Technology

China's Impact on the Semiconductor Industry*

2006 / Update

Table of Contents

About This Report

The 2006 annual update assesses the current status of the semiconductor industry in China and how it has changed since our previous update. As with our previous reports on this issue, we conducted a second-order analysis for the 2006 update. To accomplish this, first we reconciled data from different, incomplete, and often contradictory reports from various sources. These sources included industry associations and third-party research firms located in Asia and the West. Then we analyzed the reconciled data with an eye toward filling in gaps and revealing information that was not apparent in the original source material.

Our intent with this method was to construct a more comprehensive, telling, and yet quantitatively based picture of the industry than was previously available. Using this method, we surfaced additional findings and considered the ramifications of those findings for multinational semiconductor industry companies. Then finally, based on this newly developed information, we formulated a current set of recommendations for industry companies.

One final point we should note on the data sources: the metrics we developed had to be sufficiently comprehensive to be useful for the type of report we wanted to publish. Because 2006 annual numbers are not available in calendar year 2006 and quarterly numbers were neither comprehensively reported nor available, we used 2005 numbers. We also interviewed industry executives to obtain current views from various parts of the value chain. We then reviewed three production forecast scenarios against actual production and consumption growth realized during the period.

Our report also examines the composition of the semiconductor value chain in China and compares it with the worldwide value chain. As part of this analysis, the report reviews both demand for semiconductor equipment in the country and the primary equipment suppliers to the market.

The original 2004 report explored in detail the overall dynamics of the global semiconductor industry and various issues that make China's part of that industry different or even unique. Those fundamental findings are still valid; readers who would like to gain a better understanding of those fundamentals should refer to the original report, available at
www.pwc.com/techcenter.

The growth of China's semiconductor market—which consists primarily of electronics manufacturing services (EMS) companies, original design manufacturers (ODMs), and original equipment manufacturers (OEMs) that consume chips in China—continues to be the major catalyst for changes in the industry. For this reason, we assessed the status of the market in depth and considered its effects on semiconductor production: wafer fabs; packaging, assembly, and test facilities; and integrated device manufacturers (IDMs) of the industry. To assess the design and marketing capabilities of Chinese semiconductor companies as a group, we also reviewed the status of fabless and design companies.

Executive Summary

PricewaterhouseCoopers began the study series *China's Impact on the Semiconductor Industry* in 2004 in response to our clients' interest in the rapid growth of the semiconductor industry in China. Specifically, clients wanted to find out whether China's production volumes would contribute to worldwide overcapacity and a subsequent downturn. At the time, multinational integrated device manufacturers (IDMs) were closing down their fabs in North America, and foundries such as Grace Semiconductor Manufacturing Corporation, Hua Hong NEC, and SMIC were adding capacity. Some multinationals were transferring to joint ventures in China certain equipment and production activities focused on selected products. Many industry participants talked of significant future investments in wafer fabs.

Since then, it has become clear that market growth in China is a phenomenon at least as important as industry growth—if not more so. Electronics system vendors in China increased their consumption of semiconductors in 2005 by 31 percent over 2004 levels. The boom in electronics systems production in China has stood in direct contrast to flat or declining systems production in most other countries. In 2005, 24 percent of the worldwide semiconductor market was in China. On the production side, investment in Chinese wafer fabs has not materialized to the extent some industry observers thought it would, but Chinese semiconductor industry growth overall has been strong, at 35 percent in 2005. China accounted for 7 percent of worldwide semiconductor production in 2005.

One fact stands out above the others in this year's report: China was responsible for 90 percent of growth in worldwide semiconductor consumption in 2005, continuing a trend we first observed beginning in 2003. All of the semiconductor executives we interviewed for this update believe the market in China will continue to grow at a much faster rate than the worldwide rate in 2005.

The Chinese operations of electronics manufacturing services (EMS) companies and original design manufacturers (ODMs), as well as China's own original equipment manufacturers (OEMs), collectively caused nearly all of the growth in the worldwide market. The percentage of semiconductor sales for systems built in China for export increased to 64 percent in 2005, up from 60 percent in 2004. China exports these systems to such places as North America, Europe, and developed Asia.

One clear implication emerges: if semiconductor companies do not have a sufficient presence in China, they will not be able to supply the vast majority of new demand for chips in China. Therefore, our main recommendation in this report is that semiconductor companies assess their presence in China closely and take steps to remedy any deficiencies they note in the country. What are their relationships there? Are they calling on enough customers? Do they understand the requirements of the system vendors there? Are they designing to the vendors' specifications? Do they have sufficient packaging, test, and assembly tailored to Chinese demand, and is it close enough to the demand? What else can they do to position themselves for demand growth in the country?

As a first step, companies need to benchmark themselves against the industry average: is their market share sufficient or not? To assist, we considered that question for the 70 largest semiconductor companies in the industry and compiled a table (see the Appendix on page 64) comparing the percentage of each company's business in China with its overall business. As the table shows, 10 of these companies had above-average shares of sales to China compared with their worldwide sales, 24 had average shares, and 36 had below-average shares.

Findings

The following is a summary of our findings for this 2006 update. These findings reflect secondary research, interviews with industry executives, and our own analysis.

Nearly all worldwide semiconductor market growth in 2005 was due to new electronics systems production occurring in China. Demand in China for semiconductors was responsible for 90 percent of total worldwide market growth. In 2005, for the first time, the China market alone was larger than that of Japan, the Americas, Europe, and the rest of the world. By 2010, fully one-third of the worldwide market for semiconductors could be in China.

Eighty-six percent of worldwide demand growth for integrated circuits (IC) was in China. China's IC market amounted to $46.9 billion of a total $192.4 billion market, nearly 25 percent of worldwide.

China's discrete market is now growing at the expense of the discrete market in other countries. China's discrete market increased by more than $1 billion in 2005 compared with less than $1 billion in market growth worldwide. By the end of that year, China had generated 22 percent of worldwide discrete industry revenues.

Western awareness is low regarding the strength of the Chinese industry in some areas and its associated impact on pricing. In the discrete market, for example, the Chinese play a major role. However, because World Semiconductor Trade Statistics (WSTS), for example, does not have the participation of any Chinese semiconductor companies, it could be missing significant discrete device demand or consumption that is completely satisfied by local Chinese companies. As a result, multinational semiconductor companies may be underreporting the size of the worldwide discrete as well as the total semiconductor market and may be unaware of potential competitors that are developing in a very cost-sensitive environment and establishing supplier relationships with major electronics manufacturing services (EMS), original design manufacturer (ODM), and original equipment manufacturer (OEM) customers.

Chinese OEMs increased production substantially in 2005, and as a result their share of chips consumed in China increased. We estimate that 26 percent of Chinese demand in 2005 was from domestic OEMs compared with 20 percent in 2004.

Export demand for chips expanded faster than domestic demand did, reversing an earlier trend. The percentage of semiconductor sales for systems built in China for export grew to 64 percent in 2005, or $37.1 billion of a total $57.9 billion market, up from 60 percent of the market in 2004.

Many observers expect demand growth in China to continue at a high rate for several years. Semiconductor executives interviewed agreed that the Chinese semiconductor market will continue to grow at a much faster rate than the worldwide rate for at least the next five years. We believe it can happen only if worldwide electronics systems production continues to shift to China, but that might be deterred (or prevented) by the emergence of lower-cost, competitive locations; increases in the cost of logistics; increasing environmental regulations and/or costs; or intellectual property protection concerns.

Most major semiconductor companies need to improve their position in China if they want to continue to capture new demand growth. As pointed out earlier, nearly all demand growth is in China, yet we found that 36 of the top 70 suppliers to the worldwide semiconductor market had below-average shares of the Chinese market in 2005.

Despite China's substantial demand for chips, no Chinese-branded companies ranked in the top 70 chip suppliers to China in 2005. Each of the top 10 suppliers to China exceeded $1 billion in sales in 2005. By contrast, the top Chinese semiconductor company in 2005 was Zhuhai Actions Semiconductor Co., Ltd., which had $155 million in sales. Two of the top three, as well as other Chinese semiconductor companies that focused on addressing niche markets by using international standards, achieved significantly above-average growth. However, the companies that addressed unique Chinese standards did not achieve the same level of growth.

The largest Chinese semiconductor manufacturers grew only half as fast as the Chinese industry did in 2005. The top 50 Chinese semiconductor manufacturers reporting revenues in both 2004 and 2005 grew at an average rate of 18 percent compared with China's industry growth of 35 percent.

China's integrated circuit consumption/production gap increased by the greatest amount during 2005 and reached a new peak of $38.3 billion for the year. That gap, the difference between IC consumption and IC industry revenues, has now grown from $5.9 billion in 1999 to $38.3 billion in 2005, and Chinese authorities expect that it will continue to increase through at least 2010. It provides continuing motivation for the Chinese government's initiatives to increase indigenous production.

Unlike the previous year, demand in 2005 for semiconductors for products made in China for export increased faster than domestic demand. Chip consumption for export grew 36 percent and for domestic use grew 16 percent.

The Chinese domestic semiconductor industry was even less concentrated in 2005 than in the previous year. The top 50 Chinese semiconductor manufacturers in 2005 accounted for only 46 percent of semiconductor industry revenue, down from 49 percent in 2004.

The Chinese government has scaled back its plans to foster the development of a major indigenous integrated device manufacturer (IDM) and to increase 300mm wafer fab capacity. Previously, Hua Hong Semiconductor International had been anticipating $400 million to $500 million in funding from the government for a 300mm wafer fab as part of a larger vision of transforming Hua Hong Group into an international-caliber IDM, according to *EE Times.* Current plans are for the expansion of existing 200mm capacity only at the company, but a Chinese Semiconductor Industry Association (CSIA) official confirmed the government still hopes the country will have several big IDMs; Hua Hong is one of them.

Influxes of used equipment could increase the likelihood of greater-than-expected downward-pricing pressure. The Semiconductor Equipment and Materials International association estimated that used equipment represented more than 20 percent of the Chinese semiconductor equipment market in 2005 and will continue to average more than 20 percent for the next three years. Equipment from many of the fabs that were shut down elsewhere in the world was relocated to China. Since the equipment is for mature or lagging technology, the fabs installing the used equipment can compete only on price.

Provincial governments continue to possess the potential for noneconomic investment in plant capacity. Recently announced investments in two new wafer fabrication plants by the Wuhan (Hubei province) and Chengdu (Sichuan province) city governments show that competition between provincial governments could result in plant investments that would then contribute to excess capacity worldwide.

Comparisons between Taiwan and China and the concentration of plant capacity in greater China are often overlooked. During 2005, Taiwan's semiconductor market increased by only 8 percent to $18 billion. In spite of this, greater China constituted 33 percent of the entire $227 billion worldwide market for semiconductors in 2005.

Recommendations

The following recommendations provide some initial guidance on the basis of our current findings. These recommendations should be considered in addition to those published in our previous reports on this topic. Those previous recommendations included steps for intellectual property protection, risk assessment, and contingency planning.

Reassess company presence in China and take steps to increase business development efforts in China if benchmarked with lower-than-average sales there. As noted, 90 percent of worldwide net growth in semiconductor consumption in 2005 occurred in China. Many new opportunities for serving the worldwide market are emerging inside China.

Use a range of different channels to gain access to the market. Chinese foundries and other local participants in the supply chain should be better able to connect multinationals to sources of local demand.

Place packaging, assembly, and test facilities near electronics manufacturing services, original design manufacturer, and original equipment manufacturer companies. The supply chain continues its process of integrating in these areas.

Design to specific requirements of the local market. Successful Chinese fabless companies have seized the opportunity evident in low-cost consumer electronics and communications niches that meet international standards.

Monitor and evaluate the potential to take advantage of successful unique Chinese standards. Some proposed Chinese standards, if successful, may provide more effective solutions than do accepted international standards for specific developing-country environments that have large potential markets.

Use local foundries to gain pricing leverage. Chinese foundries may provide a lower-cost alternative for some product categories.

Consider transferring mature product lines to extend the competitiveness of those lines. First movers have used this strategy successfully.

Expand a product line by rebranding products for the Chinese and other markets. A local entity could take care of the development effort.

Discrete device companies should preempt market share losses by participating actively in the Chinese market. Chinese companies are competing most effectively in the discrete area, and they could soon be gaining the scale, qualifications, and recognition necessary to grow into potential worldwide competitors.

Explore partnering opportunities with Chinese manufacturing companies. Many companies inside China have underutilized plants and equipment.

Explore partnering opportunities with Chinese design companies as a strategy to tackle the local market. The vast majority of design companies are small, and some of them are focused on domestic opportunities that foreign companies have overlooked. Design companies can bring considerable local market intelligence and relationships to bear on a Chinese market initiative.

Seize new opportunities that are evident from shifts in the competitive landscape on both the demand and supply sides. These may not have been observed or responded to by the industry at large. For example, the growth of domestic original equipment manufacturers (OEMs) is a clear opportunity that may not have been fully assessed or addressed by foreign chip suppliers. Intelligence is scarce on Chinese supply-and-demand dynamics. High-growth Chinese semiconductor companies have found niches that could indicate other, similar niches that have not yet been exploited. Rapid growth in certain chip categories may indicate an underserved market. Similarly, rapid growth

by one or another original design manufacturer (ODM) or electronics manufacturing services (EMS) company may indicate tightening of supply and a related opportunity.

Invest in industry disaggregation within the context of the Chinese market opportunity. China is a prime indicator of the continuing strong growth of the fabless/foundry business model, intellectual property (IP)-only companies, and semiconductor assembly and test services (SATS). Focus investment in these newer, more flexible, and less capital-intensive approaches to doing business.

Monitor the status of Taiwan with an eye toward new market risks and opportunities in China. Taiwan appeared more open in 2006 toward loosening restrictions somewhat on semiconductor-related trade with China. Accordingly, Taiwanese companies will increase their presence in China, and their supply chains will follow suit.

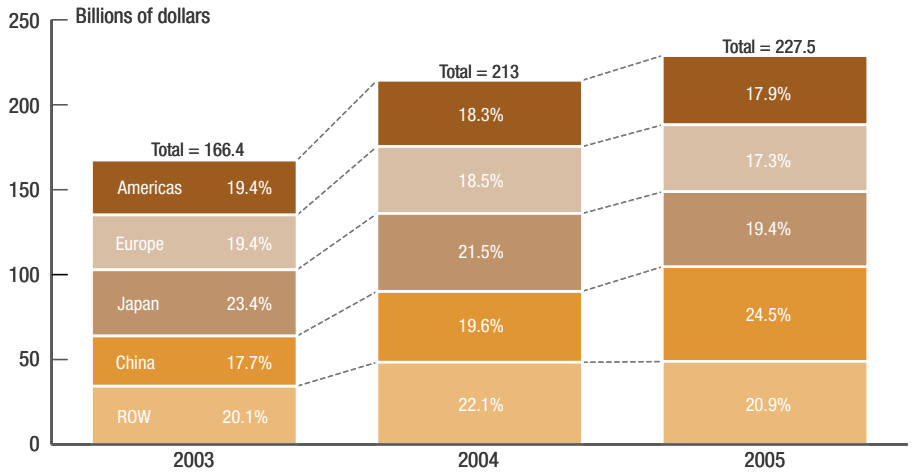
Remember the need to diversify manufacturing by location to reduce risk. Greater China had 56 percent of all fab capacity under construction in 2005.

The Semiconductor Market in China

Overall Consumption

In 2005, China became the largest single semiconductor market in the world, gaining a nearly 5 percent share from its 2004 levels to account for more than 24 percent of the worldwide share. (See Figure 1.) This increase accounted for slightly more than 90 percent of worldwide net growth. As in prior years, China's semiconductor market growth can be attributed to the continuing shift of worldwide electronics systems production to China. Electronics systems production in China increased by 18 percent in 2005—more than three times the worldwide growth. At the same time, the semiconductor content of China's electronics systems production also increased, to 27 percent—up from 24 percent in 2004. In 2005, China's share of the worldwide semiconductor market surpassed Japan's share for the first time, having already exceeded the Americas and Europe in 2004.

Figure 1: Worldwide Semiconductor Market by Region, 2003–2005



Source: CCID, SIA, 2006

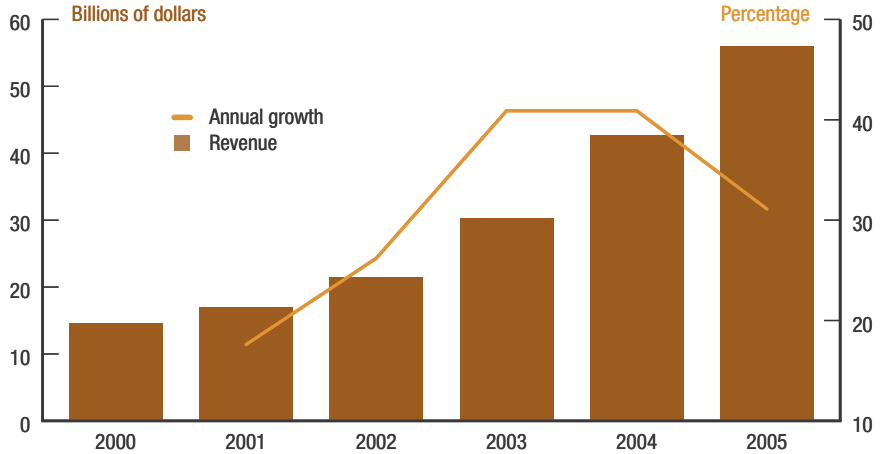
Worldwide semiconductor consumption growth slowed in 2005, declining from 28 percent in 2004 to 7 percent in 2005. In contrast, although China's own growth rate also declined—from 41 percent to 31 percent—it represented a new market peak of $56 billion. (See Figure 2 on page 8.) Many industry executives expect the growth of the Chinese semiconductor market to continue to outpace the worldwide average during the next five years. Chinese authorities estimate that by 2010 the Chinese semiconductor market could exceed a 33 percent share of the forecasted $363 billion worldwide total.

All of the semiconductor industry participants in China we interviewed for this report believe that both the Chinese semiconductor market and industry will continue to grow at twice or more than twice the worldwide average rate. However, this forecast could be an example of simply extrapolating the current industry and market trends that have misled the worldwide industry in the past.

Today, the worldwide IC market is forecast to grow at a compound annual growth rate (CAGR) of 9.4 percent from 2005 to 2010. There is considerable spread between the two leading local forecasts for the growth of China's IC market, with the China Center for Information Industry Development (CCID) Consulting forecasting a 30 percent CAGR; and the Chinese Semiconductor Industry Association (CSIA), a more conservative 17 percent CAGR. If the CSIA forecast is realized, it would mean that China would account for slightly more than half of the whole increase in the worldwide IC market from 2005 to 2010. If the more aggressive CCID forecast is realized, it would mean that China's IC market would have grown at the expense of the IC market in other countries from 2005 to 2010.

Electronic systems production has become a very low-margin activity that is especially cost and time-to-market sensitive. Production has been shifting to China in order to take advantage of China's basic business model: a low-cost producer of goods designed abroad that consist largely of imported components. The goods are assembled by an inexpensive labor force working in factories facing questionable environmental controls.

