The challenge of China

As barriers to Chinese competition weaken, local and foreign semiconductor players must consider issues such as intellectual property and knowledge transfer to fully capture opportunities in this important market.

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Since the late 1980s, the Chinese government has made efforts to build an indigenous semiconductor industry by providing financial incentives, developing talent and technology, and crafting alliances with global players. And though the country has assumed a central role in the manufacture of many computing and consumer-electronics products, its role in the semiconductor sector has remained surprisingly limited. In the industry value chain, China has a strong share in only the assembly-and-test and back-end-manufacturing segments. Aside from these two (admittedly considerable) areas, the country is largely missing from semiconductor league tables.

In fact, today China is primarily a consumer of semiconductors, rather than a producer of them. The country's semiconductor trade association published a report in March 2011 that estimated that the Chinese semiconductor market accounted for fully 33 percent of global supply. The share of those chips used in domestic products accounts for 15 percent of the global semiconductor market. The remaining share is installed in a wide range of export goods. Furthermore, our research indicates that Chinese companies influence the design and other elements of just 1 to 2 percent of finished chips.

It would be logical to expect that a country of China's size would be a leading stakeholder in discussions about technology standards and the designs for next-generation platforms, but that is not the case. Despite consuming 33 percent

Exhibit 1

Chinese foundries lack leading-edge technologies because of export controls.

The 1996 Wassenaar Arrangement puts export controls on manufacturing technology . . .

- Until 2010, controls prevented the export of <90nm manufacturing technology to China
- Until 2010, Taiwan restricted the export of <180nm manufacturing technology to China
- In 2010, the Wassenaar Arrangement was updated: controls now prevent <65nm manufacturing technology from being exported to China
- In 2010, Taiwan signed an agreement with China (the Export Promotion and Cooperation Agreement) that allows the export of manufacturing technology that is 2 generations behind leading edge

. . . which has prevented Chinese companies from accessing <65-nanometer (nm) node technology

Chinese foundry

Company	2009 nodes, microns		Number of fabs		
	Mainstream[1]	Leading edge	<6"	8"	12"
TSMC	<0.13	0.045	1	8	2
UMC	<0.15	0.045	1	7	2
Chartered Semiconductor	<0.18	0.045	0	5	1
SMIC	<0.18	0.09	0	5	3
VIS	<0.20	0.09	0	2	0
Dongbu Electronics	<0.25	0.09	0	2	0
FAB	<0.35	0.13	4	2	0
I-NEC	<0.25	0.13	0	2	0
ALTIS	<0.18	0.13	0	1	0
HeJian	<0.25	0.15	1	1	0
Tower Semiconductor	<0.18	0.13	1	2	0
Grace	<0.18	0.13	0	1	0
SilTerra	<0.18	0.09	0	1	0
SSMC	<0.18	0.13	0	1	0
ASMC	<0.50	0.25	2	1	0
Jazz	<0.25	0.13	1	1	0
EPISIL	<0.50	0.25	3	2	0
China Resources	<0.50	0.25	3	1	0

[1] "Mainstream" includes nodes utilized in more than 50% of the foundry's total capacity.

Source: iSuppli, H1 2009; World Fab Watch 2009; Wassenaar Arrangement Web site, Category 3 list; Semiconductor Equipment and Materials International; *Taipei Times*

of the global market for semiconductors, Chinese companies claim less than 4 percent of global revenue in the lucrative segments of semiconductor design and front-end manufacturing.

There are four reasons for this state of affairs. First, China exerts little influence on semiconductor design and selection in major product categories such as mobile phones and laptop computers. The majority of design decisions for these goods are made by global champions—such as Nokia, Acer, and Apple—in their home countries, at the headquarters level.

Second, the home countries of major semiconductor companies ban the export of leading-edge manufacturing technologies to China. Both the United States and the island of Taiwan prohibit the export of equipment used to manufacture sub-65-nanometer process technologies, which leaves mainland Chinese foundries two generations behind the current 32-nanometer standard (Exhibit 1).

Third, concentrated clusters of semiconductor excellence failed to fully develop in China. Instead of focusing investments on one location, as did the island of Taiwan with Hsinchu Science Park, the Chinese government made investments in multiple provinces, setting up semiconductor fabrication plants as far north as Jilin and Dalian, as far south as Shenzhen, and as far west as Chengdu. In all, fabs capable of producing more than 1,000 wafers per month are spread across 19 cities. Because the industry was so fragmented, government support did not lead to the formation of a vibrant semiconductor ecosystem in any single location.

