Bora were assembled in

⁹ We saw analogous movements toward this kind of localization upgrading in visits to auto suppliers, woodworking machinery, and drive train and braking systems producers in the Shanghai and Tianjin regions.

the facility. Although German engineers codesigned the equipment and supervised its implementation, local Chinese engineers, maintenance, and setup specialists were deployed to implement, maintain, and operate this quite sophisticated equipment.

Audi's traditional German suppliers—e.g., Bosch, ZF, Hella—were also forced to adjust to the design changes introduced into the A6 (and other VW models) in China. Since the changes were China specific, it made sense for these suppliers to implement those changes locally, in their Chinese operations, as well. These changes then forced all of those producers to alter their external sourcing strategies to incorporate more local Chinese suppliers. This process, in turn, led Audi suppliers to implement the kind of modifications in material usage and manufacturing engineering and technology described earlier in the case of our German front end supplier. Characteristically, once the expanded Audi China production complex proved successful, it made further innovation possible. VW used its Chinese competence to transform the Jetta into the Bora, a simple yet sophisticated hybrid model that mimics characteristics of the Jetta (Golf platform) and the company's simpler Polo model.

The organization of *mutual learning*: systematically disrupting routine and inducing reflection, experimentation, and creativity within and among firms

We have shown that the foreign MNCs and indigenous manufacturers are altering their strategies and commitments in the Chinese market. Rather than simply purchasing component inputs from Chinese suppliers or running sleepy low-tech operations producing anachronistic technologies, MNCs are developing serious Chinese production and design operations to compete in a dynamic and rapidly changing market. Indigenous producers, for their part, are eagerly casting off their apprentice relations and engaging foreign customers in more collaborative, design-intensive, and high value-added business.

We argue that these changes have given rise to a new multidirectional learning dynamic both within MNCs and between MNCs and their Chinese suppliers. What is remarkable about the stories we've related is that the upgrading processes have a snowball quality: the transfer of capability fosters indigenous competence development that, in turn, creates additional possibilities that require still more

competence transfer and indigenous competence development. We observe that much of this process is not at all random or an expression of some sort of 'natural' development path. Rather MNCs and the indigenous Chinese producers they interact with are systematically inducing and optimizing learning through the procedures they deploy to combine (global) products, standards, and metrics with disciplined local discretion. Continuous adaptability and innovation, driven by experimentation and learning is essential for competitiveness in the Chinese market. Moreover, MNCs view the learning and innovation taking place in their Chinese operations as a source of global advantage that can benefit operations elsewhere. As a result, the formerly one-way learning relations characteristic of the communities of manufacturing practice described earlier are giving way to recursive, multidirectional, mutual learning relations based in joint reflection and experimentation.

The paradigmatic mechanism used to generate these new mutual learning dynamics is the formal CPS that manufacturing firms increasingly deploy throughout their global operations. Examples include the ACE system at United Technologies, Formel ZF at ZF, the Siemens Production System, the VW production system (known as 'The Volkswagen Way') and the Caterpillar Production System, among countless others (cf. Sabel, 2005; Spear, 2009; Fujimoto, 1999). Some, mostly smaller MNCs like the wood-working machinery producer in our *Globale Komponenten* case studies, stop short of branding their corporate systems, but nonetheless self-consciously deploy extensive formal procedures that mimic many aspects of the CPSs in larger MNCs.

Many of the companies we interviewed not only infused all of their operating practices with the formal procedures of a CPS, but also maintained elaborate continuous improvement teams (CITs) that were charged with the responsibility of spreading the CPS gospel throughout the global organization. CITs teach employees lean production, team collaboration, and realistic target setting, while providing consulting services and reengineering input to teams, departments, and production cells to help them implement new forms of organization and practice. In the German automobile components and complex machinery sectors, CITs were among the most globally active players within the firm (e.g., Soder, 2006).