Figure 2: China's Semiconductor Market Growth, 2000–2005



Market reporting has changed since 2003, and optical semiconductors are now included as part of the discrete device segment, which along with integrated circuits make up the total semiconductor market.
Source: CCID, SIA, 2004–2006

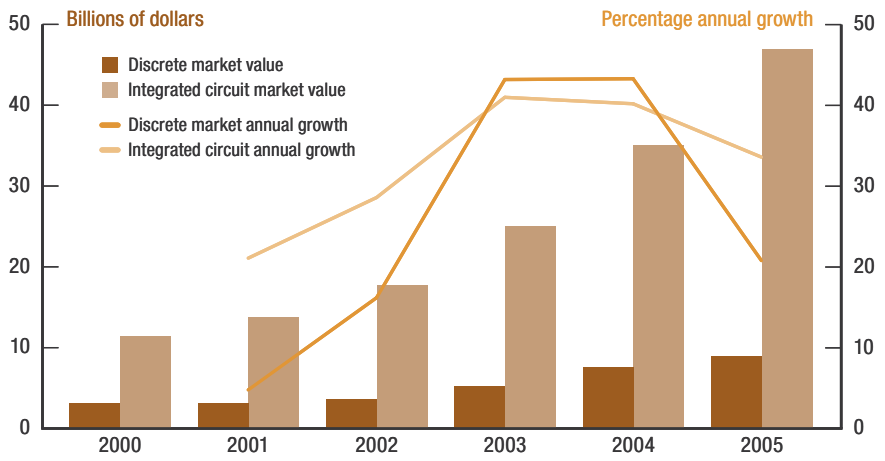
Whether China can continue to maintain this pace of IC market growth in future years can be achieved only if China's existing business model is sustained and if there is a continuing further shift of worldwide electronic systems production to China. At the same time, the Chinese government aspires to change this basic business model to evolve from a phase of quantitative expansion to one of qualitative improvements powered by technology innovations.

The Market for Integrated Circuits and Discrete Devices

In 2005, China's integrated circuit (IC) market increased 34 percent (almost $12 billion) from 2004 levels to reach $46.9 billion. (See Figure 3.) This increase represented the majority of the worldwide market growth, which totaled just less than $14 billion to reach $192.4 billion in 2005.

During that same period, China's discrete device market share increased 21 percent (more than $1 billion) to reach $9 billion. China's market value gain represented a greater increase than that of the worldwide market, which increased less than $1 billion to reach $35 billion in 2005. The disproportionate increase in the discrete device market in China is likely the result of the mix of electronics systems products that are being built in China and is the first example we have observed of the country's taking share away from other market participants.

Figure 3: China's IC and Discrete Market Growth, 2000–2005



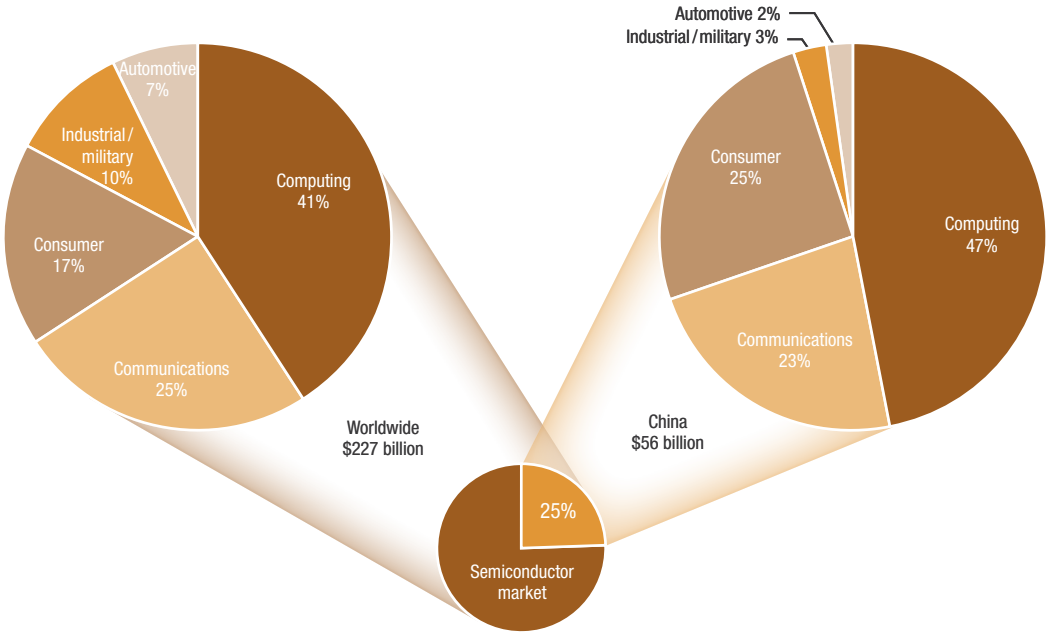
Market reporting has changed since 2003, and the definition of the discrete device market now includes optical semiconductors.
Source: CCID, CSIA, 2004–2006

Market reporting has changed since 2003 so that the definition of the discrete device market now includes optical semiconductors. The inclusion of actuator and photoelectronics components increased the reported Chinese discrete device market in 2005 by 12 percent and contributed 13 percent of the reported 2005 increase in that market. In making this reporting change, China was following a change in worldwide reporting made by World Semiconductor Trade Statistics (WSTS) and others.

Market by Application

Compared with the worldwide semiconductor market, the distribution of China's 2005 semiconductor consumption is somewhat more concentrated in the consumer and computing sectors and less in the communications, automotive, and industrial/military sectors. China's consumer sector consumption increased by 4 percent in 2005, while its computing and communications sectors decreased by 2 percent each. Low-volume industrial/military chip consumption remained concentrated in Europe, Japan, and the United States. (See Figure 4.)

Figure 4: China Compared with Worldwide Semiconductor Market by Application, 2005

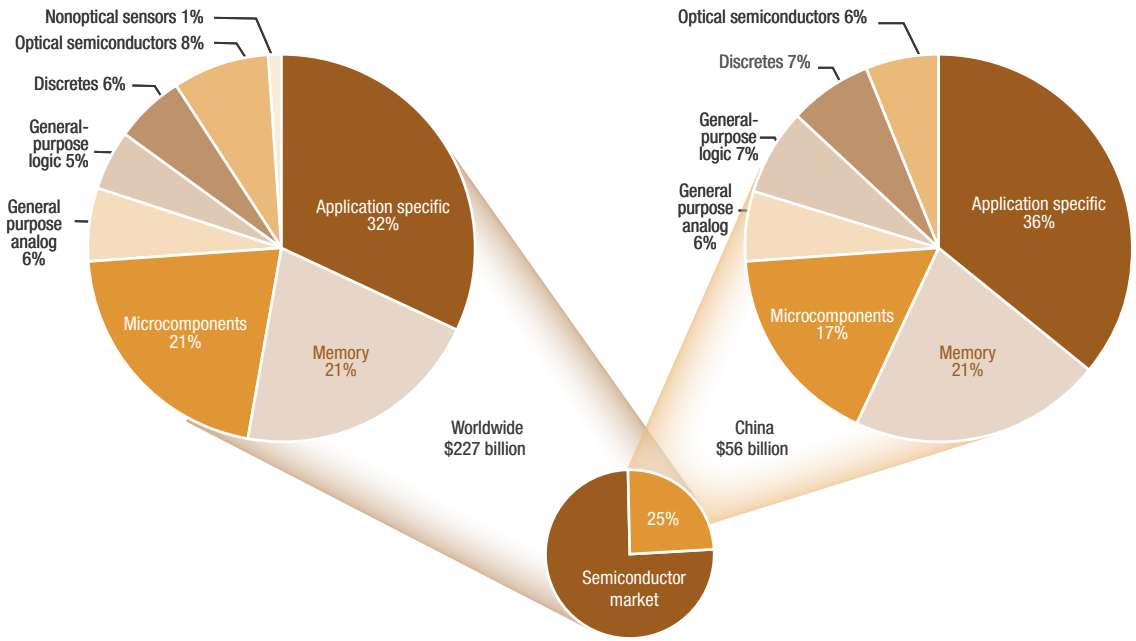


Source: CCID, Gartner Dataquest, 2006

Market by Device Type

China's semiconductor market in 2005 remained somewhat more concentrated in the application-specific and general-purpose logic sectors than in the worldwide market. As a result of systems production demand in China for consumer and computing products, China's market became slightly more concentrated in the discrete sector. At the same time, the 2005 Chinese semiconductor market remained less concentrated in the microcomponents sector. (See Figure 5.)

Figure 5: China Compared with Worldwide Semiconductor Market by Device, 2005



Source: CCID, Gartner Dataquest, 2006

Table 1: Chinese Semiconductor Companies by Revenue, 2005

Rank		Company	Revenue in 100 million RMB			Sector
2004	2005		2004	2005	Change (%)	
4	1	Zhuhai Actions Semiconductor Co., Ltd.	4.60	12.58	173.5	Design (Fabless)
1	2	Wuxi China Resources Microelectronics Co., Ltd.	11.09	12.12	9.3	IDM/Discrete
6	3	Beijing Vimicro Co., Ltd.	4.16	7.79	87.3	Design (Fabless)
7	4	Jilin Huaxing Electronics Group Co., Ltd.	4.12	6.07	47.3	Discrete
3	5	Hangzhou Silan Microelectronics Co., Ltd.	5.09	6.06	19.1	Design (Fabless)
2	6	Datang Microelectronics Technology Co., Ltd.	7.50	5.72	-23.7	Design (Fabless)
	7	Shenzhen ZTE Microelectronics Technology Co., Ltd.	1.44	5.71	296.5	Design (Fabless)
8	8	GOOD-ARK (Suzhou) Electronics Co., Ltd.	3.75	5.52	47.2	Discrete
19	9	Shangahi Hua Hong IC Design Co., Ltd.	2.07	3.73	80.2	Design (Fabless)
11	10	Tianjin Zhonghuan Semicondutor Co., Ltd.	3.03	3.44	13.5	Discrete
	11	Beijing Huada Electronics Design Co., Ltd.	1.82	3.17	73.8	Design (Fabless)
	12	Shenzhen Shenai Semiconductor Co., Ltd.	2.45	3.09	26.1	Discrete
12	13	Shanghai Belling Co., Ltd.	2.90	2.94	1.4	IDM/Foundry
16	14	Hangzhou Youwang Electronics Co., Ltd.	2.47	2.51	1.6	Design (Fabless)
15	15	Shaoxing Chip-Valley Technology Co., Ltd.	2.53	2.33	-7.9	Design (Fabless)
	16	Beijing Tsinghua Tongfang Microelectronics Co., Ltd.	0.83	2.32	179.5	Design (Fabless)
17	17	Wuxi China Resources Semico Co., Ltd.	2.28	2.25	-1.3	Design (Fabless)
	18	Fongshan Lanjian Electronics Co., Ltd.	1.98	2.23	12.6	Discrete
	19	Yangzhou Jinglai Semiconductor (Group) Co., Ltd.	2.09	2.14	2.4	Discrete
24	20	Shanghai Fudan Microelectronics Co., Ltd.	1.33	2.11	58.6	Design (Fabless)
	21	Spreadtrum Communications Inc.	1.32	2.08	57.6	Design (Fabless)
	22	CECT (55th Research Institute)		2.03		Discrete
	23	Haier (Beijing) IC Design Co., Ltd.	1.57	2.01	28.0	Design (Fabless)
	24	Shantou Huashan Electronics Device Co., Ltd.	2.08	1.99	-4.3	Discrete
	25	Jingnan Jingheng Co., Ltd.	1.88	1.99	5.9	Discrete
21	26	Beijing Sigma Microelectronics Stock Co., Ltd.	1.74	1.94	11.5	Design (Fabless)
18	27	Huayue Microelectronics Co., Ltd.	2.10	1.91	-9.0	IDM
	28	Shenzhen State Microelectronics Co., Ltd.	1.53	1.75	14.4	Design (Fabless)
	29	Ningbo Mingxin Microelectronics Co., Ltd.		1.63		Discrete
	30	BLX IC Design Corporation Ltd.		NA		Design (Fabless)

Chinese Companies

Revenue in millions of dollars		
2004	2005	Reference
56	155	CCID 05-06 & FSA
134	150	CCID 05-06
51	95	CCID 05-06, FSA & PwC
50	75	CCID 05-06
61	75	CCID 05-06 & FSA
91	71	CCID 05-06
17	70	CCID 05-06
45	68	CCID 05-06
25	46	CCID 05-06
37	42	CCID 05-06
22	39	CCID 05-06, FSA & PwC
30	38	CCID 05-06
35	36	CCID 05-06
30	31	CCID 05-06
31	29	CCID 05-06
10	29	CCID 05-06
28	28	CCID 05-06
24	28	CCID 05-06
25	26	CCID 05-06
16	26	FSA & PwC
16	26	CCID 05-06
0	25	CCID 05-06
19	25	CCID 05-06
25	25	CCID 05-06
23	25	CCID 05-06
21	24	CCID 05-06
25	24	CCID 05-06
18	22	CCID 05-06
	20	CCID 05-06
		MPR

Table 1 lists the Chinese semiconductor companies that have the largest 2005 revenue, the threshold of which was $20 million. The listing also includes BLX IC Design, because of its significant role in the development of China's first families of microprocessors, Godson I and Godson II.

By definition, the companies on the list are the largest indigenous Chinese companies that design, manufacture (or have manufactured), market, and sell semiconductor devices; they do not include foundries or packaging and testing companies. As such, the companies included in our ranking should also be included in the semiconductor market share reports compiled by industry analysts, yet many companies continue to be overlooked.

More than half of the companies on the PricewaterhouseCoopers list are missing from other industry rankings. For example, only 14 of the companies were included in third-party research firm Gartner Dataquest's database entitled Top Companies (ALL) Revenues from Shipments of Total Semiconductor—Worldwide (Millions of $US), which ranked 227 companies by their 2005 revenue. The companies at the bottom of Gartner's list had less than $10 million in revenue, yet Wuxi China Resources Microelectronics, the second-largest company on the PricewaterhouseCoopers list with $150 million in revenue, was omitted from the Gartner ranking because of an oversight. If Wuxi had been included, it would have ranked 139th among worldwide semiconductor companies. Nevertheless, industry awareness of Chinese semiconductor companies has increased somewhat since 2004, when only 9 of the top 26 companies were included in a similar industry database.

PricewaterhouseCoopers' 2004 ranking of the largest Chinese semiconductor companies had a revenue threshold of $15 million and included 25 companies, compared with the 30 on this year's list. This year's ranking included 12 new Chinese semiconductor companies. The most significant new addition was Shenzhen ZTE Microelectronics Technology, a design (fabless) company that tripled its revenue to $70 million in 2005 via signifi-

cant design wins. The company specializes in special-purpose communications and large-scale IC devices for domestic systems original equipment manufacturers (OEMs).

Two other companies on the PricewaterhouseCoopers list achieved some worldwide notice during 2005: Actions Semiconductor and Beijing Vimicro. Both completed successful NASDAQ initial public offerings and achieved noticeable penetration in focused market niches. Actions Semiconductor gained a 30 percent share of the worldwide market for the non-iPod MP3 player system-on-a-chip, and Vimicro gained a significant share of the PC video camera chip market.

The combined 2005 revenue of the 30 companies on the list was $1.4 billion, representing less than 1 percent of the worldwide industry. These top companies together constitute 51 percent of the Chinese IC design sector, 5 percent of the discrete sector, 7 percent of the IC manufacturing sector, and 34 percent of the IC integrated device manufacturer subsector, which includes foundry revenue.

Suppliers to the Chinese Market

For the largest semiconductor suppliers to the Chinese market, sales increased by 29 percent—somewhat less than the growth of the overall Chinese semiconductor market. Table 2 lists the suppliers that have the largest sales revenue from the Chinese market. Together these 15 suppliers had a total 49 percent share of the Chinese market in 2005. In comparison, the 15 suppliers that had the largest sales to the worldwide market had a total 58 percent share of the worldwide market in 2005.

All of the largest suppliers to the Chinese market were international semiconductor companies and not indigenous Chinese companies. According to Gartner Dataquest, no Chinese companies (or brands) were among the top 70 suppliers to the Chinese semiconductor market in 2005. Even if the Chinese semiconductor companies that were missing from the international rankings sold all of their output within China, no Chinese semiconductor company would be among the top 45 suppliers.

The majority of the suppliers to the Chinese market also rank among the largest suppliers in the worldwide semiconductor market. Only ATI Technology, Broadcom, and NVIDIA were not among the 15 largest suppliers to the worldwide market. Of the 15 largest worldwide suppliers, Matsushita, NEC Electronics, and Sony were not among the 15 largest suppliers to the Chinese market.

Table 2: Semiconductor Suppliers to the Chinese Market 2004–2005

Rank			Revenue in millions of dollars			Market share %	
2004	2005	Company	2004	2005	Change %	2005	Reference
1	1	Intel	5,823	7,750	33	13.8	CCID
4	2	Samsung Electronics	1,674	2,930	75	5.2	CCID
2	3	Texas Instruments	1,849	2,270	23	4.1	iS
5	4	Philips Semiconductor	1,657	1,872	13	3.3	GDQ
3	5	STMicroelectronics	1,746	1,837	5	3.3	GDQ
7	6	Toshiba	1,426	1,760	23	3.1	CCID
8	7	Hynix Semiconductor	1,136	1,750	54	3.1	CCID
6	8	Infineon Technologies	1,445	1,740	20	3.1	CCID
9	9	Freescale Semiconductor	1,070	1,350	26	2.4	CCID
10	10	AMD	843	1,140	35	2.0	CCID
Subtotal for top 10			18,669	24,399	31	43.6	
13	11	ATI Technology	617	729	18	1.3	GDQ
11	12	Micron Technology	673	704	5	1.3	iS
14	13	Broadcom	502	690	37	1.2	GDQ
12	14	Renesas Technology	630	620	-2	1.1	GDQ
15	15	NVIDIA	327	541	65	1.0	GDQ
Subtotal for next 5			2,749	3,284	19	5.9	
Total for all 15			21,418	27,683	29	49.4	

Domestic Consumption and the Chinese Export Market

The Chinese semiconductor market has two distinct parts: the domestic market and the much larger export market. More than 64 percent of the semiconductors consumed in China during 2005 were used in components of finished products assembled in China and exported for sale in other countries. Table 3 on page 16 shows a breakdown by segment. During 2005, the consumption of semiconductors in China for export products increased by 36 percent, and domestic product semiconductor consumption increased by 16 percent to $21 billion. The consumer sector experienced the largest consumption gains for both domestic and export products. Since at least 2003, China's domestic consumption of semiconductors has exceeded its semiconductor industry revenue,

creating a production-consumption gap. (For a detailed discussion on that gap, see page 50.) The continued growth of domestic consumption provides another reason for the Chinese government to increase domestic semiconductor production.

Table 3: China's Semiconductor Exports by Segment, 2004–2005

	Total sales		Export sales			
Market segment	2004	2005	2004	% of total	2005	% of total
Data-processing	22.9	28	11.1	49	14.6	52
Communications	11.8	13.9	7.8	66	10.0	72
Consumer	9.7	14.7	7.7	79	11.5	78
Automotive	0.9	1.3	0.7	75	1.0	75
Totals	45.3	57.9	27.3	60	37.1	64

Source: Gartner Dataquest, PricewaterhouseCoopers, 2006 *In billions of dollars*

The values shown in Table 3 may be larger than the values of semiconductor devices sold to customers in China, because some customers—due to supply chain considerations such as control of key inventory items and intellectual property protection—will buy semiconductor devices outside of China and transship them to China for use and consumption. Estimates suggest that in 2005, the total consumption market in China could have exceeded the sales to the market by as much as one-third.