Fourth, and perhaps most important, foreign players own most of the intellectual property throughout the semiconductor value chain. Applied Materials, for instance, dominates manufacturing equipment, while Intel, Nvidia, and Qualcomm control key parts of integrated-chip design for microprocessors, video cards, and mobile handsets, respectively. Owning the intellectual property means these foreign players also garner the lion's share of revenues. In the front-end-manufacturing segment, non-Chinese players (for example, Samsung, Intel, and Hynix) earn 96.3 percent of all revenues. In design, foreign players earn 96.1 percent of revenues. Even in the silicon segment, 93.0 percent of revenues go to non-mainland-Chinese companies. China has a decent share in only two areas, back-end manufacturing and assembly and test, where Chinese companies earn 28.6 percent of total segment revenues.

Taken together, these four hurdles have made it difficult for Chinese semiconductor players to compete in the last decade. However, three of

Exhibit 2

Lack of intellectual property and know-how remains the only barrier to increased competition from Chinese semiconductor players.

Barriers are weakening	Details
End-system design in China, for China	**Increasing end-user consumption in China is likely to drive local system design** • ZTE became the No. 5 player in mobile handsets in 2010 • Huawei is a top 3 player in all major telecommunications-equipment segments • Lenovo is the No. 3 PC vendor in the world
Declining share of leading-edge nodes	**The effect of Moore's Law on the global semiconductor market is declining** • Leading-edge nodes now represent 14% of total demand for logic chips and microcomponents, making access to manufacturing technology less important • Several large segments, such as analog integrated circuits ($42 billion in 2010) and microcontrollers ($18 billion), are using older technology
Renewed focus on clusters of excellence	**Several Chinese cities are beginning to attain critical mass as clusters of excellence** • Shenzhen, Chengdu, and Dalian have made significant progress • Texas Instruments and Freescale Semiconductor set up manufacturing plants in Chengdu • Intel set up a 90-nanometer fab in Dalian

Issues related to intellectual-property know-how are the only major roadblock

Source: iSuppli; Databeans

those four barriers are now weakening, and with recent events likely to serve as a tipping point, we believe the lack of intellectual property and know-how is the remaining impediment to Chinese semiconductor players' progress. This portends significant shifts in the international semiconductor situation (Exhibit 2).

The emergence of a Chinese middle class is creating a domestic industry—one with export ambitions

The first barrier—the modest influence China exerts on semiconductor design and selection in major product categories—is eroding as a robust domestic market emerges, particularly because first-time consumers of major product categories that use semiconductors do not need leading-edge products. As a consequence, a substantial "built in China, for China" market is taking shape. To get a sense of the scale of this market, consider the following facts: 26 percent of all automobiles sold in the world in 2010 were sold in China. Chinese citizens bought 19 percent of the global PC supply last year and accounted for 18 percent of LCD-TV sales. In the robust global market for mobile handsets, the Chinese commanded 14 percent of unit sales in 2010. And Chinese companies are leveraging their domestic scale to sell outside of China, thereby shaking up league tables further in a number of industries. Lenovo, for example, is now the third-largest vendor of PCs in the world. ZTE became the fifth-largest handset manufacturer in the world in 2010. And Huawei has become a top-three player in all major segments of the telecommunications-equipment market.

China's emergence is significantly enabled by a declining need for ever-increasing processing speed. As the semiconductor industry moves closer to the physical limits of silicon, fewer devices are relying on truly leading-edge technologies. In fact, leading-edge nodes now represent only 14 percent of total demand for logic chips and microcomponents. There is, consequently, generally less pressure to have state-of-the-art manufacturing technology (Exhibit 3). This opens the door for Chinese semiconductor players.