CPSs establish group-based goal setting and monitoring procedures that systematically induce collective self-observation, problem diagnosis, and

problem solving experimentation among all players throughout a firm's value chain. In such systems, internationally composed team negotiations typically establish common MNC-wide product designs, quality standards, cost targets, and even manufacturing procedures. Crucial in these arrangements is that the targets or standards (or, in cases of simultaneous engineering, the designs) are sufficiently general to allow for considerable local discretion in implementation. Actors in specific markets are encouraged to experiment with adapting the standards, targets, and procedures to local conditions. Local players, however, are not given *carte blanche* to deviate from common targets. Rather, they are required to justify their decisions to the central teams and provide elaborate quantitative and organizational evidence for the local superiority of their modifications. The possibility of discretion gives local players incentive to experiment and be innovative, while the requirement of justification (and continuous monitoring and dialogue with skilled and interested teams in other locations) wraps processes of local experimentation with discipline (for a theoretical description of this process, see Sabel, 2005).

These formal systems of joint goal setting, local discretion, and mutual monitoring aim to generate positive learning spirals of local adaptation and global improvement, product optimization, and innovation. Product norms, standards, and metrics for local targets are explicitly, continuously (re)constructed by relevant stakeholders in production—manufacturing teams, design teams, customer-focused teams, purchasing teams, often with the input of CIT players. Teams are constituted at the local and central MNC levels and are interdependent: the success of the local players relies on central actor input while, at the same time, the success of the central actors depends on local player success. At regular, formally proscribed intervals (and more frequently on an informal basis in between), central and local actor deliberation generates continuous, mutual self-analysis among production stakeholders (see Romme, 1996, 1997, for an interesting theoretical rendering of this dynamic).

In effect, team actors in different locations jointly reflecting on their mutual activities makes practices in each location transparent to all players—the tacit features of local actions are made explicit. Local discretion combined with joint scrutiny induces disruption of routine and encourages plant teams to experiment with designs, materials, and production organization. The multidirectional learning gener-

ated by this process is recursive, in the sense that the output from one application of a procedure or sequence of operations becomes the input for the next, so that iteration of the same process produces changing results (Sabel and Zeitlin, 2012). Local deviations from central designs and practice made by local teams must be justified to their central counterparts. When the changes are accepted they are then themselves formalized and turned into standard local practice. The new local 'standards' are, in turn, benchmarked by higher order teams within the organization against similar practices in other areas. Where appropriate or possible, adjustments are made elsewhere, which then results in the creation of new higher order standards and targets. The dialectical logic of:

jointly negotiated central standards → local discretion with public justification (peer review) → recursive adjustment of central standards

creates a continuous process of experimentation and optimization within the firm that globalizes learning across the entire MNC.

Interestingly, although these systems rely heavily on formal procedure (metrics, standards, writing things down), technology plays only a secondary role in the arrangement of the governing relations (facilitating data collection and monitoring, for example). Indeed, in practice, such systems can be surprisingly low tech. For example, at our *Globale Komponenten* project's woodworking machinery producer, the firm-managed machinery production transfer to its Chinese (and Central European) production locations with what it called a 'cookbook' system. German production teams took pictures of each discrete step in the home plant machining processes to be transferred abroad—including machine layout (tools and fixtures), individual setups, tool positioning, transfer procedures, and work organization. The pictures were then annotated with instructions for setup procedures, machining speeds, tact times, and expected output for each stage in the production and assembly flow. These 'cookbooks' were then sent to the company's Chinese operations, along with the blueprint designs for the machines, to guide the construction of Chinese manufacturing operations for all woodworking machine models.

The cookbook functioned as a set of very specific guidelines, but local players were empowered to use discretion while implementing them. The

implementation process allowed for any number of local design and procedural modifications in manufacture: the reduction or enhancement of product functionality, the excision or addition of steps in the production process, and the substitution of materials were all fair game as the local players sought to adapt the home firm's designs to the Chinese regulations, consumer interests, and competitive cost conditions. But local modifications had to be justified to the exporting multifunctional teams and managers that originated the cookbook. Acceptable changes were noted, new pictures were taken, and a local cookbook was constructed. If the changes implemented locally improved the way the machines were produced, the local innovation was embraced by German teams and the new procedures were photographed and integrated into the home cookbook.