The size, growth, and makeup of this total consumption market constitute China's most significant current impact on the semiconductor industry. Every company in the semiconductor value chain should evaluate whether it is gaining, maintaining, or losing a proportionate share of this crucial market. PricewaterhouseCoopers performed an analysis of the top 70 international semiconductor companies to determine the relative share of their worldwide sales to China. Our analysis revealed that in 2005, 10 companies had an above average (more than 25 percent) share of worldwide sales to China, 24 companies had an average (15 to 25 percent) share, and 36 companies had a below average (less than 15 percent) share of worldwide sales to China.

The companies with an average share of 2005 worldwide sales from China had the best results in 2005. Their worldwide sales grew by 9.6 percent, and they reported average net revenues of 15.9 percent of sales. The companies with a below average share of sales from China had noticeably poorer results. Their worldwide sales grew by only 2.5 percent, and they reported average net revenues of 9.2 percent of sales. The com-

panies with an above-average share of sales from China had mixed but somewhat better results. Their worldwide sales grew by 4.8 percent, and they reported average net revenues of 8.9 percent.

Domestic OEM Buying Power

China's 10 largest OEMs had a more than 49 percent increase in their combined revenue during 2005 to reach a record total of $55.2 billion. (See Table 4.) Assuming the semiconductor content of their products was 27 percent (the average for all of China's electronics systems production in 2005), these 10 Chinese OEMs were responsible for semiconductor consumption of $14.7 billion, or 26 percent of China's total semiconductor market.

Table 4: Chinese OEMs by Revenue, 2005

Rank			Revenue in millions of dollars		
2004	2005	Name of Company	2004	2005	Change %
4	1	Lenovo (with IBM PC)	2,938	14,698	400.3
1	2	Haier Group	12,991	13,629	4.9
6	3	Huawei	4,500	7,400	64.4
2	4	TCL/ALC/TTE	4,226	6,118	44.8
3	5	Hisense Group	3,298	3,354	1.7
7	6	Midea Group	2,319	2,694	16.2
5	7	ZTE Corporation	2,563	2,677	4.4
9	8	Changhong	1,419	2,060	45.2
8	9	Konka Group	1,612	1,320	-18.1
10	10	Skyworth	1,113	1,274	14.5
		Totals	36,979	55,224	49.3

Source: iSupply, 2006

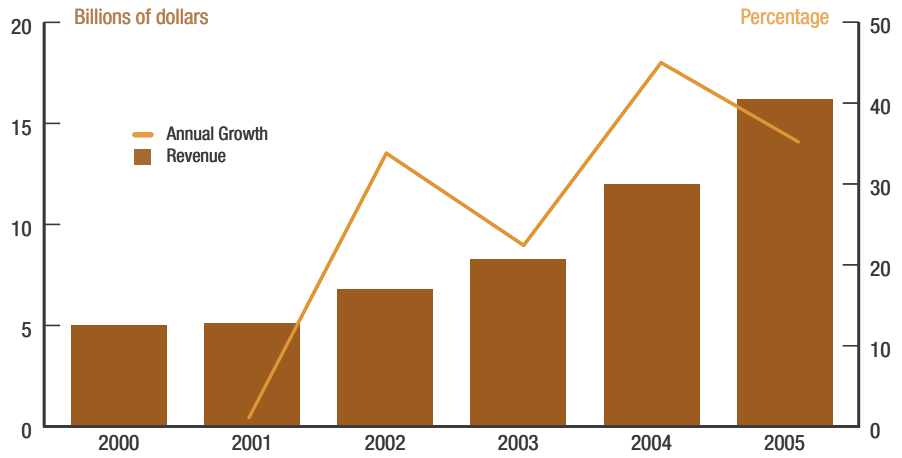
These leading Chinese OEMs need to purchase a significant number of semiconductor devices and could be important customers for many international semiconductor companies intending to participate in the continuing growth of the Chinese semiconductor market. The strategies of these OEMs could affect the design and sales operations of several international semiconductor companies.

The Semiconductor Industry in China

Production Growth

China's reported semiconductor production revenue increased by 35 percent in 2005 to $16.2 billion, notably larger than the 2005 worldwide increase of 7 percent. (See Figure 6.) More than 3 percent of this increase is due to China's revaluation of its currency. China's semiconductor production revenue, as reported, represented 7 percent of worldwide semiconductor industry revenue for 2005, up from 5 percent in 2004.

Figure 6: China's Semiconductor Industry Revenue and Growth, 2000–2005



Source: CCID, CSIA, PwC, 2004–2006

The growth of China's semiconductor industry remains more concentrated in discrete devices. In 2005, discrete devices accounted for 47 percent of China's reported semiconductor industry revenue and for 51 percent of its 2005 increase. However, the discrete device sector remains generally less recognized in China because of the continued government focus and industry media attention placed on the integrated circuit (IC) sectors since 2000.

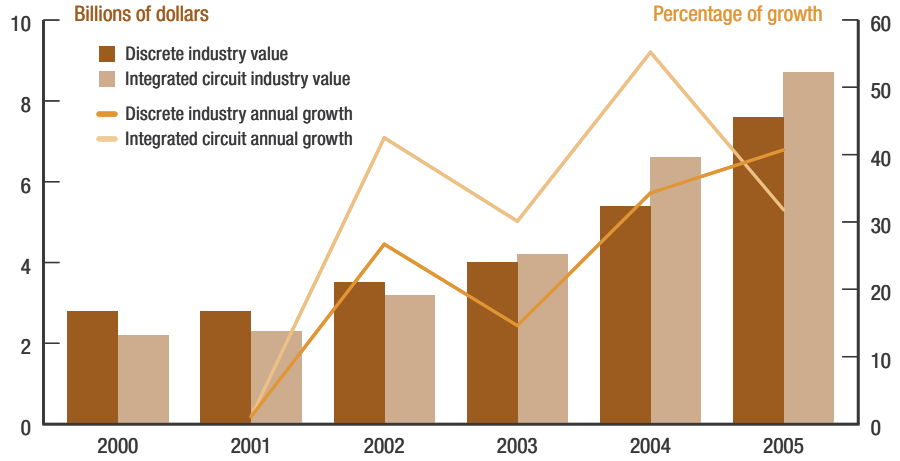
Because of the possibility of overstatement or double counting, a comparison between China's semiconductor industry revenue and the sum of worldwide semiconductor device sales, plus foundry and semiconductor assembly and test services (SATS) revenue, may provide a more representative measurement of China's impact on the semiconductor industry. That comparison indicates that China's semiconductor industry accounted for 6 percent of the worldwide industry in 2005, up from 5 percent in 2004 and 2 percent in 2000. However, even that measurement is probably overstated because some integrated device manufacturers

(IDMs) use the sale/buy-back or die-included price model for semiconductor packaging, assembly, and test (SPA&T) transfer pricing. For an explanation of how such double counting could occur, see “Probable Double Counting: A Hypothetical Example,” on page 61.

Discrete and IC Growth

China’s reported discrete device industry revenue increased 41 percent in 2005 to $7.6 billion, representing almost 22 percent of worldwide discrete device revenue. (See Figure 7.) China’s revaluation of its currency during 2005 accounts for 3 percent of the increase. Without the currency revaluation effect, China’s discrete device industry grew by $2.0 billion in 2005, while the reported worldwide industry grew by only $400 million. This data suggests that $1.6 billion of discrete device production shifted from other locations to China in 2005—a 5 percent shift in a single year. Taking into account that since 2003 the discrete device industry definition has been expanded to include all semiconductor products other than ICs, the shift could represent as much as 10 percent of worldwide traditional discrete production.

Figure 7: China’s Discrete and IC Industry Revenue and Growth, 2000–2005



Source: CCID, CSIA, PwC, 2004–2006

Our analysis shows that China’s discrete device semiconductor industry is more significant than previously recognized. For example, the World Semiconductor Trade Statistics (WSTS) organization, which is made up of 70 worldwide semiconductor organizations, does not have the participa-

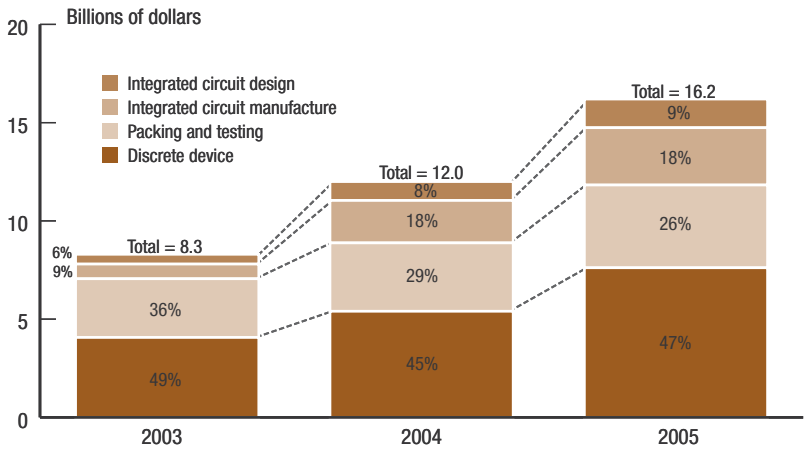
tion of any Chinese semiconductor companies. Therefore, it could be missing significant discrete device demand or consumption that is wholly satisfied by local Chinese companies. As a result, multinational semiconductor companies may be under-reporting the size of the worldwide discrete and total semiconductor market. At the same time, this lack of market-size knowledge may mean that multinational semiconductor companies are unaware of potential competitors that are developing in China.

China's reported 2005 IC industry revenue increased by 32 percent to $8.7 billion. Although China's increase was substantially more than the worldwide average of 9 percent, China's 2005 IC industry production accounted for only 5 percent of worldwide revenue.

Industry by Sector

The distribution of China's semiconductor industry continued to change in 2005 as a result of the above-average growth of the IC design and discrete device sectors. The discrete device sector, which includes discrete packaging, testing, and design as well as manufacturing, gained 2 percent of industry share to reach 47 percent and remained the largest sector of China's semiconductor industry. (See Figure 8.) IC design was the fastest growing sector, but because of its smaller size, gained only 1 percent of industry share to reach 9 percent. IC manufacturing, which includes the IC foundries, grew by 32 percent—less than China's industry average—but remained at 18 percent of China's semiconductor industry. IC packaging and testing production revenue increased by 25 percent in 2005 but declined to a 26 percent overall share of China's semiconductor industry.

Figure 8: China's Semiconductor Industry by Sector, 2003–2005



Source: CCID, CSIA, PwC, 2004–2006

China's IC design and IC manufacturing sectors were forecast to grow faster than China's overall semiconductor industry. However, China's IC industry revenue growth to more than twice its discrete device industry revenue will not be likely until 2010. PricewaterhouseCoopers' 2004 report assumed continuing levels of growth, and it forecast the doubling would occur in 2009. The change reflects the relative slowing in growth of the IC manufacturing sector and the surprising strength of the discrete device sector.

Wafer Fab Capacity

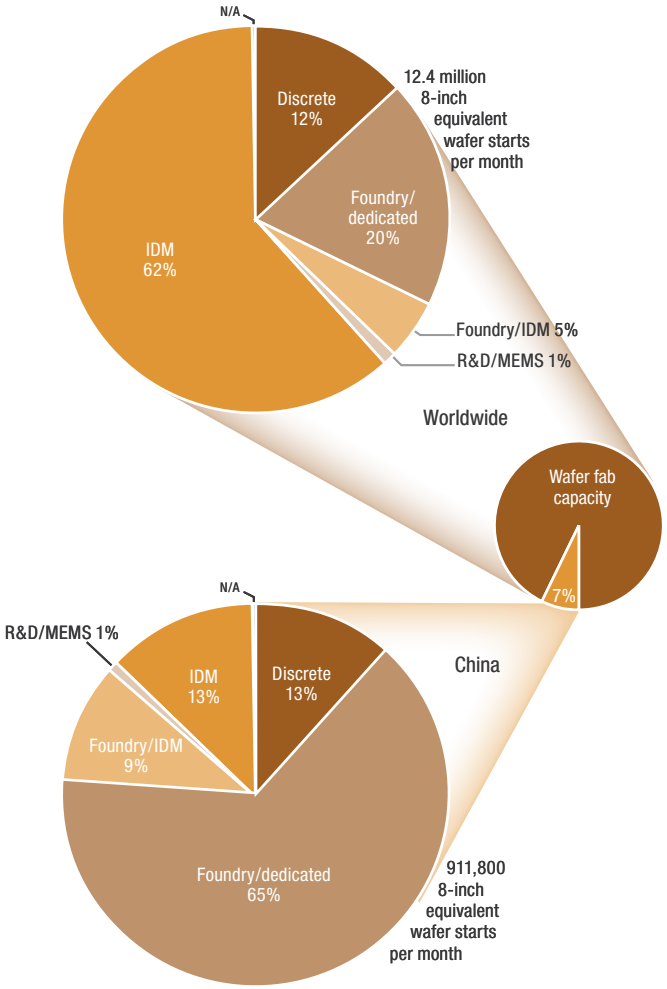
Figure 9 shows a comparison of China's current wafer capacity and worldwide capacity. In 2005, China had 75 wafer fabrication plants in production. Using its current capabilities, China could increase its share of total worldwide semiconductor wafer production from the 2 percent realized in 2003 to more than 7 percent by 2008. It could accomplish this increase by fully equipping and ramping to full capacity at mature yields all of its existing wafer fabrication modules. Such development would more than triple China's share of worldwide wafer production from that of 2003 and represent a noteworthy long-term impact.

In 2004, China had 65 wafer fabrication plants in production and the capability to increase its share of total worldwide semiconductor wafer production to slightly less than 7 percent by 2007. Since 2003, China put into production a net of 15 additional wafer fabrication modules—an increase in potential capacity of 49 percent. China accounted for 13 percent of worldwide wafer fab capacity added during 2004 and 2005.

From a business model standpoint, China's current wafer fabrication capabilities are noticeably different from the worldwide capabilities. Foundry capacity dominates China's current capabilities. When fully equipped and ramped, more than 74 percent of China's current wafer fabrication capabilities will be dedicated to foundry production, compared with the worldwide 25 percent. Using these current capabilities, China could increase its share of worldwide foundry production to almost 23 percent by 2008.

The 13 percent of China's current wafer fab capacity dedicated to IC IDMs remains significantly less than the 62 percent of worldwide, which could be attributed to several factors: the timing of China's opening the semiconductor sector to foreign investments, an election to mimic the Taiwanese model, and the very weak market position of China's state-owned semiconductor companies. As of 2005, only five foreign IDMs with invested wafer fabrication capacity were in production in China: Hynix, NEC group, ON Semiconductor, STMicroelectronics, and Philips (ASMC and JiLin joint venture now known as NPX).

Figure 9: Current Wafer Fab Capacity Comparison, China and Worldwide



Source: World Fab Watch, 2006

WFW probability ≥ 1.0

Worldwide Fab Capacity Share

China had 19 new wafer plants under construction in 2005, representing 34 percent of the 56 new fab plants under construction worldwide but only 23 percent of worldwide new plant capacity. These plants included 10 facilities dedicated to foundry production, 5 for IDM production, 2 for discrete production, 1 for microelectromechanical systems (MEMS) production, and 1 that remained unknown. The new plants could further increase China's wafer fabrication capacity by 62 percent and represent 23 percent of the capacity of all wafer fabrication modules currently committed and under construction worldwide.

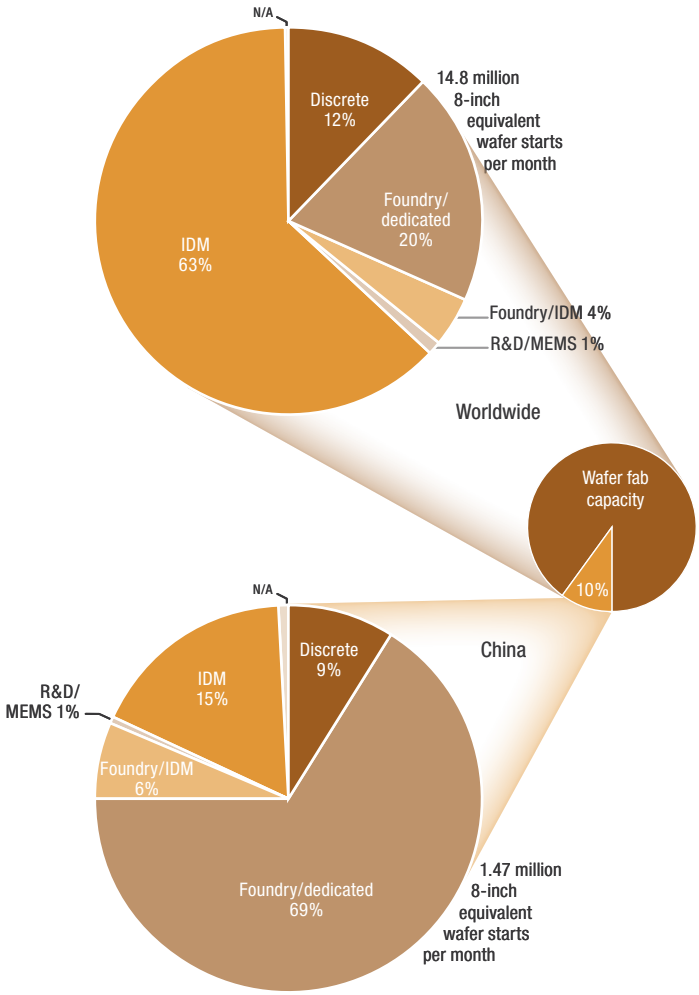
China's 2005 committed capabilities—plants in production plus plants under construction—could enable China to increase its share of total worldwide semiconductor wafer production from the less than 2 percent realized in 2003 to more than 10 percent by 2010. (See Figure 10.) Achieving this increase would require financing for completing the 19 wafer fabrication plants currently under construction and for fully equipping and ramping to full capacity at mature yields both the new plants and all of the existing wafer fabrication modules. China's share of worldwide wafer production could then increase by more than five times and have a significant impact on the semiconductor industry. As a result, China's share of worldwide foundry production could increase to more than 25 percent. At the same time, its share of wafer fab capacity dedicated to IC IDM production would be at 17 percent and account for only 3 percent of worldwide capacity.

In addition to the 94 wafer fabrication plants in production or under construction in China, 15 new plants were announced or planned in 2005. This represents 25 percent of the 59 new wafer fabrication plants announced or planned worldwide but only 17 percent of their equivalent capacity. If all of these additional new fabs were completed and ramped into full production at mature yields, China could increase its share of total worldwide semiconductor wafer production to more than 11 percent by 2013. This is slightly higher than the plans of a year ago and could have a further significant impact on the semiconductor industry.

While it is unlikely that all of the announced or planned wafer fab plants will be realized, this activity provides a measure of the current enthusiasm for the Chinese semiconductor industry. Only two 12-inch (300mm) fabs were included among these 15 additional announced or planned new fabs, along with three 6-inch (150mm) and nine 8-inch (200mm) fabs. The 8-inch fabs constitute 65 percent of this possible additional capacity. Most of the planned plants would be for foundry capacity, which amounted to 64 percent of the total in 2005; IC IDMs accounted for 24 percent of the total, and discretes made up 12 percent of the total.