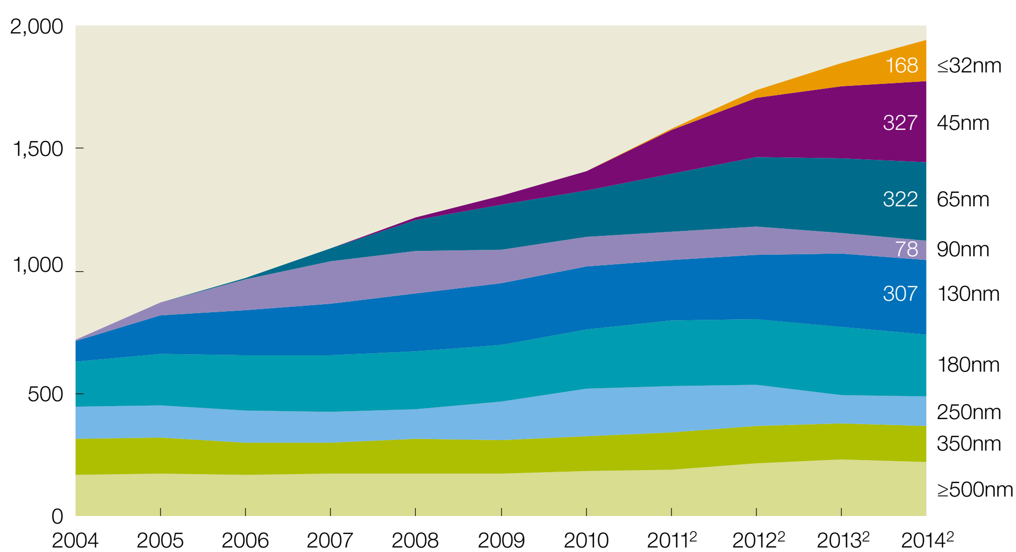
Certain segments of the market have found success using technology that is one or two generations behind the leading edge. For example, analog integrated circuits and microcontrollers (which account for $42 billion and $18 billion in revenues, respectively) are leveraging process technology that is at least two years old. The proliferation of devices powered by less-than-cutting-edge chips means that the playing field for Chinese semiconductor manufacturers is much more level than ever before.

Even if consumers in China become less willing to settle for second-best technology as their

Exhibit 3

Leading-edge nodes are only a small share of foundry volume.

Total foundry capacity per node,
300mm equivalent KWPM[1]



[1]Thousands of wafers per month.
[2]Estimated.

Source: Gartner, converted from 200mm to 300mm scale with 8" equivalent to 2.25

affluence grows, share is unlikely to shift decisively back to the West. Chinese semiconductor companies are developing process technologies more quickly. SMIC has now achieved the same two-year development cycles as industry leaders. Even though the company may be at a disadvantage due to Western export controls, it achieved stable output at the 65-nanometer level in 2010 and is ramping up additional capacity in 2011. And SMIC's 65-nanometer fabs are running at 95 percent capacity, indicating that there is intense local demand for these chips.

So the emergence of a local market and the apparently limited effect of Western export controls mean that the first two barriers to a significant Chinese presence in all segments of the semiconductor industry are coming down.

The third barrier is also falling, because clusters of excellence are finally coming together in China. Several cities, including Shenzhen, Chengdu, and Dalian, have developed expertise in the local workforce, reached a critical mass in number of fabs, and connected with relevant suppliers nearby. A sure sign of this evolution is that Texas Instruments and Freescale Semiconductor have both opened manufacturing plants in Chengdu, and Intel has set up a $2.5 billion 90-nanometer fab in Dalian.

Looking ahead to the coming decade, it is important to note that China has the world's most comprehensive, well-funded, and ambitious technology-industry policy, and the semiconductor sector is 1 of the 16 sectors into which stakeholders want to make significant inroads. The country's industrial policies for semiconductors are already beginning to show results as domestic end-to-end value chains emerge: for example, in wireless-communications semiconductors, an end-to-end value chain has developed among SMIC, HiSilicon, Huawei, China Mobile, China Unicom, and China Telecom. Similarly, in wireless systems on a chip, the domestic value chain consists of Taiwan Semiconductor Manufacturing Company (TSMC), Spreadtrum, Huawei, Tianyu, China Mobile, China Unicom, and local consumers.

With three of the four barriers weakening, the lack of intellectual property and know-how is the only significant barrier remaining. While the Chinese have found many ways to acquire the intellectual property needed to establish domestic industries, challenges related to complexity and materials science in semiconductors are more burdensome than in other fields. Acquiring intellectual property and know-how will thus be crucial for Chinese players as long as the semiconductor sector remains a priority industry for government development programs. It should be noted that China has made multiple attempts to entice foreign players to transfer technology, for example, licensing Geode microprocessor-design technology from AMD.

What does this mean for a strategic China engagement model?

As the Chinese government increases efforts to develop the industry, it will likely offer more promising incentives for semiconductor companies to do business in China. This creates a dilemma: it will be difficult for foreign companies to compete from outside the country as their competitors establish beachheads there, but at the same time, the Chinese endgame is clearly the transfer of intellectual property and know-how to allow Chinese companies to compete globally—that is, not just to compete for the emerging local market currently owned by Western players, but to turn around and challenge Western players on their own turf.