Because the cookbook is a detailed deconstruction of a machine into literally hundreds of discreet manufacturing operations, it was possible for home country players to adopt small alterations for their own use at home, even as the overall character of the specific machinery model diverged from the one that the company was manufacturing back in Germany. In this way, the formal process of systematic stakeholder monitoring of the cookbook created a recursive multidirectional process of organizational learning that combined disciplined local innovation and product adaptation with openness to global design and manufacturing process innovation.

Crucially, these formal translocational learning practices are also deployed, in modified form, to govern relations between customers and suppliers. Instead of a formal cookbook of pictures and instructions for how to implement and adapt proprietary machinery and operations, MNC customers provide Chinese suppliers with clear targets for cost, quality, and delivery time for a part or component that the customer and supplier design together. Both parties observe the progress of the supplier relative to the target and, in cases where targets are missed, both immediately seek to identify the reason and work toward a resolution. When successful, such formally self-analyzing relations produce learning and continuous upgrading, for both the customer and the supplier, not only across Chinese supply chains, but across entire global production networks (Ivarsson and Alvstam, 2010; Lui, forthcoming).

We observed such relations in a variety of our firms. Take the relations between a German gear unit MNC and its Chinese supplier of aluminum

housings. In this case, the Chinese supplier did both casting and machining for the German firm (the latter, in part, on machinery that had been transferred from the German company's home plant in Germany). In both cases, the customer specified broad production quality and cost targets. Formal audits and regular joint procedure reviews with the customer took place: engineers from the German company's Chinese plant in Suzhou regularly visited the Chinese supplier, as did skilled workers from the gear producer's German plants. The aim was to help their Chinese counterparts set up the new machinery and understand how to solve problems generated in aluminum housing machining.

These interactions yielded a number of jointly agreed upon deviations from original customer designs and practices, in particular regarding materials used in molds, casting techniques (more skilled laborer input, less automation), and even the maintenance procedures of the German company's former machinery. In order to optimize the changes, the Chinese supplier upgraded its manufacturing engineering and design capabilities (an expense which it was encouraged to incur, not only from its German customer, but also from the regional Chinese government, which gave tax breaks to firms increasing design capacity). The resulting supplier improvements helped the German company maintain its quality and cost targets, while simultaneously stimulating ideas to adapt the overall gear unit designs to facilitate entry into a new user market—Chinese omnibus manufacturers. Perhaps most significantly, the company took machining process modification ideas introduced in China and used them to experiment with the setup of similar processes in its Russian and Indian subsidiaries. This successful mutual learning, moreover, created the possibility for additional more challenging design intensive collaborations between the German MNC and the Chinese supplier in the next contract round.

Discussion: is mutual learning really beneficial to MNCs?

There are obvious benefits to Chinese manufacturing suppliers (and, in reverse, to Chinese OEMs working with foreign MNC component suppliers or capital good producers) from mutual learning activity. It allows Chinese producers to break through the self-limiting structures of the older unidirectional export oriented community of practice. The benefits to foreign MNCs, however, may appear to be more

ambiguous. On the one hand, the new relations produce mutual learning and, consequently, MNCs gain the ability to improve not only local Chinese operations, but also similar operations in other locations. On the other hand, if their Chinese collaborators are becoming such successful and sophisticated learners that they provoke MNC learning processes as well, isn't there a danger that the Chinese will abandon the collaboration with the foreigner and manufacture the product on their own? That is, aren't MNCs worried about losing intellectual property and, hence, market presence to their increasingly sophisticated Chinese collaborators?

Our interviews uniformly reveal that foreign manufacturing MNCs in China engage in these recursive collaboration, learning, and upgrading relations despite the fact that intellectual property cannot be guaranteed in the relationship, especially not in any long-term sense. Moreover, foreign automobile and complex machinery managers broadly acknowledged that their indigenous Chinese employees (managers and skilled workers) were gaining knowledge of proprietary products, technologies, and procedures and at least some of them were taking what they were learning and deploying that knowledge for their own ends.

The same was true of suppliers. Successful collaborators were looking to establish ties with other potential customers that explicitly leveraged what they learned in their relationship with the MNC. In most interviews, foreign managers viewed these dynamics as inevitable and, after a certain point, nonpreventable. All players acknowledge, moreover, that this is true despite what most observe to be continuous improvement in the capacity of Chinese authorities to protect property rights.