Foreign companies would be involved with 7 of these additional wafer fabs, representing more than 57 percent of the possible additional capacity.

Figure 10: Current and Committed Wafer Fab Capacity Comparison, China and Worldwide



Source: World Fab Watch, 2006

WFW Probability ≤ 0.8

Capacity by Process Node

China's wafer fabrication capabilities in 2005 were somewhat bimodal but remain reasonably comparable with worldwide capabilities; the one exception is the leading-edge < 0.12µm node. China had 30 to 32 percent of capacity at the mature ≥ 0.4µm nodes, 20 percent in the midrange of < 0.4 to ≥ 0.16µm, a notable 28 percent at the < 0.16µm to ≥ 0.12µm node, and 20 percent at < 0.12µm node. In comparison, the worldwide capacity at each node is 25 percent, 20 percent, 16 percent, and 39 percent, respectively. (See Tables 5 and 6.)

Table 5: Comparison of Current Wafer Fab Capacity, 2005

	China capacity %		World capacity %	
Total	911.8		12,390.8	
By geometry				
≥ 0.7 µm	173.1	19	2,119.9	17
< 0.7 to ≥ 0.4 µm	103.0	11	1,016.3	8
< 0.4 to ≥ 0.3 µm	52.4	6	935.3	8
< 0.3 to ≥ 0.2 µm	89.6	10	1,014.8	8
< 0.2 to ≥ 0.16 µm	35.8	4	549.3	4
< 0.16 to ≥ 0.12 µm	253.0	28	1,934.5	16
< 0.12 µm	181.1	20	4,770.7	39
n/a	23.8	2	50.0	0
By wafer size				
≥ 4 inch	74.1	8	589.5	5
5 inch	57.4	6	785.4	6
6 inch	277.1	31	2,686.1	22
8 inch	413.0	45	5,329.5	43
12 inch	90.0	10	3,000.3	24

Capacity = 8-inch equivalent wafer starts per month in thousands
Source: SEMI World Fab Watch, 2006 *World Fab Watch probability > 1.0*

From a wafer-size standpoint, China's current capabilities are also reasonably comparable with worldwide capabilities, the exception being a dearth of 12-inch (300mm) capacity. Of the 58 300mm wafer fab modules

currently in production worldwide, only 2 are in China. A variety of geo-political reasons explain the low number, but the implication is that until at least 2009, wafer fab plants in other locations have the capabilities for retaining low-mix/high-volume/advanced technology (e.g., DRAM) wafer manufacturing cost leadership. After that time period, six additional 12-inch (300mm) wafer fabs have been committed in China, which, when completed, equipped, and fully ramped to full capacity at mature yields, will constitute 30 percent of China's wafer fab capacity and nearly 9 percent of worldwide 12-inch (300mm) capacity.

Table 6: Current and Committed Wafer Fab Capacity, 2005

	China capacity %		World capacity %	
Total	1,474.6		14,840.7	
By geometry				
≥ 0.7 µm	173.2	12	2,121.3	14
< 0.7 to ≥ 0.4 µm	103.0	7	1,020.3	7
< 0.4 to ≥ 0.3 µm	83.3	6	966.6	7
< 0.3 to ≥ 0.2 µm	177.6	12	1,122.9	8
< 0.2 to ≥ 0.16 µm	70.8	5	718.0	5
< 0.16 to ≥ 0.12 µm	349.3	24	2,118.2	14
< 0.12 µm	493.6	33	6,723.4	45
n/a	23.8	1	50.0	0
By wafer size				
≥ 4 inch	74.1	5	592.4	4
5 inch	57.4	4	785.4	5
6 inch	331.2	22	2,741.9	19
8 inch	573.0	39	5,618.2	38
12 inch	438.8	30	5,102.8	34

Capacity = 8-inch equivalent wafer starts per month in thousands
Source: SEMI World Fab Watch, 2006 *World Fab Watch probability > 0.8*

China has a greater than worldwide average concentration of 6-inch fab capacity. China currently has 22 such wafer fabs in production, which constitute 31 percent of its total capacity compared with a worldwide average of 22 percent.

Table 7: Chinese Semiconductor Manufacturers by Revenue, 2005

Rank				Revenue in 100 million RMB		
2004	2005	Company	Sector	2004	2005	Change (%)
2	1	SMIC	Foundry	80.7	95.0	17.7
1	2	Freescale (China) Electronics Ltd.	Packaging & Testing	81.2	64.6	-20.4
11	3	Shenzen STS Microelectronics Co., Ltd.	Discrete/Packaging & Testing	11.5	30.7	167.3
4	4	RF Micro Devices (Beijing) Co., Ltd. (RFMD)	Packaging & Testing	25.8	29.3	13.4
7	5	Jiangsu Changdian Electronics Technology Co., Ltd.	Discrete/Packaging & Testing	19.3	25.8	34.0
5	6	Renesas (Beijing & Suzhou) Co., Ltd.	Packaging & Testing	22.8	25.2	10.6
3	7	Shanghai Hua Hong NEC Electronics Co., Ltd.	Foundry	26.8	24.1	-10.0
6	8	Hejian Technology (Suzhou) Co., Ltd.	Foundry	20.0	21.7	8.5
29	9	Infineon Technologies (Suzhou & Wuxi) Co., Ltd.	Packaging & Testing	n/a	18.3	
8	10	Intel Products (Shanghai) Co., Ltd.	Packaging & Testing	16.0	18.2	13.8
16	11	Shanghai Matsushita Semiconductor Co., Ltd.	Packaging & Testing	8.6	17.9	108.4
9	12	Nantong Fujitsu Microelectronics Co., Ltd.	Packaging & Testing	14.5	17.6	21.6
10	13	Leshan Radio Co., Ltd.	Discrete	13.4	14.4	8.0
23	14	Zhuhai Actions Semiconductor Co., Ltd.	Design (Fabless)	4.6	12.6	173.5
13	15	Wuxi China Resources Microelectronics Co., Ltd.	IDM/Foundry/Discrete	11.1	12.1	9.3
	16	Leshan Phoenix Semiconductor Co., Ltd. (ON Semiconductor)	Discrete	n/a	11.6	
15	17	Shougang NEC Electronics Co., Ltd.	Foundry	9.0	11	22.1
	18	Samsung Electronics (Suzhou) Semiconductor Co., Ltd.	Packaging & Testing	n/a	9.8	
12	19	ASMC	Foundry	11.5	9.0	-21.9
17	20	STATS ChipPac (Shanghai) Co., Ltd.	Packaging & Testing	7.8	8.9	14.2
14	21	Shanghai Grace Semiconductor Manufacturing Co., Ltd.	Foundry	9.7	8.5	-11.9
26	22	Beijing Vimicro Co., Ltd.	Design (Fabless)	4.2	7.8	87.3
27	23	Jilin Huaxing Electronics Group Co., Ltd.	Discrete	4.1	6.1	47.3
22	24	Hangzhou Silan Microelectronics Co., Ltd.	Design (Fabless)	5.1	6.1	19.1
20	25	CSMC (Central Semiconductor Manufacturing Corp.)	Foundry	6.4	6.0	-6.2
21	26	Amkor Technology	Packaging & Testing	5.2	6	15.6
	27	Phillips Semiconductor (Suzhou) Co., Ltd.	Packaging & Testing	n/a	6.0	
18	28	Datang Microelectronics Technology Co., Ltd	Design (Fabless)	7.5	5.7	-23.7
	29	Shenzhen ZTE Microelectronics Technology Co., Ltd.	Design (Fabless)	1.4	5.7	296.5
30	30	GOOD-ARK (Suzhou) Electronics Co., Ltd.	Discrete	3.8	5.5	47.2
25	31	GAPT (Global Advanced Packaging Technology) Co., Ltd.	Packaging & Testing	4.3	5.1	20.0
33	32	FASL Suzhou Co., Ltd. (Spansion)	Packaging & Testing	3.0	4.4	45.2
39	33	Tianshui Huatian Microelectronics Co., Ltd.	Packaging & testing	2.7	4.3	58.5
37	34	Shanghai Simconix Electronics Co., Ltd.	Discrete	2.9	3.7	28.0
35	35	Toshiba Semiconductor (Wuxi) Co., Ltd.	Packaging & Testing	2.9	3.6	24.1
	36	TSMC	Foundry	n/a	3.6	
28	37	Shanghai BCD Semiconductor Manufacturing Co., Ltd.	Foundry	3.9	3.5	-11.2
34	38	Tianjin Zhonghuan Semicondutor Co., Ltd.	Discrete	3.0	3.4	13.5
24	39	Beijing Huada Electronics Design Co., Ltd.	Design (Fabless)	1.8	3.2	74.2
43	40	Shenzhen Shenai Semiconductor Co., Ltd.	Discrete	2.5	3.1	26.1
36	41	Shanghai Belling Co., Ltd.	IDM/Foundry	2.9	2.9	1.4
	42	Fairchild Semiconductor (Suzhou) Co., Ltd.	Packaging & Testing	1.7	2.5	46.5
42	43	Hangzhou Youwang Electronics Co., Ltd.	Design (Fabless)	2.5	2.5	1.6
46	44	Millennium Microtech (Shanghai) Co., Ltd.	Packaging & Testing	2.2	2.5	13.4
41	45	Shaoxing Chip-Valley Technology Co., Ltd.	Design (Fabless)	2.5	2.3	-7.9
	46	Beijing Tsinghua Tongfang Microelectronics, Co., Ltd.	Design (Fabless)	0.8	2.3	179.5
	47	National Semiconductor (Suzhou) Ltd.	Packaging & Testing	n/a	2.3	
45	48	Wuxi China Resources Semico Co., Ltd.	Design (Fabless)	2.3	2.3	-1.3
	49	Fongshan Lanjian Electronics Co., Ltd.	Discrete	2.0	2.2	12.6
	50	Yangzhou Jinglai Semiconductor (Group) Co., Ltd.	Discrete	n/a	2.1	

Revenue in millions of dollars		
2004	2005	Reference
975	1,172	CSIA 06 & PwC
981	797	CSIA 06 & CCID 05-06
139	379	CSIA 06 & CCID 05-06
312	361	CSIA 06 & CCID 05-06
233	318	CCID 05-06
276	311	CCID/PwC
324	298	CSIA 06 & CCID 05-06
242	268	CSIA 06 & CCID 05-06
	225	CCID/PwC
193	225	CSIA 06 & CCID 05-06
104	221	CSIA 06
175	217	CSIA 06
161	178	CCID 05-06
56	155	CSIA 06 & CCID 05-06
134	150	CCID/PwC
n/a	143	CSIA/PWC
109	136	CSIA 06 & CCID 05-06
n/a	121	CCID 05-06
139	111	CSIA 06 & CCID 05-06
94	110	CCID 05-06
117	105	CSIA 06 & CCID 05-06
51	95	CSIA/CCID/PWC
50	75	CCID 05-06
61	75	CSIA 06 & CCID 05-06
78	74	CSIA 06 & CCID 05-06
63	74	PwC
n/a	74	CCID 05-06
91	71	CSIA 06 & CCID 05-06
17	70	CCID 05-06
45	68	CCID5-06
51	63	CCID 05-06
36	54	CCID 05-06
33	53	CCID 05-06
35	46	PwC
35	45	CCID 05-06
n/a	44	PwC
48	43	CCID 05-06
37	42	CCID 05-06
22	39	CCID 05-06
30	38	CCID 05-06
35	36	CCID 05-06
21	31	CCID/PwC
30	31	CSIA 06 & CCID 05-06
26	30	CCID 05-06
31	29	CSIA 06 & CCID 05-06
10	29	CSIA 06 & CCID 05-06
n/a	29	PwC
28	28	CSIA 06 & CCID 05-06
24	28	CCID 05-06
n/a	26	CCID 05-06

The Top Chinese Semiconductor Manufacturers

Table 7 lists the 50 largest semiconductor manufacturers in China—those that reported 2005 revenue of $28 million or more. In PricewaterhouseCoopers' previous report, the listing used a revenue threshold of $25 million and contained 46 companies. In 2005, there were 52 companies that exceeded the $25 million revenue mark.

The combined reported 2005 revenue for the 50 largest semiconductor manufacturers in China was $7.4 billion, which represents 46 percent of China's total semiconductor industry revenue of $16.2 billion. China's industry is significantly less concentrated than the worldwide industry, in which the top 50 companies represent more than 80 percent of the total market. In PricewaterhouseCoopers' 2004 listing, the largest semiconductor companies in China represented 49 percent of total 2004 revenue. The decrease in representative share (from 49 percent to 46 percent) among the largest companies may be due to the increase in the number of manufacturing companies in China and may indicate that China's industry is undergoing continued dispersion.

The remaining 54 percent market share ($8.8 billion) could be accounted for in a number of ways. Given that at least 900 semiconductor manufacturing companies are in China, this data suggests that the remaining 850 companies could have had average 2005 revenue of $10.5 million each. Such a scenario seems unlikely given available information. Other explanations for the makeup of the remaining share are that some larger companies have not been reported or listed or that the number of smaller semiconductor companies is even greater than reported.

The table contains 10 new Chinese semiconductor manufacturers. The most significant of the new additions were companies that had not been correctly identified or reported in prior years: Leshan Phoenix Semiconductor Co., Ltd., Samsung Electronics (Suzhou) Semiconductor Co., Ltd., and Phillips Semiconductor (Suzhou) Co., Ltd. had 2005 revenue of $143 million, $121 million, and $71 million, respectively.

The combined revenue for the 43 companies with reported revenue for both 2004 and 2005 increased by 18 percent—significantly less than China's overall semiconductor industry growth of 35 percent. Although SMIC remained China's largest semiconductor manufacturer, its revenue growth of almost $200 million in 2005 represented only an 18 percent increase. Three of the five fastest growing companies were design (fabless) companies, while the other two were packaging and test companies. In 2005, China's largest foundry manufacturers had only relatively modest revenue growth—averaging just 9 percent, while its largest design (fabless) companies averaged a 45 percent increase. China's largest packaging and testing companies averaged an increase of 18 percent, while its largest discrete companies averaged a 22 percent increase.

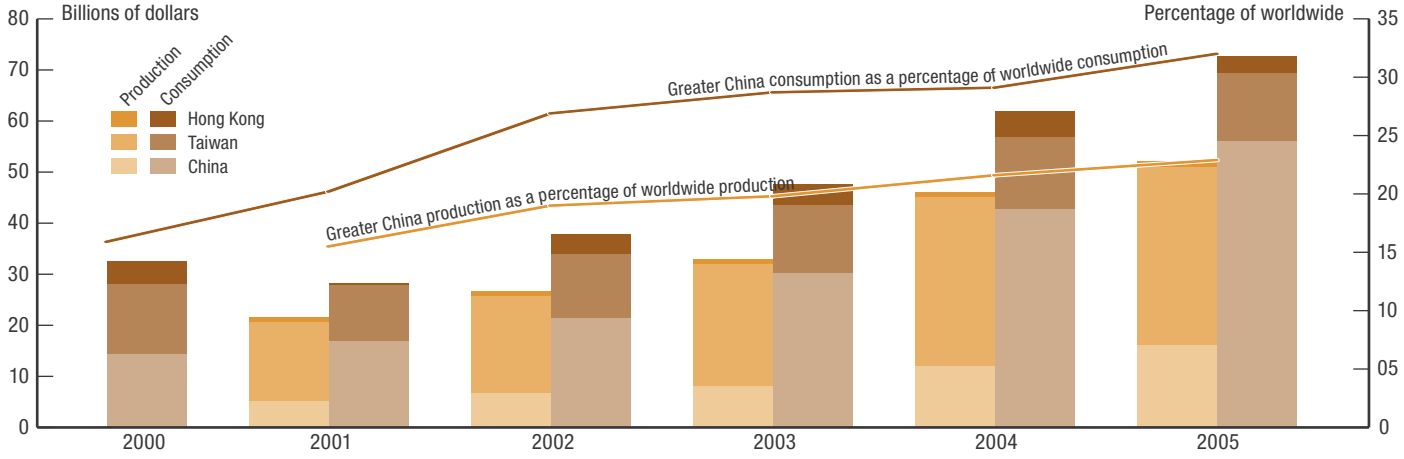
What About Greater China?

Separate from the political considerations, studies have found an increasing amount of interdependence and interaction among China, Hong Kong, and Taiwan in the semiconductor industry. According to the Chinese Semiconductor Industry Association (CSIA), Taiwan is China's largest source of semiconductor imports when measured by value. Those imports likely include a significant number of integrated circuit (IC) wafers from Taiwan's foundries for China's packaging and testing industry sector. Hong Kong, according to the CSIA, is China's largest destination for semiconductor exports, which include a significant quantity re-imported to China as part of the Hong Kong turnaround.

Other evidence of the symbiotic relationship:

- Taiwan's electronic manufacturing investments in China are booming, as China has become an increasingly important location for the mass production and sale of electronic goods. According to Taiwan's Market Intelligence Center, about 65 percent of Taiwan's telecommunications products were made in China in 2006. With more companies transferring production there, the percentage carried out in China will continue increasing to reach 90 percent or more of total output by 2007.
- Several of Taiwan's leading IC foundry, semiconductor assembly and test services (SATS), electronics manufacturing services (EMS), and original design manufacturer (ODM) companies have started operations in China.
- Taiwanese government restrictions on investments by IC foundry, packaging, testing, and design companies in China were eased in 2002 and 2006 to allow a limited number of semiconductor companies to establish wafer fabrication facilities in China using mature process technology.
- Two of Taiwan's largest integrated device manufacturers (IDMs) have announced plans to build new IC wafer fabrication plants in China.
- To allay the concerns of an exodus of semiconductor companies from Taiwan to China, those semiconductor companies that have received Taiwanese government approvals to invest in China have also pledged to build state-of-the-art plants using advanced technology in Taiwan over the next few years. As a result, a division of labor will exist between their manufacturing facilities in China and those in Taiwan, which is determined by the maturity, labor, value-added content, and scale of production for any particular product.

Greater China's Share of the Worldwide Semiconductor Industry, 2000–2005



Source: Gartner Dataquest, CCID, CSIA, TSIA, IC Insights, PwC, 2006

Taken together, these facts raise the question: What is the impact of greater China on the semiconductor industry? In 2005, greater China increased its share of the worldwide semiconductor market by 4 percentage points to 33 percent, representing $75 billion of the Semiconductor Industry Association's reported worldwide semiconductor market of $227.3 billion. In comparison, Japan had a 19 percent share, the Americas 18 percent, Europe 17 percent, and the rest of the world made up the remaining 13 percent. (See Figure.)

Greater China's semiconductor industry production revenue increased 9 percent—from $46 billion in 2004 to $50 billion in 2005—to remain at 19 percent of the worldwide revenue. In 2005, Taiwan's semiconductor industry production revenues were almost two and a half times as large as (or more than 230 percent of) China's semiconductor industry revenues. During 2005, Taiwan foundries accounted for more than 70 percent of worldwide foundry revenues, Taiwan's SATS suppliers accounted for more than 45 percent of worldwide SATS revenues, and Taiwan had three IDMs with revenues greater than $1 billion each.