A similar scenario played out in the mid- to late 2000s, when the Chinese government launched a major policy initiative to promote the high-speed-rail industry. Seeing a $50 billion market, many foreign players, including Kawasaki, Siemens, Bombardier, and other companies, expressed interest. In 2004, several joint ventures were set up between foreign and local rail companies. While Siemens refused to transfer intellectual property to its joint-venture partner without adequate compensation, Kawasaki and one other player agreed to transfer significant intellectual property to their respective partners on less demanding terms.

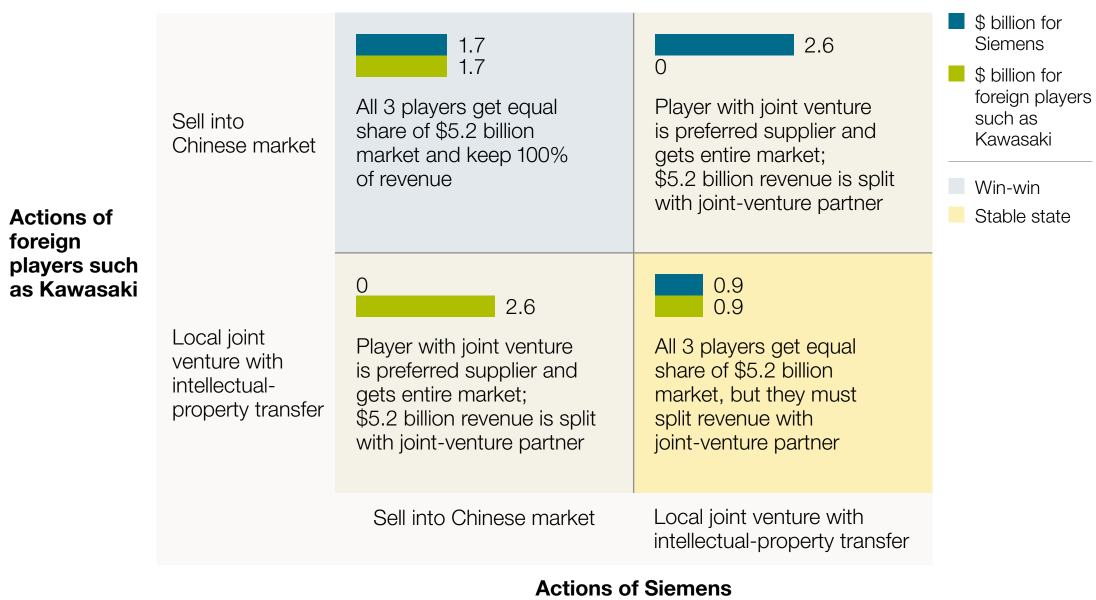
As classic game theory would predict, had all three players sold into China on similar terms, the $5.2 billion in potential reward would have been divided among the three equally ($1.7 billion for each, as seen in the top-left box in Exhibit 4). Since, however, Kawasaki and one other player agreed to Chinese terms on intellectual property but Siemens did not, it seemed likely that the two companies that shared IP would split the market equally. But Siemens felt it had little choice but to set up a joint venture including intellectual-property transfer to claim its share of revenues, so another scenario from the initial game-theory projection played out:

Exhibit 4

Classic game theory can be used to predict potential outcomes of partnerships in Chinese high-speed rail.

Once Kawasaki and another foreign player agreed to joint ventures, Siemens had to do so as well

Potential rewards, 2004–06: total orders of $5.2 billion



Source: *New York Times*; *Financial Times* each of the three players divided their share of the $5.2 billion market equally, and then split that amount with their Chinese partners.

However, at the three-year mark, all the local joint-venture partners, having carefully incorporated key intellectual property from the foreign players, began launching independent products. Since 2007, these products have attracted $20 billion in orders from various state-owned enterprises; foreign players have not won any orders at all.