Why do foreign MNCs nonetheless proceed with the creation of these types of mutual learning relations? They do it because the emerging Chinese competitive and strategic conditions are becoming similar to those in the MNC home regions. Competitive pressure for continuous innovation, cost reduction, and change drive most relations in the global market place. Regardless of property right quality, in relatively mature, integrated product architecture-based manufacturing sectors, there are few guarantees that a given product or technology will maintain an advantageous position in any market for very long. Rather than orienting their strategies around protecting technology and product designs, then, firms continuously improve and transform designs to match changing customer needs and identify new

customers. Global MNC production arrangements and relations with suppliers are, in this sense, strategic formally governed systems focused not on making specific products but on constructing collaborative continuous learning processes that drive competence expansion, innovation, and self-transformation.

The Japanese and German CNC controller manufacturers we discussed earlier are exemplary of the larger trend. Their long-term market strategy is not to produce simple but sophisticated technologies (such as CNC units), but to be recognized by consumers as reliable and quality manufacturers in their industry (e.g., computer automation equipment). Such firms believe that if they can create dynamic learning relationships in China, they will be able to leverage the global technological know-how they have in automation equipment (or gear units or woodworking technologies) to make those Chinese relations continuously and reliably competitive in the dynamic and expanding Chinese market. The idea is to establish dynamic learning capabilities in China that can, in turn, participate in emergent global learning and innovation operations. This strategy promises more return in the long term than one that seeks to protect market share on any particular product model or generation in a specific national market.¹⁰

CONCLUSION

This article describes contemporary Chinese manufacturing upgrading as a multidirectional, interactive, recursive, and learning-driven process. Far from a technological *cul de sac*, the experience of export processing and participation in transnational supply chains in a broad array of cases helped Chinese producers learn international manufacturing best practices. It apprenticed them in cooperative, learning-driven supply chain relations and it schooled them in the global disciplines of lean production and supply chain collaboration. Such learning prepared the ground for them to be able to produce their own designs and participate substantively and creatively in CPSs. Moreover, this manufacturing upgrading process created increasingly

¹⁰ This orientation may be specific to the sectors we studied and less characteristic of the views of players in industries, such as the electronics and software industries, where first-mover monopolies account for an enormous share of the value producers are able to capture. We note this possibility and leave its exploration to a future article.

sophisticated demand for manufactured products within China itself, and this new demand, in turn, gave rise to new forms of competitive and cooperative market dynamics among both indigenous Chinese and foreign MNCs.

We argue that this new market situation is associated with a shift to a new, more dynamic multidirectional and recursive form of mutual learning among Chinese producers and foreign MNCs. Chinese producers, engineers, and skilled workers—suppliers, customers, and local personnel in upgrading MNC Chinese locations—are helping foreign MNCs understand how to adapt their products to the specificities of the Chinese market. Foreign MNCs are radically altering their commitments to the Chinese market by developing more capacious engineering, design, and organizational capabilities and practices in their subsidiary operations. Key mechanisms for this transformation are the recursive, team-based, mutual learning processes that are generated by the formal procedures in CPSs. Such systems create global learning spirals by imposing systematic interaction between local discretion and global standards. Though highly competitive (and, hence, like any market process capable of producing losers), our story suggests that the larger interactive dynamic between Chinese players and MNCs has many surprisingly mutually beneficial dimensions.

Finally, we can't help pointing out that our story is, at least from one point of view, ironic. Initially, the worry with developed country engagement with China was that offshoring and outsourcing relations would involve the loss of competence to China and/or a shift of home country competence away from manufacturing (e.g., Bronfenbrenner and Luce, 2004). Our research shows, however, that these worries are misplaced (or perhaps overtaken by events) in the automobile and complex machinery sectors. Current Chinese engagements systematically recompose global MNC internal flows and Chinese offshore experiences through recursive mutual learning. As a result, China operations supply MNC home country product development and production processes with useful benefits. The benefits are likely to be all the greater, moreover, as the gap between Chinese and developed country market sophistication narrows—in part, as a result of the mutual learning processes this article outlines.¹¹

¹¹ We develop this argument more extensively in Herrigel, Wittke, and Voskamp (forthcoming).

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