While China's semiconductor production gap (value of production less consumption), which has been growing consistently since 2000, reached $40 billion in 2005, Taiwan has been achieving a semiconductor production surplus that reached $16 billion in 2005. As a result, greater China had a 2005 production gap of $24 billion—less than that of China alone but about 11 percent of the total worldwide semiconductor market.

On the basis of the number of wafer fabs in production as of the first quarter of 2006, greater China is likely to have 24 percent of total worldwide fab capacity, including 66 percent of worldwide foundry capacity, 32 percent of 300mm capacity, and 25 percent of advanced <12µm capacity once those fabs become equipped and ramped to full capacity.

Regarding worldwide wafer fabs under construction, China had a 43 percent share during the first quarter of 2006, accounting for 56 percent of total capacity. Once those fabs are completed, put into production, equipped, and ramped to full capacity, it is estimated that greater China will have 29 percent of total worldwide fab capacity—including 68 percent of worldwide foundry capacity, 41 percent of 300mm capacity, and 33 percent of advanced <12µm capacity.

Nearly 75 percent of the more than 60 new semiconductor package, assembly, and test (SPA&T) facilities added worldwide during the past three years have located in greater China. As a result, greater China currently accounts for more than 30 percent of total worldwide SPA&T capacity.

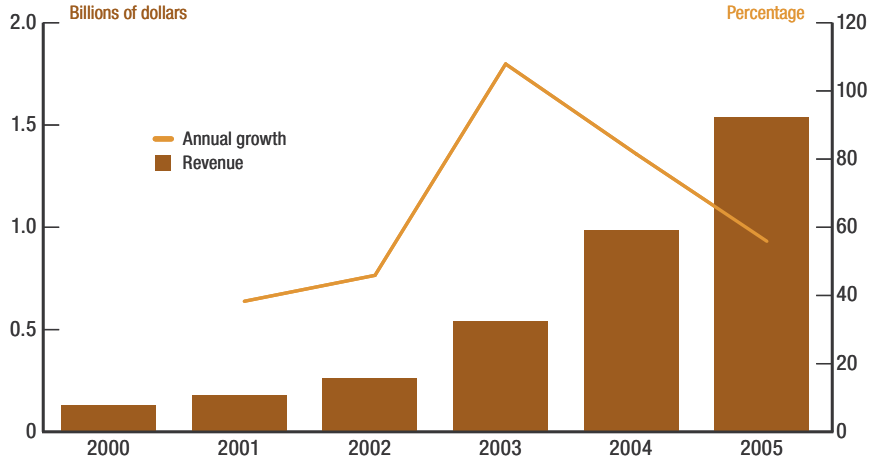
In summary, greater China in 2005 represented:

Design in China

IC Design

Since 2001, integrated circuit (IC) design has been the fastest growing segment of China's semiconductor industry. It grew from $178 million in revenue in 2001 to $1.5 billion in 2005—experiencing a compound annual growth rate (CAGR) of 71 percent. (See Figure 11.) Correspondingly, the design segment's share of China's semiconductor industry increased from 6 percent in 2001 to 10 percent in 2005. Growth in 2005 can be almost solely attributed to the performance of China's fabless semiconductor companies, which constitute about 4 percent of the $40 billion worldwide fabless semiconductor market, up from a 1 percent share in 2001.

Figure 11: China's Integrated Circuit Design Industry Revenue and Growth, 2000–2005

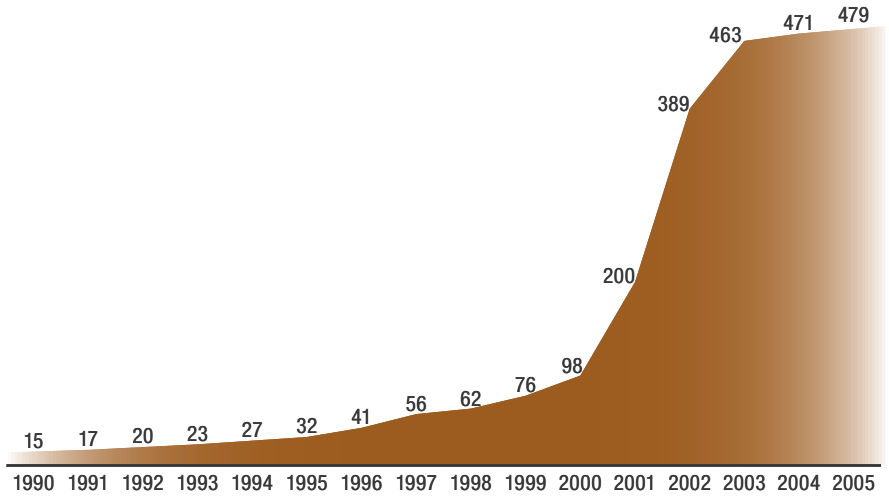


Source: CCID, 2006

Design Enterprises

China had 479 IC design companies at the close of 2005, according to the Chinese Semiconductor Industry Association (CSIA). (See Figure 12.) This number comprises about 380 domestic companies, as well as approximately 100 design units (or "activities") of foreign-invested or subsidiary multinational companies in China.

Figure 12: Number of IC Design Enterprises in China, 1990–2005



Source: CCID, 2005

The domestic enterprises fall into two broad segments that have somewhat incompatible goals: those that are domestically focused and those that are globally focused. The domestically focused segment consisted of government-connected companies operated by locally educated Chinese who have lower levels of experience and technological expertise. Some of these companies were government funded and incubated in one of the seven government-sponsored IC incubation centers, while others were joint ventures with or spinoffs from local universities, or spinoffs from local original equipment manufacturers (OEMs). This segment has been somewhat dependent upon and has continued to lobby for exclusionary domestic standards, such as smart ID cards, TDSCMA, and DMBT.

The second, more entrepreneurial, segment consisted of outwardly directed, globally capable enterprises operated primarily by foreign-educated Chinese. This segment comprised companies that were autonomous, privately run, more technically advanced, and, within their respective niches, rapidly becoming globally competitive. Included are

some notable startups—Actions Semiconductor, Vimicro, Celestial Semi (Beijing) Integrated Circuits Co., Chipnuts Technology, Huaya Microelectronics, and Spreadtrum Communications—organized by returning Chinese technologists who have extensive semiconductor industry experience.

This globally focused segment likely offers China the best prospects for a healthy IC design industry, yet local governments seem determined to cultivate the domestic segment through large-scale investments. The practice by local government to create and protect specific IC clusters, if not properly managed, could result in economically unsound investments, excess capacity, lack of industry cooperation, and extreme price competition—all of which could limit Chinese opportunities for achieving success globally.

During 2005, China's first IC design enterprise broke the $100 million revenue mark, as Actions Semiconductor reported $155 million in revenue. Also during 2005, Actions Semiconductor and the second largest Chinese fabless semiconductor company, Vimicro ($95 million in revenue), were the first Chinese fabless semiconductor companies to be successfully listed on the NASDAQ stock exchange. Despite these noteworthy milestones, the majority of IC design companies contribute significantly less to the market; only 11 of China's design enterprises achieved 2005 revenues of more than $25 million, and just 30 enterprises had revenue of more than $5 million.

The design activities conducted by foreign-invested or subsidiary integrated device manufacturers (IDMs), fabless companies, or electronic design automation (EDA) multinationals in China encompass a variety of functions. These activities include adapting parent-company standard products for local market use, providing lower-cost capacity for standardized back-end design functions that are integrated into the parent company's design flow, and completing complex module designs.

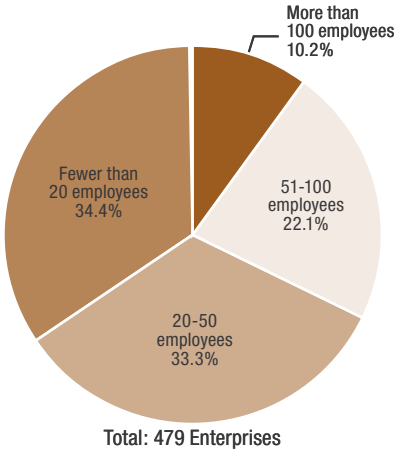
The contribution of many of these foreign design activities may not be recognized in the reported revenue totals for China's IC design industry. The number and functionality of these activities are expected to continue to increase for the rest of this decade. Their greatest long-term impact will be in providing training and experience in worldwide competitive technologies, processes, tools, and design management techniques for significant numbers of local engineers and designers.

Of the approximately 100 reported design activities conducted by multinationals in China in 2005, PricewaterhouseCoopers' analysis identified only 63. This group was somewhat concentrated among the largest of the more than 200 multinational semiconductor companies in the Gartner Dataquest market share database. It included the Chinese design activities of 18 of the top 25 multinational semiconductor companies.

Design Employees

In aggregate, China's IC design industry employed approximately 20,000 workers in 2005. One-third of China's design enterprises had fewer than 20 employees each, and a second third had fewer than 50 employees each. (See Figure 13.) Looking at the four design companies with the largest revenue, the employee count was as follows, according to the Fabless Semiconductor Association (FSA) as well as China Center for Information Industry Development (CCID) reports: Actions Semiconductor had 257 employees, Vimicro had 324 employees, Silan Microelectronics had 560 employees, and Datang Microelectronics had more than 700 employees. Of these, only Actions Semiconductor, which had a sales-per-employee productivity level of $586,000 in 2005, was equal to or better than the FSA average of $545,000 in 2005. The others were significantly lower: Vimicro at $294,000, Silan at $139,000, and Datang at $101,000.

Figure 13: China's IC Design Enterprises by Employee Count, 2005



Source: CCID, 2006

The growth of China's IC design industry depends upon the availability of qualified and experienced designers and engineers. During 2005, China's Ministry of Information Industry (MII) estimated that by 2010 China would need around 250,000 IC designers. At the end of 2005, China had an estimated 6,000 to 8,000 qualified IC designers, an increase from about 3,000 two years earlier. China has formed a preliminary IC talent training base and plans to train 40,000 IC designers and 10,000 IT technical personnel over a six- to eight-year period.

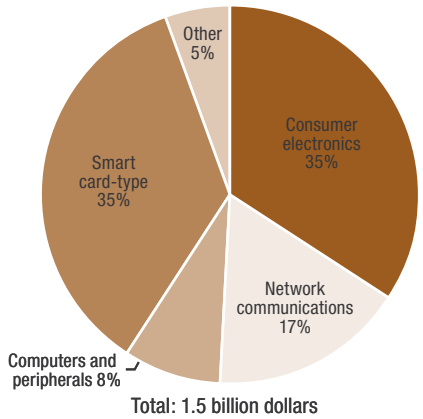
Design Focus

The Gartner Dataquest – EE Times-Asia 2005 EDA survey provides further insight into the state of IC design in China. The survey respondents comprised 378 electronic designers from more than 100 companies in China. More than half of the EDA respondents worked for companies with annual sales of less than $50 million; also more than half worked for companies that were either local subsidiaries of or joint ventures with foreign companies.

Of the EDA respondents, no more than 40 percent were involved in IC circuit design (16 percent in application-specific IC [ASIC] design, 15 percent in field-programmable gate array (FPGA)/complex programmable logic device (CPLD) design, and 8 percent in other IC design), while 31 percent focused on printed circuit board (PCB) design and 29 percent on system design.

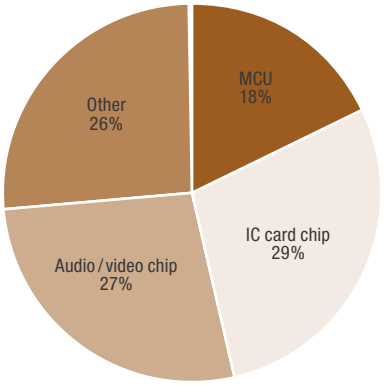
Those in IC circuit design focused on the following applications: 30 percent were in consumer electronics; 21 percent in telecom and data communications; 18 percent in industrial controls, instruments, and medical electronics; 16 percent in computers and computer peripherals; 6 percent in military aerospace; 4 percent in automotive; and the remaining 5 percent in design services and other applications. (See Figures 14 and 15 for similar IC design enterprise breakdowns by application and product mix.)

Figure 14: China's IC Design Industry by Application Mix, 2005



Smart card-type includes card reading tools
Source: CCID, 2006

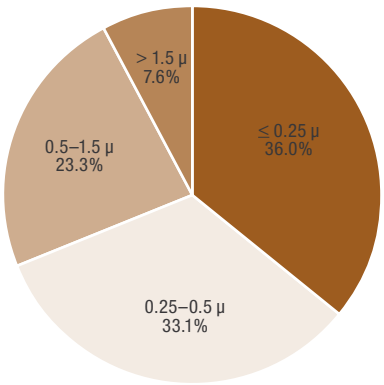
Figure 15: China's IC Design Industry by Product Mix, 2005



Source: CCID, 2006

Answers to survey questions about the process technology in use showed that 34 percent of designs used 0.13 micron or less, 33 percent used 0.18 micron, 17 percent used 0.25 micron, and 16 percent used 0.35 micron or more. This distribution is notably more advanced than that depicted in Figure 16. The difference may be due to the EDA survey requirement that respondents verify that they were users of EDA tools, which may have precluded designers from many of China's smaller startup enterprises from participating.

Figure 16: China's IC Design Industry by Process Technology, 2005



Source: CCID, 2006

Among the ASIC designers who participated in the EDA survey, the largest design category was 1 million to 2.5 million gates, which accounted for one-fifth of their designs. Overall, less-than-1-million-gate and more-than-1-million-gate designs each shared about 50 percent of ASIC designers' total designs, while the share of 10-million-or-more gates was 9 percent of their total.

Among the FPGA/CPLD designers, the largest design category was the 500,000-or-more gate FPGA/CPLD, which accounted for 30 percent of their total in 2005. More than 85 percent of both the ASIC and FPGA/CPLD designers used cores in 2005; hard cores, soft cores, and memory compilers were the three most popular types. Independent third-party suppliers were the most predominant source of cores used; about 60 percent of cores came from those suppliers. ASIC or FPGA/CPLD companies were the main sources of cores used by the FPGA/CPLD designers; about 30 percent came from those suppliers. With both of these groups, independent foundries gained share as a source of cores in 2005, while EDA vendors lost share.

The designers who participated in the EDA survey all used tools from the largest EDA vendors: the top choices were Cadence, Mentor Graphics, and Synopsys. All of the industry executives PricewaterhouseCoopers interviewed for this report indicated that they knew of almost no use of Chinese-sourced EDA tools or cores.

The EDA survey participants indicated that the importance of EDA tools to them was greater than their satisfaction with the tools, although their level of satisfaction was higher in 2005 than in 2004. The difference between importance and satisfaction was greatest for timing analysis, electromagnetic interference (EMI) signal integrity, and PCB layout, indicating that these areas have the most problems for EDA vendors to resolve. Among the EDA respondents, the most important goals for their next design project were increasing functionality (24 percent), reducing costs (24 percent), and increasing reliability (23 percent).

Design Industry Outlook

China's 11th Five Year Plan, which covers 2006 through 2010, calls for the development of five IC design companies, each worth 1 billion to 3 billion yuan (revenue of $375 million to $624 million), and 10 companies each worth 1 billion to 3 billion yuan (revenue of $125 million to $375 million). If this goal is realized, these 15 companies alone would contribute IC design industry revenue of $3.1 billion to $6.9 billion by 2010. Similarly, CCID forecast that China's IC design industry revenue would grow to $8.5 billion by 2010.

It is important not to misinterpret the status or importance of China's IC design industry. According to industry executives, it takes at least 6 to 10 years to develop IC design expertise. As Lung Chu, corporate vice president of EDA toolmaker Cadence says, "Our tools are very sophisticated. You have to understand IC design, and then you have to understand how the tools are used to solve a design problem. It is not that easy; it is pretty difficult, actually. IC design skill is much more difficult than learning the tools."

During the remainder of this decade, the fairly large number of existing design startup companies likely will decrease to a core of about 100 viable companies. Those that are successful will represent the best opportunity for the Chinese government to achieve progress in developing some degree of IC technology independence. However, even if China's IC design industry achieves the goals of its 11th Five Year Plan, it would place China's share of worldwide fabless semiconductor revenue at only 6 to 8 percent. This share would constitute no more than 3 percent of the total worldwide IC industry revenue by 2010. PricewaterhouseCoopers believes that this is a rationally possible but unlikely outcome that could have a noticeable but moderate impact on the semiconductor industry.

At a minimum, achieving even the lower range of the 11th Five Year Plan revenue goals would require China's 15 current IC design leaders to maintain a 32 percent CAGR for the next five years, from 2006 through 2010. Achieving the upper range would require maintaining a much higher CAGR of 40 to 55 percent, while companies other than the top 15 would need to maintain a 40 to 55 percent CAGR to achieve the lower range of the 11th Five Year Plan. By comparison, only 43 (24 percent) of the176 public fabless semiconductor companies included in the FSA's Global Financial and Fundings Report (GFFR) database maintained a CAGR of 32 percent or higher for the past four years (2001 through 2005). Only 15 of those 43 were of a size comparable to China's top 15 IC design companies. Earlier data is not available, because the FSA started the GFFR database from 2001. This history suggests that China's IC design indus-

try will face significant challenges in achieving the revenue growth goals of its 11th Five Year Plan, which PricewaterhouseCoopers therefore evaluated as being rationally possible but unlikely.

The primary factors that will spur such industry growth include China's continually growing IC market, support from favorable government policies, increased domestic wafer fabrication capabilities, continuing availability of low-cost engineers and technicians, increasing presence of foreign design enterprises, and progress in local product design innovations. Factors that could hinder IC design growth include: lagging technology, low value-added IC industry services, the small IC industry scale, low research and development (R&D) spending, increasing global competition, increasing investment requirements, and a shortage of high-level design talent.

China and the Semiconductor Value Chain

Value Chain Revenue

Table 8 lists worldwide semiconductor value chain revenue for 2000 and 2005 compared with forecasts for 2010. For comparison purposes, the 2010 forecasts and the compound annual growth rate (CAGR) for the 10-year period remain unchanged from PricewaterhouseCoopers' original 2004 report.

Table 8: Worldwide Semiconductor Value Chain Revenue and Forecast, 2000–2010

In billions of dollars	2000	2005	2010	CAGR 2000–2010
Electronic design automation	3.8	4.0	7.8	7
Semiconductor intellectual property	0.7	1.4	2.3	13
Equipment	52.5	32.9	43.3	-2
Materials	26.6	31.4	35.7	3
IDMs	184.0	187.3	291.7	5
Fabless	20.4	40.0	44.6	9
Foundries	7.4	19.5	49.6	21
SATS	10.9	15.3	26.0	9
Totals	306.3	321.8	501.0	5

Source: SEMI, EDAC, FSA, IC Insights, Gartner Dataquest, PwC, 2001–2006

In aggregate, semiconductor value chain revenue increased only 3 percent in 2005 from the previous year. Notable increases from the previous year in some segments were offset by equally significant declines in others. The fabless device, semiconductor intellectual property, foundry, and semiconductor assembly and test services (SATS) segments realized double-digit increases over 2004, while the equipment and materials segments experienced double-digit declines. The largest segment, integrated device manufacturers (IDMs), realized a modest 4 percent increase over the previous year.

A comparison of data from 2000 and 2005 reveals the pronounced impact of the continuing trend toward a fabless business model. Foundry revenue increased 164 percent, fabless device revenue increased 96 percent, and SATS revenue increased 40 percent. For the same period, IDM revenue increased just 2 percent, while equipment revenue declined by 37 percent and materials revenue declined by 20 percent.