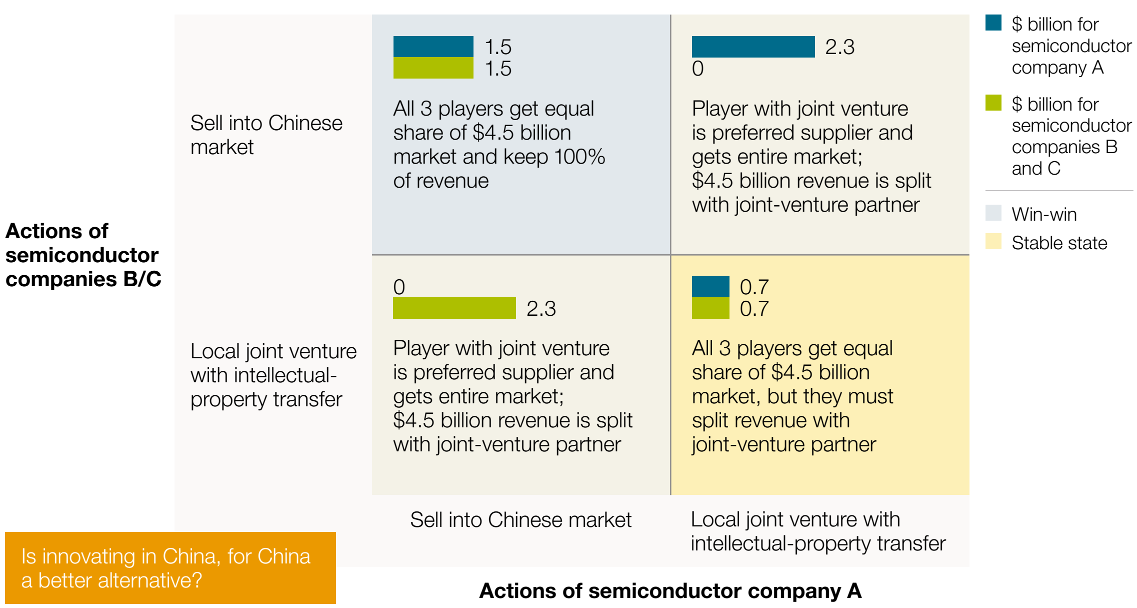
This cautionary tale is not presented as definitive proof that the joint-venture structure is flawed irremediably. Rather, we mean to suggest that other structures must be energetically reviewed; companies should consider options that do not include the transfer of intellectual property.

For instance, a number of leading multinational companies have adopted an "innovate with China" approach, which consists of launching R&D centers in China that focus on developing

Exhibit 5

Reviewing joint-venture structures can help avoid the prisoner's dilemma, as in this electric-vehicles scenario.

Potential rewards, 2015–20: total potential orders of $4.5 billion[1]



[1]The Chinese government set a goal of 5 million electric cars in China by 2020; $900 in semiconductor content per hybrid or electric car.

Source: *New York Times*; *Financial Times* technologies for the Chinese market. General Electric, for example, established a China R&D center that focuses on developing products in line with local market demand and stated government priorities, such as rural health care and sustainable development. Siemens has a similar center working on LED lighting products and low-cost medical equipment. Each product from these centers is tailored to the Chinese market and could potentially be sold in other developing markets. This approach serves to limit the exposure to intellectual-property risks to technologies or products developed in China (Exhibit 5).

More broadly, there are a few simple steps that foreign players can take to boost their chances of success in the Chinese market. Keys include developing a go-to-market approach that addresses the problems of Chinese customers, nurturing strong relationships with large state-owned enterprises, and presenting an innovative in-channel model to take advantage of unique characteristics of the market.

Four strategic questions to consider

Until now, foreign players have focused on protecting their intellectual property and know-how by selling finished chips into China. One common tactical approach is known as price customization; companies offer special product numbers and packaging, and although product performance is slightly lower, the goods cost less. While this approach meets basic market requirements, it creates an opportunity for local players; they can add features and differentiate themselves significantly. To head off that threat, many foreign semiconductor players have begun designing products for China, in China, yet they remain wary of the risks of transferring intellectual property and know-how.

From a strategic perspective, there are four key questions that semiconductor companies must answer to successfully address the opportunity in the Chinese market.

The first question concerns the engagement strategy for intellectual property and know-how. Simply put, what is the best way to use intellectual property in China? Two common strategies are to sell into China while keeping intellectual property in-house and to launch a joint venture with an agreed-upon transfer of intellectual property. However, several other options exist. Companies could launch indigenous development centers in China, which will develop key technologies for the unproven, next-generation markets likely to take off should they become widely adopted in China. Another option is for companies to partner with local downstream players, such as automobile manufacturers or even financial investors. The right way to frame this strategy is at the individual product-line level, not the business-unit or company level. A robust China strategy may include a number of different approaches used throughout the product portfolio.

After determining a strategy, semiconductor players can derive a proper operating model. A carefully crafted operational strategy will focus primarily on competitive activity, a proper understanding of the level of capital investment required, and active government relations. The Chinese government is not monolithic; there are national, provincial, and local stakeholders with whom to negotiate and build longer-term relationships. Managing those relationships is crucial in accessing government contracts and the Chinese market at large.