Table 9 presents our current analysis of China's estimated contributions to worldwide semiconductor value chain revenue for 2005. We also characterize China's role within each value chain segment, on the basis of its relative revenue for production and consumption (where the data is available).

Table 9: China's Contribution to Worldwide Semiconductor Value Chain Revenue, 2005

	Worldwide	China		
Value chain segment	Revenue	Sales	Consumption	China's Role
Electronic design automation	4.0	n/a	0.1	Software user, not producer
Semiconductor intellectual property	1.4	n/a	0.2	Licensee of IC design and foundries, not licensor
Equipment	32.9	0.04*	1.3	First-tier and wafer-fab buyer; used equipment favored
Materials	21.4	0.50*	1.6	First-tier buyer; second- or third-tier producer
IDMs	187.3	7.9	44.7	Plant location for large IDMs' SPA&T; domestic source of smaller IDMs
Fabless	40.0	1.5	11.3	Small, rapidly growing domestic presence
Foundries	19.5	2.3	4.7	Substantial: almost 23% worldwide capacity by 2008
SATS	15.3	2.7	3.8	Substantial: more than 19% worldwide SATS

In billions of dollars
**Chinese domestic companies only, without local subsidaries of foreign companies*
Source: SEMI, EDAC, FSA, IC Insights, Gartner Dataquest, PwC, 2001–2006

China's role on the production side continued to be most significant in foundry, SATS operations, IDM assembly and test facilities, and possibly discrete device manufacturing. China's foundry revenue accounted for just less than 12 percent of worldwide foundry revenues in 2005, yet its role in the foundry segment increased the competitiveness in the market, putting downward pressure on foundry pricing and offering an alternative source of capacity for small startup fabless companies. We estimate that the total revenue of China's semiconductor production activities increased by more than 40 percent in 2005. However, even with these gains, China still accounts for less than 5 percent of the worldwide aggregated revenue.

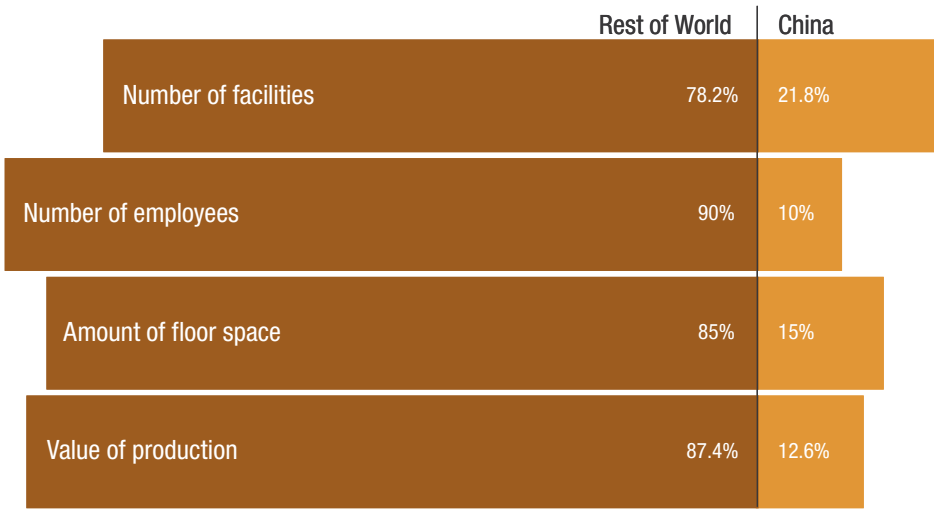
On the consumption side, China's role continues to be first and foremost as a consumer of semiconductor devices, a role that is forecast to continue throughout the rest of this decade. During 2005, 64 percent of the semiconductor devices China consumed were built into products for

export, and China continued to be a growing buyer of materials, a cyclical user of equipment, and a modest licensor of semiconductor intellectual property and electronic design automation tools. China's materials consumption exceeded new equipment purchases for the first time in 2005, reflecting a greater emphasis on achieving wafer fabrication productivity and utilization than on adding new capacity. We estimate that the total revenue of China's semiconductor consumption activities increased to 21 percent of the worldwide aggregated activity revenue during 2005.

Packaging, Assembly, and Test Production

As shown in Figure 17, China had 90 semiconductor packaging, assembly, and test (SPA&T) facilities by the end of 2005. These facilities represented 22 percent of the total number of worldwide SPA&T facilities, 10 percent of the total number of worldwide employees, and 15 percent of the total worldwide SPA&T manufacturing floor space. During 2005, China added a net of 8 SPA&T facilities, or 75 percent of the SPA&T net additions worldwide. Those 2005 additions were large facilities that accounted for more than 90 percent of the net SPA&T manufacturing space added worldwide, thereby continuing the trend noted in 2004 of China having the largest share of new SPA&T facilities added worldwide.

Figure 17: Comparison of China and All Remaining Countries' SPA&T Resources, 2005



Source: Gartner Dataquest, PwC, 2006

Various incentives and relatively low land and construction costs have encouraged companies to build large SPA&T facilities and hold significant portions of the manufacturing floor space in reserve for future rapid capacity expansion. We believe this is one of the reasons for China's relatively low reported share of SPA&T employees. The lack of reporting by several of the SPA&T facilities in China also could contribute to the low reported number of SPA&T employees.

Of the total SPA&T facilities in China, about 30 percent belong to Chinese companies—a significant increase from 2004 figures. These Chinese company facilities have only 17 percent of the SPA&T employees and 15 percent of the manufacturing space in China.

The value of China's IC SPA&T production increased in 2005 to represent almost 11 percent of the value of worldwide production, up from slightly more than 9 percent in 2004. During 2005, China's reported IC SPA&T production units represented 22 percent of worldwide units, a significant increase that surpasses our own prior-year estimates of China's achieving 17 percent of worldwide units.

The value of China's discrete SPA&T production was an estimated 21 percent of worldwide production in 2005, an increase from 16 percent in 2004. China's reported discrete SPA&T production units increased in 2005 to about 38 percent of worldwide units. This share seems questionably high but is possible in view of China's discrete device industry average selling price (ASP), which is only 56 percent of the worldwide average.

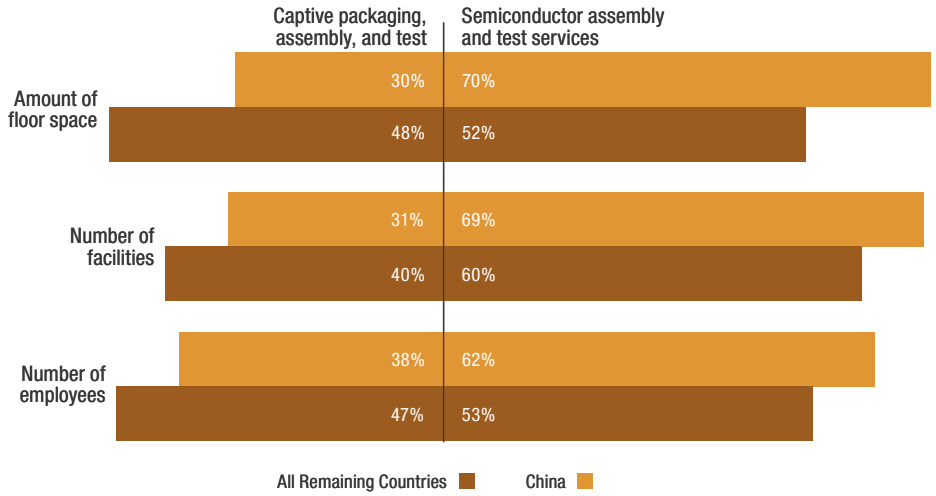
The composite weighted average value of China's SPA&T production in 2005 was estimated to be 13 percent of worldwide SPA&T production, up from 10 percent in 2004 and 2003.

SATS and Other SPA&T Trends

Figure 18 shows China's share of its SPA&T capacity that is dedicated to SATS suppliers compared with all other regions' SATS share of SPA&T capacity. China's share remains slightly more concentrated than other regions' share. China's SATS resources represented 62 percent of its SPA&T employees, 69 percent of its SPA&T facilities, and 70 percent of its SPA&T manufacturing space.

At the end of 2005, 63 SATS facilities were in production in China. Of these, 29 belonged to Chinese companies and 34 to foreign companies. Each of the five largest multinational SATS companies already has a facility in China. By contrast, all of the 27 IDM SPA&T facilities in production in China by the end of 2005 were owned by foreign companies.

Figure 18: Comparison of China and All Remaining Countries' SATS Share of SPA&T Capacity, 2005



Source: Gartner Dataquest, 2006

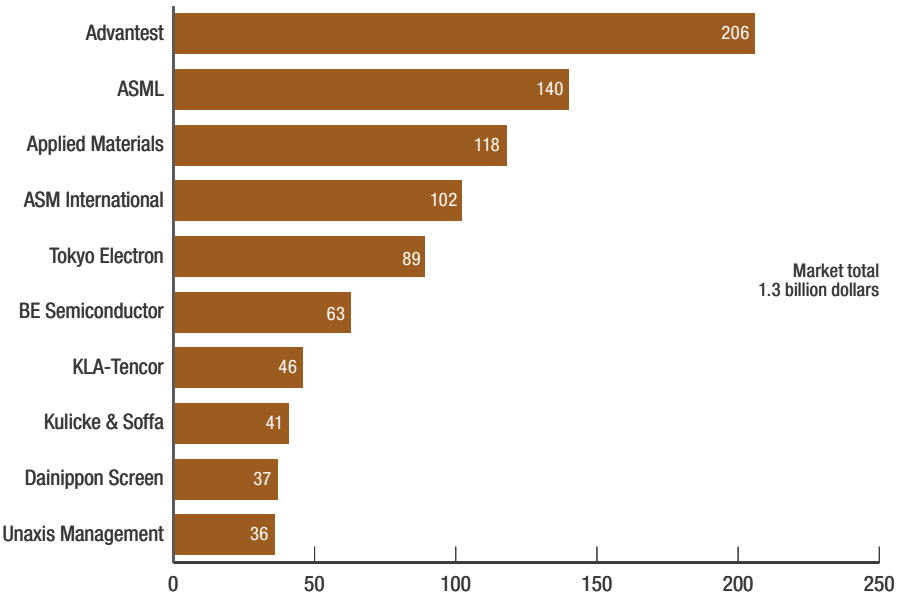
Equipment Market Shares

Semiconductor equipment sales to China decreased by just more than 50 percent in 2005. (See Figure 20 on page 49.) This decline reflects the cyclical nature of wafer fabrication facility startups in China. During 2004, a number of new large wafer fabs installed their first complete modules of new equipment, resulting in a very significant increase in equipment sales for that year. By contrast, during 2005, most of these same wafer fabs focused on bringing that equipment into full production and high utilization, and there were few other new fabs installing complete modules of new equipment, resulting in the significant drop in equipment sales for the year. According to Semiconductor Equipment and Materials International (SEMI), semiconductor equipment sales to China are forecast to more than double in 2006, driven by investments in new 300mm wafer fabrication facilities and advanced technology.

The sales of the top 10 semiconductor equipment suppliers to China decreased by 44 percent in 2005 and represented only 54 percent of that market. The composition and ranking of these 10 suppliers that had the largest market share (shown in Figure 19 on page 48) changed as some assembly equipment and automatic test equipment (ATE) suppliers displaced wafer fab equipment suppliers. Similarly, the concentration of suppliers to the Chinese market was reduced in 2005, when the top 15 suppliers achieved only a 64 percent share, down from 70 percent in

2004 and 77 percent in 2003. Of these 15 suppliers, 8 were manufacturers of wafer fabrication equipment, 5 of assembly equipment, and 2 of automatic test equipment. In addition to the recognized international companies that compose this top 15, a large and growing number of other suppliers, including many regional and several indigenous Chinese suppliers, are trying to establish a presence in the market.

Figure 19: Equipment Sales to China by Vendor Revenue, 2005



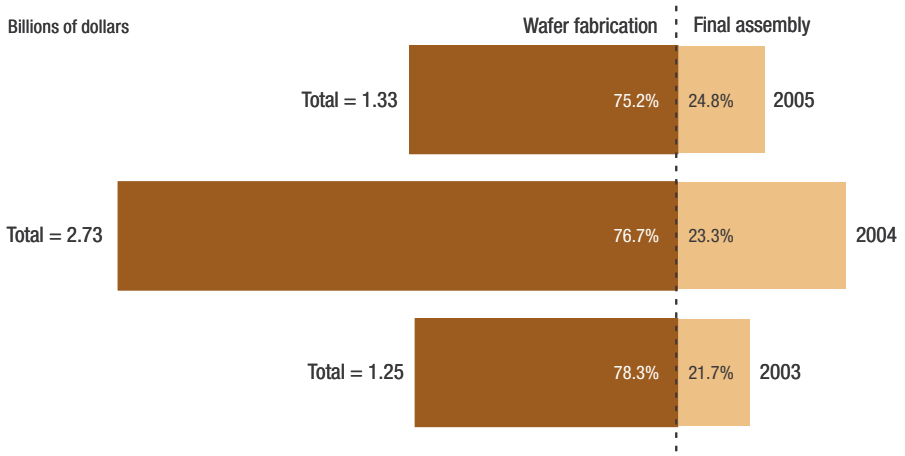
Source: Gartner Dataquest,SEM, 2006

SEMI estimated that sales of used equipment in China represented more than 20 percent of the Chinese semiconductor equipment market in 2005, up from an estimate of 7 to 9 percent in 2004. SEMI also forecast that sales of used equipment would continue to average more than 20 percent of the Chinese semiconductor equipment market for the next three years.

Equipment Sales

Equipment sales to China in 2005 represented an amplified response to the historical worldwide semiconductor business cycle. After the 2004 peak of the current cycle, 2005 was the first decline year. Worldwide semiconductor sales growth slowed from 28 percent in 2004 to 7 percent in 2005, while worldwide semiconductor capital expenditure growth declined from 58 percent in 2004 to 0 percent in 2005. Worldwide semiconductor equipment sales declined by 11 percent and semiconductor equipment sales to China declined by 51 percent in 2005. (See Figure 20.) Wafer fabrication equipment sales in China decreased 52 percent in 2005 to $1 billion, 75 percent of total equipment sales. Packaging, assembly, and test equipment sales in China decreased by 48 percent to $330 million, 25 percent of total equipment sales.

Figure 20: China's Semiconductor Equipment Market and Growth, 2003–2005



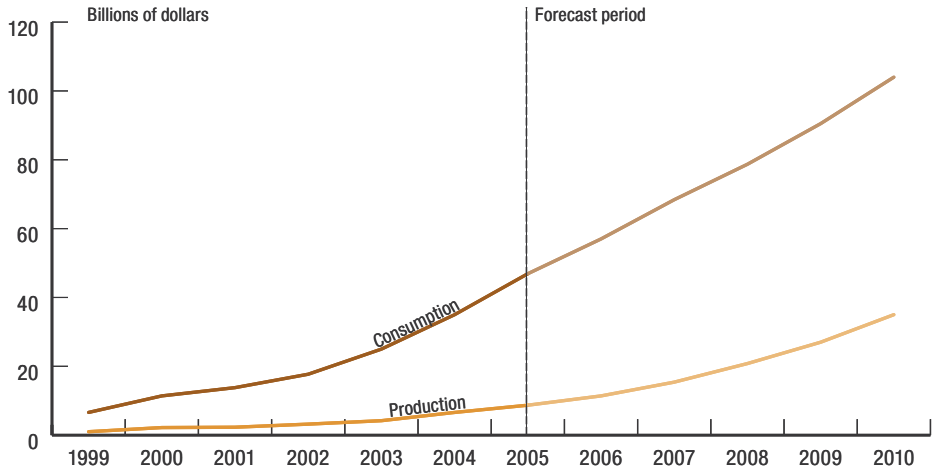
Source: SEMI, Solid State Technology, 2006

China's IC manufacturing sector production revenues (which includes foundries) grew by 32 percent, and China's IC packaging and testing production revenues grew by 25 percent in 2005. Given the significant reduction in 2005 semiconductor equipment sales to China, it appears that China made substantial improvements in IC equipment and capacity utilization during 2005.

IC Consumption/Production Gap

China's IC consumption/production gap, the difference between IC consumption and IC industry revenues, continues to increase at a faster rate despite government plans and efforts to contain it. During 2005, China's IC consumption grew at a slightly faster rate (34 percent) than did its IC industry (32 percent). (See Figure 21.) China's IC consumption increased by $11.9 billion to $46.9 billion, while China's IC industry revenues increased by only $2.1 billion, to $8.7 billion. As a result, China's IC consumption/production gap increased by $9.8 billion in 2005 to $38.3 billion for the year. This represents both the largest absolute increase and gap to date. This consumption/production gap has now grown from $5.9 billion in 1999 to $38.3 billion in 2005, and the Chinese authorities expect that it will continue to increase through at least 2010.

Figure 21: Comparison of China's Integrated Circuit Consumption and Production, 1999–2010



Source: CCID, CSIA, PwC, 2004–2005

According to the Chinese Semiconductor Industry Association (CSIA) 2006 report, China's IC market was forecast to grow to $104 billion by 2010, while its IC production was forecast to grow to $35 billion. This forecasted growth would result in a further widening of China's IC consumption/production gap to $69 billion. This gap also contributes to the Chinese government's initiatives to increase indigenous production.

Production Growth Scenarios

Overview

PricewaterhouseCoopers' original 2004 report examined the effects that different levels of growth in the Chinese integrated circuit (IC) semiconductor industry would have on the greater industry. We used scenarios that spanned the time period of 2003 to 2010, and we also analyzed the developments, investments, and milestones that would need to occur for China to achieve each level of growth during the forecast period. Finally, we predicted the likelihood that China would achieve each level of growth—conservative, moderate, or aggressive—based upon current market conditions. Annually, we reexamine these original production growth scenarios and update our analysis. As of November 2006, we have not identified any fundamental changes that would cause our original production growth scenarios to be revised or the related findings to be significantly altered.

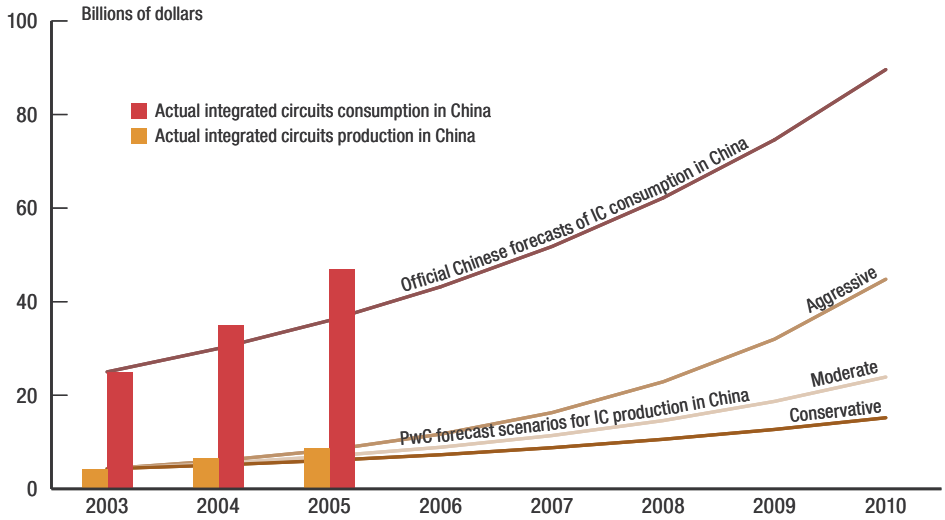
PricewaterhouseCoopers' scenarios were as follows:

- Conservative growth—This scenario assumed that China would be able to equip and ramp to full capacity at mature yields all current and committed wafer fabrication plants that existed as of mid-2004. Under those original assumptions, China's IC industry revenue was forecast to reach $16 billion by 2010.
- Moderate growth—In this scenario, China would achieve the specific objectives articulated by the Chinese Semiconductor Industry Association (CSIA) in 2002, including increasing production to equal 50 percent of consumption by 2010. This moderate growth scenario forecast that IC production revenues would reach $24.1 billion by 2010.
- Aggressive growth—This scenario assumed that the Chinese semiconductor market would grow from its 2003 level at a 20 percent compound annual growth rate (CAGR)—twice the worldwide rate. In this scenario, China also would achieve its goal of Chinese IC industry revenue equal to at least half of Chinese market demand by 2010, amounting to $44.8 billion in that year. Under those original assumptions, China's IC market was forecast to reach $89.5 billion by 2010.

China's Performance Compared with the Scenarios

In this second annual update, the production scenarios and consumption forecasts shown in Figure 22 remain unchanged from the original report. However, we have added consumption and production results for China through 2005, so we can compare actual performance with the forecasts.

Figure 22: China's Integrated Circuit Production and Consumption, Forecasts Compared with Actual



Comparing actual performance with the original scenarios shows that both China's IC consumption and production for 2004 and 2005 have exceeded PricewaterhouseCoopers' aggressive growth scenarios.

Several factors contributed to this significant growth, including the continuing shift of electronics systems production to China and the increase in the amount of semiconductor content in those systems. In addition, 2004 represented the peak year of the current semiconductor business cycle. During 2004 and 2005, the worldwide IC market grew at a 17 percent CAGR, while China's market grew at a 37 percent CAGR. At the 2004 peak, the worldwide market increased by 28 percent over the previous year; yet in 2005, the first downward-trending year, it grew only 8 percent. In contrast, China did not experience an equivalent decline in growth in 2005 and instead accounted for almost 87 percent of the total net increase in the worldwide IC market in 2005.

Whether China can continue to sustain this level of market growth in future years is a key question. The majority of the semiconductor executives interviewed for this report expect that the Chinese semiconductor market will continue to grow at a much faster rate than will the worldwide average for at least the next five years. As Danny Perng, general manager of Mentor Graphics (Shanghai) explains, "The rate of growth of China's semiconductor market will continue at two to three times the worldwide average for the next several years. If you look at the trend, the [electronics system] manufacturing cost is a lot cheaper in China, which attracts—like a magnet—more and more companies to come to China to be competitive."

However, with the current worldwide forecast for 2006 and the latter half of the decade at an average 9 percent CAGR, we believe that this growth can happen only if there is a further shift of worldwide electronics systems production to China. Such a shift could result from one of many factors, including China's continued availability of low-cost labor, components, land, construction, facilities, utilities, and services. A further production shift might also result from an above-average growth in consumption of electronics systems in China or other developing countries.

At the same time, possible negative impacts could stem the shift of electronics production to China, which then could affect the relative growth of China's semiconductor market. These negative factors might include the emergence of lower-cost locations, increases in the cost of logistics, increasing environmental regulations or costs, and intellectual property protection concerns.

During the past two years, China's IC production increased by an average 42 percent CAGR—slightly exceeding our most aggressive scenario. This high rate of growth was the result of an extraordinary 190 percent increase in the IC manufacturing (primarily foundry) sector in 2004 and the continuing high rate of growth in the IC design (fabless) sector. However, China's overall IC production growth slowed somewhat to 32 percent in 2005 and is forecast by Chinese authorities to continue at a slightly lower average CAGR through 2010. Therefore, it appears unlikely that our aggressive IC production scenario will continue to be exceeded during the remainder of this decade.

Scenarios for 2006–2010

To look forward the next five years, the following discussion considers industry conditions as of mid-2006 and describes refinements PricewaterhouseCoopers has made to the original scenarios. Finally, this

discussion outlines what needs to occur for China to achieve each level of growth during the forecast period and the likelihood of such achievement.

Conservative Growth Scenario

The potential capacity of all current and committed wafer fabrication plants in China as of mid-2006 increased by about 48 percent over capacity levels in early 2004 when PricewaterhouseCoopers made its original forecast. The capacity increase stemmed from the addition of 17 new plants in production (15 of which we identified in our original report), plus 19 other plants under construction.

We refined the scenario models to incorporate a trend in average wafer value from $1,200 to $800 per 8-inch equivalent wafer, as suggested by Fabless Semiconductor Association (FSA) wafer-pricing survey reports from the past three years, and an average 90 percent capacity utilization, as noted by the Semiconductor International Capacity Statistics (SICAS) reports. As a result, based upon current market conditions, our conservative growth scenario could show a modest increase to our 2010 IC production revenue forecast. Revenue would reach $18.5 billion and would require an additional investment of at least $16 billion for capital equipment and facilities. This projection represents an IC production CAGR of slightly more than 16 percent from 2005 to 2010, and attainment of this projection seems highly probable.

Moderate Growth Scenario

Our moderate growth scenario assumed China would achieve the specific objectives articulated by the CSIA in 2002. These objectives called for meeting 50 percent of domestic demand by 2010: IC production would be 20 billion pieces, and revenue would be 60 billion to 80 billion yuan ($7.2 billion to $9.6 billion) by 2005, and IC production would be 50 billion pieces and revenue would be 200 billion yuan ($24.1 billion) by 2010. This forecast represents a CAGR of 25 percent from 2004 to 2010.

According to the CSIA 2006 report, China's IC production in 2005 was 26.1 billion pieces and revenue was 70.2 billion yuan ($8.7 billion). The report forecast revenue of 91.3 billion yuan ($11.3 billion) in 2006, rising to 280 billion yuan ($34.5 billion) in 2010. This forecast puts China's IC production at meeting just under 34 percent of China's consumption demand by 2010.

To realize this moderate growth scenario, China would have to construct, equip, and ramp into full production the equivalent of the 15 wafer fabrication plants that are currently planned or rumored to be built but not yet started. This new capacity would be in addition to the 19 plants currently under construction. Furthermore, construction of these additional plants

would have to begin within the next year to realize the additional capacity for 517,000 wafer starts per month (WSpM) required to meet this forecast goal in 2010.

This goal would require a further capital investment of $14 billion in addition to the $16 billion needed for the conservative growth strategy, bringing the total capital investment requirement to at least $30 billion. Although a very substantial amount, this capital investment requirement appears to be in line with China's 11th Five Year Plan, which calls for a total investment of 300 billion yuan ($37.5 billion) in the IC industry during the five-year period from 2006 though 2010. However, Chinese authorities expect that foreign investments will take up a major percentage of this total, and that could limit the achievement of the scenario. If China can meet the goals of the 11th Five Year Plan, its IC industry will have grown to reach revenue that will represent 11 percent of the worldwide market by 2010.

Realization of this scenario now means that China's IC industry must maintain an average 32 percent CAGR over the six-year period from 2005 through 2010, an unprecedented achievement. The three economies to previously enjoy breakout growth in their own semiconductor industries—Japan, Korea, and Taiwan—were unable to sustain a CAGR of 30 percent for more than two consecutive years. Therefore, realization of this scenario appears somewhat optimistic.

Aggressive Growth Scenario

Although the Chinese authorities seem to have postponed their goal of increasing China's IC industry revenue to equal half of its IC consumption market in 2010, PricewaterhouseCoopers' aggressive growth scenario remains based upon that goal for comparative purposes. According to the CSIA 2006 report, China's IC market was forecast to reach $102.7 billion by 2010. Under the aggressive growth scenario, China's IC industry would have to reach revenue of $51.4 billion by 2010, a 43 percent CAGR from 2005 to 2010—an unlikely scenario.

Under the most likely favorable business model, this scenario would now require China to increase its wafer fab capacity to almost 3 million 8-inch equivalent WSpM. This capacity increase would require the construction and ramping to full production of at least 22 additional wafer fabs not currently under construction. All of these fabs would need to be the largest size currently planned for China. This new capacity would require an additional investment of about $55 billion, which also seems very unlikely. This sizable investment requirement and the uncertainties of being able to undertake such a plan likely explain why the authorities have deferred indefinitely the goal of growing China's IC industry to equal half of its IC market.

Appendix

Interpreting Chinese Semiconductor Statistics

This report is based, in part, on data derived from Chinese sources. We use this data for two reasons: it is the same data used by the Chinese policymakers, and Western sources on the subject are incomplete and somewhat divergent. Despite increasing international interest and press coverage, market reports and statistics of the Chinese semiconductor industry are difficult to obtain and often subject to misinterpretation or skepticism. The following explanation delineates how Chinese statistics differ from conventional semiconductor industry statistics.

The two principal indigenous sources for most Chinese semiconductor industry and market reports, data, and statistics are the China Center for Information Industry Development (CCID) Consulting and the Chinese Semiconductor Industry Association (CSIA), both of which are associated with the Ministry of Information Industries (MII) and share common data sources and industry analysts.

Definitional Differences

Because both sources compile their data and write their reports in Chinese, their English-language translations of the reports contain a number of anomalies, especially related to units of measure. Both the CCID and CSIA compile and analyze their data based upon an industry structure that is somewhat different from that employed by Western analysts. This industry structure is not clearly defined in their English-language reports, but may be best described by the following statement contained in the CSIA seminal An Investigation Report of China's Semiconductor Industry 2002: "The term 'the semiconductor industry' in this Report covers IC design, IC manufacture, packaging and test, semiconductor discrete device and semiconductor supporting sector, etc. In view that the investigation on supporting sector is not comprehensive, the term 'China semiconductor industry' in 'General Introduction' and in its relevant statistic data excludes this sector."

Therefore, according to CCID, CSIA, and MII usage, their reports on the Chinese semiconductor industry are based upon an industry structure organized into the following sectors.

IC Design. This sector includes integrated circuit (IC) design companies, institutes, and laboratories, as well as all fabless IC semiconductor companies in China regardless of ownership structure. Most of the revenue and all of the unit production reported for this sector come from product sales by the fabless semiconductor companies.

IC Manufacture. Sometimes identified as the chip manufacturing industry, this sector includes wafer foundries, wafer fabrication plants of foreign IC semiconductor companies, and Chinese IC integrated device manufacturers (IDMs). As a result, the revenue and unit production reported for this sector is a heterogeneous mix of wafer and finished-product unit sales.

Packaging and Testing. This sector, which is sometimes identified as the encapsulation and testing industry, includes the IC semiconductor packaging, assembly, and test (SPA&T) plants of foreign semiconductor companies, as well as all IC semiconductor assembly and test services (SATS) plants and companies in China. This sector does not include the discrete SPA&T plants of foreign semiconductor companies or the IC SPA&T activities of Chinese IDMs. Because some SPA&T plants of foreign semiconductor companies use a wafer/die sale/buy-back or imported processing business model and others use a consigned wafer/die or another toll-processing business model, the revenue production reported for this sector is not homogeneous and is potentially misleading. However, the unit production reported is relatively homogeneous.

Discrete Device. This sector includes all Chinese discrete IDMs and several Chinese SPA&T plants, as well as all discrete wafer fabrication and SPA&T plants of foreign semiconductor companies in China. Because many of the SPA&T plants of foreign semiconductor companies use a consigned wafer/die business model rather than the fully costed IDM business model, the revenue production reported for this sector in not homogeneous and is potentially misleading. However, the unit production reported is relatively homogeneous.

Data Compilation Methods

Both the CCID and CSIA compile their data from reports or survey responses filed by the various entities in each industry sector. These entities usually report their activities as separate standalone companies, and the CCID and CSIA consolidate the reports from each company in an industry sector without any eliminations or offsets. The results are often industry-sector totals that are aggregates of different inputs and therefore misleading. For example, the data might include foundry wafer revenues and wafer shipments combined with IDM finished-unit product sales revenues and unit shipments.

One of the most confusing terms used in the reports is “Pieces” or “pcs,” which is sometimes mistranslated as “wafers.” As used in the reports, the definition of this term varies with the type of company, so that it includes finished devices from a fabless semiconductor company, wafers from a wafer foundry, finished devices from an IDM, and assembled and possibly tested units from a SPA&T plant or SATS company. It is very difficult to

relate one to the other and therefore almost impossible to determine average selling prices (ASPs) from the CCID's or CSIA's industry sector data.

Because at least two of the largest SPA&T plants of foreign semiconductor companies use a wafer/die sale/buy-back business model, their reported revenues are approximately four times as large as they would be if reported using the conventional consigned wafer/die (cost less die) basis. This reporting difference is very significant and could account for an overstatement of 21 percent in the 2005 revenues for the IC packaging and testing sector, 10 percent in the 2005 revenues of the Chinese IC industry, and 5 percent in the 2005 revenues of the overall Chinese semiconductor industry.

Probable Double Counting—A Hypothetical Example

Because of the way the CCID and CSIA compile their data without any eliminations or offsets, double counting between sectors is very probable. The following example—a hypothetical manufacturing flow for a Chinese fabless semiconductor company that uses a Chinese wafer foundry and SATS company to manufacture its products—illustrates the impact of this approach.

In our example, Actions Semiconductor is a fabless semiconductor company in the IC design sector; GSMC is a wafer foundry in the IC manufacturing sector; GAPT is a SATS company in the packaging and testing sector; and Solectron is an electronics manufacturing services (EMS) customer.

- Actions Semiconductor buys 1,000 wafers (200mm) from GSMC for $1,000 per wafer, for a total of $1 million.
- Actions Semiconductor consigns the 1,000 wafers to GAPT for assembly and testing in plastic ball grid array (PBGA) packages with 600 net die per wafer and a die-free package cost of $0.60 per package, for a total of 600,000 finished units and value of $360,000.
- Actions Semiconductor sells the 600,000 finished units to Solectron for an average selling price of $3.33 per device, for a total of $2 million.

Using CCID and CSIA reporting practices, these transactions would be classified and recorded as follows in Table 10.

Table 10: Example Revenue Comparison

	Pieces	Revenue	Revenue using industry standards
IC manufacturing sector	1,000	$1,000,000.00	Not reported
Packaging and testing sector	600,000	$360,000.00	Not reported
IC design sector	600,000	$2,000,000.00	$2,000,000.00
Total	1,201,000	$3,360,000.00	$2,000,000.00

As a result of CCID and CSIA reporting practices, the total Chinese semiconductor industry revenue is overstated by 68 percent and the unit shipments by 100 percent when compared with conventional industry standards.

Implications of Statistical Disparities

Compared with the more conventional practices and standards of the World Semiconductor Trade Statistics (WSTS) and related industry associations and analysts, these differences in CCID and CSIA reporting practices and standards could lead to noticeable variability in reported Chinese semiconductor industry results, depending on the mix of business models employed. Furthermore, these differences could have a significant impact on China's apparent ability to increase the output of nationwide IC production to meet a greater share of its domestic consumption.

An example of an identical IC device that is wafer fabricated, packaged, assembled, and tested in China can illustrate that impact. Based upon the current CCID/CSIA reporting practices, the average reported semiconductor industry revenue for the device could be 100 yuan if the device were manufactured and sold by a Chinese IDM, but only 66 yuan if the device were manufactured by a wafer foundry and SATS supplier for a foreign fabless semiconductor company. The revenue could also be a more significant 166 yuan if the device were manufactured by a wafer foundry and SATS supplier for a Chinese fabless semiconductor company.

Increasing international interest and visibility during the next few years, along with the CSIA's recent membership in the World Semiconductor Trade Council, may encourage the CCID and CSIA to discontinue their

current Chinese semiconductor industry reporting practices and standards. If China elects to change to more conventional semiconductor industry reporting practices and standards, the country may find it desirable to revise the CSIA objectives accordingly.

Statistics Used in Our Report

Despite the evident disparities, we use the aggregate statistics as reported, while carefully noting that they represent China's semiconductor industry as reported in China—that is, the sales revenue of all semiconductor companies in China as reported to the Chinese authorities. We do so because we have no way to determine which business model is being used by every company, and because Chinese policymakers do rely upon these results. As the tendency has been for these sources to overstate the size of the industry, there is some assurance that understatement is not a possibility, and we want to be careful not to understate China's impact on the industry as a whole. In cases where the Chinese have identified individual company revenues, we have been able to augment that data with information from other sources.

Identifying Chinese Semiconductor Companies

The English names of many of the Chinese semiconductor companies are often sources of confusion for a variety of translation and structural reasons. Many companies have English names that are different from the literal translation of their Chinese names and often inconsistently incorporate location prefixes. As a result, the same company may be identified by a number of different English names in various reports and articles.

Sales Performance in China of Multinational Semiconductor Companies

Rising electronics systems production in China has created a shift in global demand no major multinational semiconductor company can ignore. Electronics manufacturing services (EMS) companies, original design manufacturers (ODMs), and original equipment manufacturers (OEMs) in China as a group caused nearly all the growth in the worldwide semiconductor market in 2005, as we noted on pages 1 and 7. Semiconductor consumption in China continues to rise at a faster rate than worldwide—indeed, the executives we interviewed for this report report all anticipate that China's share of the worldwide market will grow for at least the next five years.

For this reason, all major semiconductor companies would do well to measure their performance in terms of shipments to China regularly and ensure their activities established locally are sufficient. The following factors are essential:

- Strong relationships with the relevant parts of the domestic demand and supply chains
- A sufficiently broad and growing customer base in the country
- Responsiveness to requirements and attention to the detail of vendors' specifications
- Sufficient packaging, test, and assembly capacity tailored to Chinese demand
- Adequate intelligence on local market trends and the flexibility to be able to respond quickly enough to these trends

As a starting point for a performance assessment, we compared the sales of companies to China with their sales worldwide in 2004 and 2005 and derived a percentage of each company's revenue from China. (See table on pages 64 to 67.) For internal consistency, this table relies solely on data from Gartner Dataquest—a ranking of the top worldwide semiconductor companies, from which we selected 70 for this purpose. Ten of the companies in our analysis had above average (greater than 25 percent) share of their worldwide sales to China, 24 had average (15 to 25 percent) share and 36 had below average (less than 15 percent) share of their worldwide sales to China.