A third key question involves assessing the impact of the competitive environment (as regards both Chinese and foreign players) on a company's

Indigenous innovation and next-generation markets for semiconductors

A combination of policies designed to enable large, next-generation end-use markets for semiconductors, together with procurement policies meant to drive indigenous innovation, is likely to create a strategic dilemma for semiconductor companies looking to sell into China.

China has launched ambitious policy initiatives to develop large domestic markets for specific next-generation technologies: cloud computing, the "Internet of Things," and hybrid and electric vehicles. These three markets combined represent tens of billions of dollars of market opportunity in China for semiconductor companies.

The Chinese government is also increasingly emphasizing indigenous innovation in government procurement programs in order to reduce the country's dependence on foreign technology. In November 2009, several Chinese government agencies announced six categories of products that would be directly affected: computer and application devices, communication products (thought to include mobile phones), modernized office equipment, software, "new energy and equipment," and energy-efficient products. China's 12th five-year plan also reinforces the drive to promote domestic innovation in these areas.

Taken together, these policies and a number of stimulus programs may have significant implications for the semiconductor industry. These next-generation technologies and categories of products are expected to be growth drivers for Western semiconductor players in the decade ahead. There is a real potential for Chinese companies to emerge in these areas, as current players have not established clear leadership positions in these applications.

China has not yet tied the indigenous-innovation policy to its policies for these next-generation markets. But there is a real possibility that it will. And any move in that direction would create a strategic dilemma for semiconductor players, which are, frankly, counting on driving significant future growth from these three areas (exhibit).

Simply responding to the challenge of establishing a presence in these areas by creating individual initiatives will not be sufficient. This is a matter that should rise to the highest strategic level for any company that wishes to be a player in these markets. A good place to start would be to understand the implications of potential government and competitor moves, and to develop a response that will accommodate each.

Exhibit

The semiconductor industry may face challenges related to intellectual property for next-generation applications.

The indigenous-innovation policy . . .

- **An “indigenous innovation catalog” of domestically developed technologies was created:** approved products are to be given preferential treatment in state procurement
- **Initial focus areas include 6 high-tech industries:** targets include computing, networking, and energy efficiency
- **The goal is to move from “made in China” to “innovated in China”:** the country wants to reduce its dependence on foreign technology to 30% from its current level of 50%

. . . could have significant implications when applied to large, next-generation markets

- **Cloud computing**
  - Policy initiative launched in 2010
  - Trials will take place in 5 cities
  - Key goals include developing core technologies and formulating standards
- **“Internet of Things”**
  - Policy initiative launched in 2011
  - The goal is to develop domestic leaders in the industrial value chain
  - Stakeholders also seek to provide support to develop standards
- **Hybrid and electric vehicles**
  - Policy initiative launched in 2010
  - The aim is to make China a leader by 2020
  - The country seeks to develop 2–3 companies as global leaders in key technology areas

This may result in a strategic dilemma for the semiconductor industry

overall China strategy. A competitor selling finished chips into the Chinese market will face circumstances that differ from one investing in local R&D capacity or transferring intellectual property and know-how to a local partner. Might a Chinese player pursue intellectual property and know-how by acquiring a weaker competitor? What role, if any, will the Japanese play in the competitive situation? War-gaming the scenarios can help companies make necessary adjustments.

The last important question involves asking how a company’s short- and medium-term strategy will differ from its long-term strategy in the country. Certain tactical choices may be right in a 6- to 12-month time frame, but priorities are likely to shift over a number of years. If the goal is to establish a large local R&D presence from the outset, for instance, it may be valuable to adopt a long-term view from the very first day. Smaller commitments will call for different strategic approaches.

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Over the next five years, cloud computing, the Internet of Things, and electric vehicles are likely to be three of the strongest pools of growth for the global semiconductor industry. The Chinese government has launched a slate of initiatives aimed at developing those markets. As a result, China represents an increasingly important market for global semiconductor companies. However, the comprehensive policies of the Chinese government also indicate that the country intends to develop players who will compete in the top tier of the semiconductor industry.

Three of the four barriers to China's ability to compete are weakening, and the country is ramping up innovation in trailing-edge technology. Western semiconductor companies must determine their strategic posture now. A careful intellectual-property strategy and an operational strategy closely aligned with it will be necessary to develop and hold on to key intellectual property—and thus prosper alongside Chinese players in the increasingly competitive global market for semiconductors. ○

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