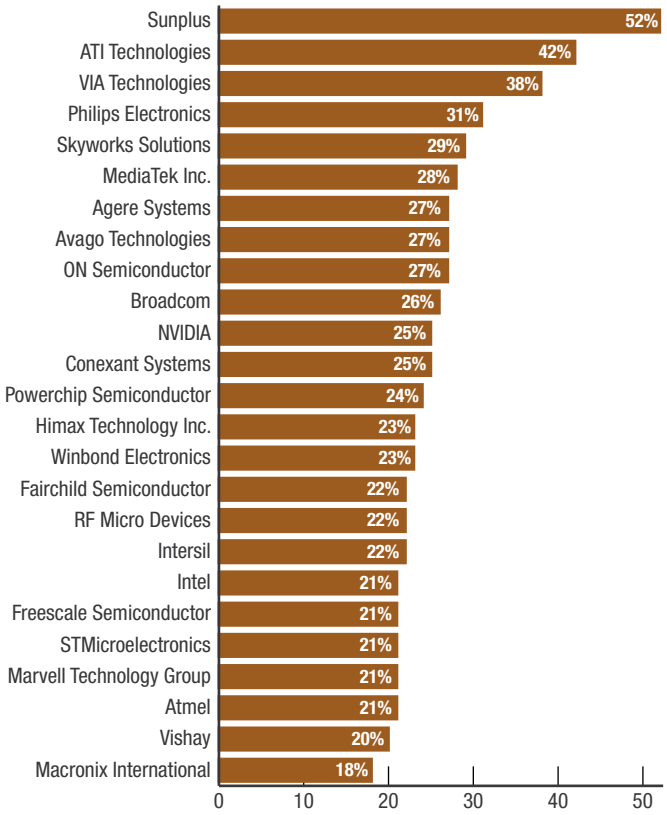
Rank		
2004	2005	
1	1	Intel
2	2	Samsung Electronics
3	3	Texas Instruments
7	4	Toshiba
6	5	STMicroelectronics
4	6	Renesas Technology
5	7	Infineon Technologies
9	8	Philips Electronics
12	9	Hynix Semiconductor
8	10	NEC Electronics
10	11	Freescale Semiconductor
13	12	Micron Technology
16	13	Sony
11	14	Advanced Micro Devices
15	15	Matsushita
14	16	Sharp
17	17	QUALCOMM
18	18	ROHM
21	19	IBM Microelectronics
22	20	Broadcom
20	21	Fujitsu
19	22	Analog Devices
25	23	NVIDIA
23	24	Sanyo Electric
	25	Spansion
24	26	National Semiconductor
33	27	Elpida Memory
42	28	Marvell Technology Group
32	29	ATI Technologies
26	30	Avago Technologies
29	31	Atmel
27	32	Maxim Integrated Products
31	33	Xilinx
28	34	Agere Systems
38	35	Nanya Technology

Worldwide revenue in billions of dollars			China revenue in billions of dollars			Percentage of revenue from China	
2004	2005	% change	2004	2005	% change	2004	2005
30.73	34.59	13	6.01	7.36	22	19.6	21.3
16.28	18.35	13	1.46	1.83	25	9.0	10.0
9.17	10.12	10	1.51	1.80	19	16.5	17.8
8.54	8.98	5	1.11	1.17	5	13.0	13.0
8.69	8.82	1	1.75	1.84	5	20.1	20.8
9.00	8.29	-8	0.63	0.62	-2	7.0	7.5
8.95	8.21	-8	1.05	1.16	10	11.8	14.1
5.69	5.96	5	1.66	1.87	13	29.1	31.4
4.65	5.72	23	0.76	0.92	21	16.3	16.0
6.44	5.66	-12	0.39	0.47	19	6.1	8.3
5.52	5.60	1	1.11	1.19	7	20.0	21.2
4.56	4.62	1	0.36	0.47	30	7.9	10.2
3.73	4.30	15	0.18	0.28	51	4.9	6.4
5.00	3.94	-21	0.47	0.33	-29	9.4	8.5
3.85	3.78	-2	0.42	0.48	15	10.8	12.7
3.91	3.57	-9	0.23	0.24	7	5.8	6.8
3.21	3.46	8	0.17	0.22	29	5.3	6.4
2.90	2.92	1	0.46	0.51	12	15.7	17.5
2.43	2.86	18	0.08	0.20	132	3.5	6.8
2.40	2.67	11	0.50	0.69	37	20.9	25.8
2.60	2.59	-1	0.14	0.14	-1	5.3	5.3
2.61	2.43	-7	0.26	0.26	2	9.9	10.8
1.81	2.20	21	0.33	0.54	65	18.0	24.6
2.16	2.05	-5	0.39	0.37	-6	18.0	17.9
n/a	2.00	n/a	n/a	0.21	n/a	n/a	10.5
2.04	1.96	-4	0.32	0.28	-12	15.5	14.3
1.57	1.78	14	0.10	0.07	-28	6.1	3.8
1.10	1.74	58	0.26	0.36	39	23.5	20.7
1.58	1.74	10	0.62	0.73	18	39.1	42.0
1.71	1.69	-1	0.50	0.45	-10	29.4	26.8
1.65	1.68	2	0.30	0.35	17	17.9	20.6
1.66	1.67	0	0.10	0.10	5	6.0	6.2
1.59	1.65	4	0.20	0.21	7	12.3	12.7
1.65	1.54	-7	0.40	0.42	4	24.2	27.0
1.19	1.44	21	0.20	0.24	18	17.2	16.7

Continued on pages 66 and 67

The 24 companies with an average (15 to 25 percent) share of their 2005 worldwide sales from China had the best results in 2005. Their worldwide sales grew by 9.6 percent, and they reported average net revenues of 15.9 percent of sales. The 36 companies with a below average (less than 15 percent) share of their 2005 worldwide sales from China had noticeably poorer results. Their worldwide sales grew only by 2.5 percent, and they reported average net revenues of 9.2 percent of sales. The 10 companies with an above average share (greater than 25 percent) of their 2005 worldwide sales from China had mixed but somewhat better results. Their worldwide sales grew by 4.8 percent, and they reported average net revenues of 8.9 percent.

The figure below ranks the top 25 companies according to their sales in China as a percentage of their total 2005 sales.



Rank		
2004	2005	
39	36	MediaTek Inc.
30	37	Fairchild Semiconductor
34	38	Nichia Chemical
35	39	ON Semiconductor
40	40	Mitsubishi
43	41	LSI Logic
36	42	Vishay
37	43	Oki Electric
45	44	Altera
52	45	SanDisk Corporation
44	46	International Rectifier
47	47	Linear Technology
41	48	Powerchip Semiconductor
53	49	Microchip Technology
49	50	ProMOS Technologies
50	51	Robert Bosch
48	52	Cypress Semiconductor
51	53	Conexant Systems
63	54	Novatek
54	55	Skyworks Solutions
55	56	Micronas
46	57	Seiko Epson
58	58	RF Micro Devices
59	59	OSRAM
57	60	Winbond Electronics
61	61	Sunplus
74	62	Integrated Device Technology
64	63	Intersil
60	64	VIA Technologies
56	65	Macronix International
65	66	Magnachip Semiconductor
82	67	Himax Technology Inc.
67	68	Stanley Electric
98	69	Cambridge Silicon Radio
62	70	Sanken

Source: Gartner Dataquest, 2006

Sales Performance in China of Multinational Semiconductor Companies

Continued from pages 64 and 65

Worldwide revenue in billions of dollars			China revenue in billions of dollars			Percentage of revenue from China	
2004	2005	% change	2004	2005	% change	2004	2005
1.16	1.44	24	0.31	0.40	30	26.4	27.7
1.60	1.43	-11	0.34	0.32	-6	21.0	22.3
1.33	1.29	-3	0.00	0.00		0.0	0.0
1.27	1.28	1	0.30	0.34	14	23.6	26.5
1.14	1.25	10	0.05	0.05	7	4.0	3.8
1.09	1.24	14	0.15	0.18	19	13.7	14.2
1.23	1.18	-3	0.23	0.23	4	18.4	19.8
1.23	1.13	-8	0.12	0.12	3	9.4	10.5
1.02	1.12	11	0.12	0.15	23	11.9	13.3
0.86	1.10	29	0.04	0.07	84	4.3	6.2
1.08	1.08	0	0.18	0.19	4	16.4	17.3
0.95	1.06	12	0.10	0.13	30	10.6	12.3
1.13	1.03	-9	0.23	0.25	7	20.6	24.1
0.83	0.89	7	0.13	0.14	8	15.3	15.4
0.90	0.87	-3	0.08	0.09	9	8.7	9.8
0.88	0.87	-2	0.02	0.02	-19	2.4	2.0
0.91	0.82	-9	0.07	0.09	23	8.2	11.1
0.88	0.81	-8	0.16	0.20	25	18.1	24.5
0.54	0.81	50	0.06	0.14	130	11.1	17.1
0.80	0.74	-7	0.21	0.21	0	26.6	28.6
0.78	0.71	-8	0.06	0.06	9	7.1	8.4
0.97	0.69	-28	0.06	0.06	5	6.2	9.1
0.65	0.69	7	0.13	0.15	18	19.9	22.0
0.62	0.67	8	0.07	0.09	43	10.6	14.0
0.67	0.66	-2	0.13	0.15	10	20.1	22.6
0.58	0.63	9	0.32	0.33	5	54.5	52.3
0.39	0.62	60	0.02	0.09	360	5.2	14.9
0.54	0.60	12	0.11	0.13	18	20.5	21.7
0.61	0.59	-3	0.22	0.23	4	35.4	38.1
0.69	0.57	-18	0.10	0.10	4	14.5	18.4
0.53	0.56	6	0.06	0.07	6	12.0	12.0
0.32	0.54	71	0.00	0.13		0.0	23.1
0.47	0.50	6	0.02	0.02	6	3.4	3.4
0.25	0.49	92	0.03	0.09	187	11.9	17.7
0.54	0.48	-11	0.06	0.06	-2	11.4	12.7

Acknowledgments

Principal Author
Ed Pausa

Contributor
Alan S. Morrison

Advisory Review Board
Raman Chitkara, Chris S. Cooper, Ken J. DeWoskin, Damian Gilhawley, David Hoffman, Joanne Oswin, Bo Parker, Allan Zhang

Project Team
Pearl Chia, Kelly Conley, Kathy Cruickshank, Irene Georgedakis, Annie Han, Amos Klausner, Bruce Leininger, Susan Mills, Saba Mirza, Peter Vigil, Matthew Wakeman,Christine Wendin, Rain Wong

Industry Perspectives
During the preparation of this report, we benefited from interviews with the following executives.

Joel J. Camarada, Senior Vice President Operations; Sipex Corp.
TS Chan, Finance Director; National Semiconductor (Suzhou) Ltd.
Richard R. Chang, President and Chief Executive Officer; Semiconductor Manufacturing International (Shanghai) Corp.
Lung Chu, President of Asia Pacific Field Operations, Corporate Vice President; Cadence Design Systems
Mark Ding, Vice President, Semiconductor Equipment and Materials International; President SEMI China
CC Kau, Chief Technical Officer; Huaya Microelectronics Inc.
Li Ke, Manager, Semiconductor Research Department, China Center for Information Industry Development Consulting; Vice Manager, China Semiconductor Industry Association
Calvin Lau, Assistant Director, Investor Relations; Semiconductor Manufacturing International (Shanghai) Corp.
Andrew Lee, Director, Program Management Global Accounts; ASE (U.S.) Inc.
Lucy Lu, Department Manager, Customer Service & Technical Support Department; Global Advanced Packaging Technology Ltd.
Danny Perng, General Manager; Mentor Graphics (Shanghai)
Wally Rhines, Chairman and Chief Executive Officer; Mentor Graphics Corp.
Christopher Seams, Executive Vice President Sales, Marketing, Operations; Cypress Semiconductor Corp.
Norman Sheridan, Executive Vice President, Technology; Zilog Inc.
James Teh, Vice President, Business Development; Millennium Microtech (Shanghai)
Lu Teh, Managing Director; National Semiconductor (Suzhou) Ltd.
James M. Thorburn Chairman and Chief Executive Officer; Zilog Inc.
Daniel Y. Wang, Executive Vice President, Chief Financial Officer; Grace Semiconductor Manufacturing Corp.
Leon Wang, Regional Director, Customer Support, China; KLA-Tencor
Julia Wu, Deputy General Manager, Head of Global Transaction Banking China; Deutsche Bank
Shuping Yin, Business Program Manager, Advanced Semiconductor Engineering (Shanghai), Inc.
Tong Zhang, Vice President, Finance Group, Huaya Microelectronics Inc.

About PricewaterhouseCoopers

The firms of the PricewaterhouseCoopers global network (www.pwc.com) provide industry-focused assurance, tax, and advisory services to build public trust and enhance value for clients and their stakeholders. More than 130,000 people in 148 countries across our network share their thinking, experience, and solutions to develop fresh perspectives and practical advice.

The depth of our industry expertise, like our international perspective, is an attribute that our clients value highly. We invest significant resources in building and sharing such expertise. As a result, the people of PricewaterhouseCoopers have the scope, depth, and experience to advise technology companies on the issues facing their business in a converging world. We work with these companies to help them achieve success and fulfill the promise of great ideas.

About the Technology Center

PricewaterhouseCoopers' Technology Center provides research and analysis of technology trends and their effects on companies, industries, and markets. The Technology Center comprises technology veterans who have extensive experience in advanced applications of existing technologies and knowledge of potential uses of emerging technologies. The Technology Center is widely known for its industry-focused publications and for delivering insightful briefings on technology trends to PricewaterhouseCoopers clients and industry leaders around the world. For more information, please visit www.pwc.com/techcenter.

PwC can help

PricewaterhouseCoopers delivers value with a global perspective through local implementation. Please contact the technology industry leader nearest you to discuss the challenges facing your company and the ways we can help you.

Argentina
Jorge Carballeira
+54 11 4850 6802
jorge.l.carballeira@ar.pwc.com

Australia
Paul McNab
+61 2 8266 5640
paul.mcnab@au.pwc.com

Austria
Aslan Milla
+43 1 501 88 1700
aslan.milla@at.pwc.com

Belgium
Koen Hens
+32 2 710 7228
koen.hens@be.pwc.com

Bermuda
George Holmes
+1 441 299 7109
george.holmes@bm.pwc.com

Bolivia
Cesar Lora Moretto
+591 2 240 8181 ext.230
cesar.lora@bo.pwc.com

Brazil
Estela Vieira
+55 21 3232 6041
estela.vieira@br.pwc.com

Brunei
Suresh Marimuthu
+67 3 2223341
suresh.marimuthu@bn.pwc.com

Bulgaria
Borislava Nalbantova
+359 2 9355 200
borislava.nalbantova@bg.pwc.com

Canada
Ben Kaak
+1 416 365 8858
ben.kaak@ca.pwc.com

Chile
Rafael Ruano
+56 2 940 0181
rafael.ruano@cl.pwc.com

China/Hong Kong
William Molloie
+86 21 6123 2777
william.molloie@cn.pwc.com

Colombia
Diego Henao
+57 1 634 0555 ext.338
diego.henao@co.pwc.com

Czech Republic
Petr Sobotnik
+420 251 152 016
petr.sobotnik@cz.pwc.com

Denmark
Allan Vestergaard Andersen
+45 39 45 91 12
ava@pwc.dk

Ecuador
Luciano Almeida
+593 4 228 1555
luciano.almeida@ec.pwc-ag.com

Finland
Eija Kuittinen
+358 9 2280 1274
eija.kuittinen@fi.pwc.com

France
Xavier Cauchois
+33 1 56 57 10 33
xavier.cauchois@fr.pwc.com

Germany
Kerstin Müller
+49 69 9585 5700
kerstin.mueller@de.pwc.com

Gibraltar
Colin Vaughan
+350 73520
colin.p.vaughan@gi.pwc.com

Greece
George Naoum
+30 210 6874 030
george.naoum@gr.pwc.com

Guatemala
Luis Valdez
+502 2420 7800
luis.a.valdez@gt.pwc.com

Hungary
Nick Kós
+36 1 461 9335
nick.kos@hu.pwc.com

India
Joydeep Datta Gupta
+91 33 2357 3417
joydeep.datta.gupta@in.pwc.com

Indonesia
Irhoan Tanudiredja
+62 21 528 90500
irhoan.tanudiredja@id.pwc.com

Ireland
Joe Tynan
+353 1 6626399
joe.tynan@ie.pwc.com

Israel
Joseph Fellus
+972 3 795 4683
joseph.fellus@il.pwc.com

Italy
Andrea Martinelli
+390 2 7785 519
andrea.martinelli@it.pwc.com

Japan
Toshio Kinoshita
+81 3 5532 3195
toshio.kinoshita@jp.pwc.com

Korea
Yong-Won Kim
+82 2 709 0471
yong-won.kim@kr.pwc.com

Lithuania
Chris Butler
+370 5 239 2303
chris.butler@lt.pwc.com

Luxembourg
Serge Saussoy
+352 49 48 48 3201
serge.saussoy@lu.pwc.com

Malaysia
Uthaya Kumar
+60 3 2693 3957
uthaya.kumar@my.pwc.com

Mexico
Carlos del Castillo
+52 55 5263 5806
carlos.del.castillo@mx.pwc.com

Netherlands
Camiel van Zelst
+31 20 568 4768
camiel.van.zelst@nl.pwc.com

New Zealand
Fred Hutchings
+64 4 462 7054
fred.hutchings@nz.pwc.com

Nigeria
Osere Alakhume
+234 1 2711 700
osere.alakhume@ng.pwc.com

Norway
Bjorn Leiknes
+47 02316
bjorn.leiknes@no.pwc.com

Paraguay
Ruben Taboada
+595 21 445 003 ext.1008
ruben.taboada@py.pwc.com

Peru
Orlando Marchesi
+51 1 211 6500 ext. 1905
orlando.marchesi@pe.pwc.com

Philippines
Wilfredo Madarang
+63 2 459 3011
wilfredo.s.madarang@ph.pwc.com

Poland
Adam Krason
+48 22 523 4475
adam.krason@pl.pwc.com

Portugal
Luis Ferreira
+351 213 599 300
luis.s.ferreira@pt.pwc.com

Russia
Natalia Milchakova
+7 495 967 62 40
natalia.milchakova@ru.pwc.com

Singapore
Greg Unsworth
+65 6236 3738
greg.unsworth@sg.pwc.com

Spain
Antonio Vázquez
+34 91 568 4674
antonio.vazquez@es.pwc.com

Sweden
Magnus Brändström
+46 8 555 333 66
magnus.brandstrom@se.pwc.com

Switzerland
Peter Wittwer
+41 58 792 76 80
peter.wittwer@ch.pwc.com

Taiwan
Wilson Wang
+886 3 5780 205
wilson.wang@tw.pwc.com

Thailand
Prasan Chuaphanich
+66 2 344 1121
prasan.chuaphanich@th.pwc.com

Turkey
Haluk Yalcin
+90 212 326 6065
haluk.yalcin@tr.pwc.com

United Arab Emirates
Douglas Mahony
+971 4 3043151
douglas.mahony@ae.pwc.com

United Kingdom
Andrew Bell
+44 1895 522106
andrew.n.bell@uk.pwc.com

United States of America
William Cobourn
+1 646 471 5750
william.cobourn.jr@us.pwc.com

Uruguay
Javier Becchio
+598 2 916 0463 ext.1352
javier.becchio@uy.pwc.com

PricewaterhouseCoopers has exercised reasonable professional care and diligence in the collection, processing, and reporting of this information. However, the data used is from third-party sources and PricewaterhouseCoopers has not independently verified, validated, or audited the data. PricewaterhouseCoopers makes no representations or warranties with respect to the accuracy of the information, nor whether it is suitable for the purposes to which it is put by users.

PricewaterhouseCoopers shall not be liable to any user of this report or to any other person or entity for any inaccuracy of this information or any errors or omissions in its content, regardless of the cause of such inaccuracy, error or omission. Furthermore, in no event shall PricewaterhouseCoopers be liable for consequential, incidental or punitive damages to any person or entity for any matter relating to this information.