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The Challenge of China and the Role of Deepening ASEAN Integration for the Philippine Semiconductor Industry

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Abstract*: From a rising share in the global semiconductor market in the 1990s, which peaked at 7.7 percent in 1999, the standing of the Philippines has since weakened with shares declining to four percent in 2005 and 2.5 percent in 2012. Heavy reliance of the Philippine semiconductor industry on foreign capital, which was concentrated largely in the United States and Japan for the most part of the past two decades, had made it vulnerable to trade risks faced by these countries that resulted in significant downturns in exports in 2001 and 2009. The erosion in the worldwide market share for the Philippines was also associated with the phenomenal rise of China as a dominant global supplier in the 2000s for advanced packaging and test services. Lacking technological capability, the Philippine semiconductor industry was pushed farther down the lower tiers of back-end manufacturing as it struggled to compete in this market with China, which sustained a strong technological leadership. Unlike the more developed Association of Southeast Asian Nations (ASEAN) member countries of Singapore and Malaysia, which have demonstrated upgraded technological intensities and have more diversified international production linkages, the Philippines has failed to optimize the huge opportunity to tap into China's large and growing semiconductor market and to attract Chinese capital inflow. Increased investments from Taiwan, South Korea, and Singapore in the 2000s, alongside a deepening ASEAN integration and economic interdependence, have cushioned the negative impact of the global crisis on Philippine semiconductor trade. This paper recommends policy reforms for the Philippines to facilitate its transition to more knowledge-intensive, higher-value operations.*

Key words: global value chain, semiconductor, technological capability, regional integration
JEL Classification: F14, F15, L63, O14

1. Introduction

Semiconductors remain as the largest merchandise export item and one of the most important manufacturing industries in the Philippines. However, the dominant position of semiconductors in Philippine exports has waned significantly since the late 1990s—from 7.7 percent in 1999 to a meagre 2.5 percent in 2012—a pattern that is likewise reflected in the country's diminishing global market share in semiconductors. After the global slump in electronic demand in 2001, the Philippines trailed farther behind China, which captured a negligible share of the global semiconductor market in the early 1990s but has emerged in the lead position in the global semiconductor trade since the mid-2000s. Furthermore, the Philippines has increasingly lagged behind its Association of Southeast Asian Nations (ASEAN) neighbours—Singapore and Malaysia—which developed their semiconductor industry at about the same time as that of the Philippines in the early 1970s.

Using data from the United Nations Commodity Trade Statistics Database (UN Comtrade), this paper analyses the changing level and configuration of Philippine trade in semiconductors over the past two decades. The focus of bilateral trade analysis is on the expanding set of major trade partners from mainly the US and Japan in the 1990s to other ASEAN countries as well as South Korea, Taiwan, and China in the 2000s. This paper discusses the factors behind the dwindling Philippine comparative advantage in semiconductors, including the country's failure to modernize in keeping with the rapid pace of advancement in chip technology.

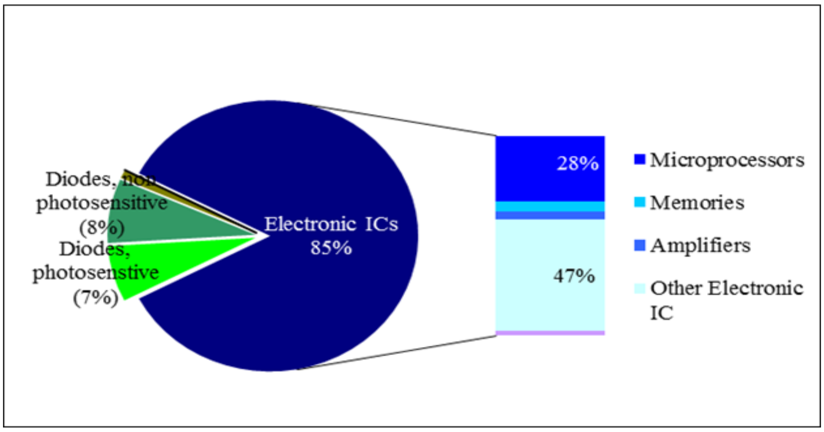
This paper also examines company investment profiles to shed some light on the country's relative position in the global semiconductor value chain. In the early 1970s, leading chipmakers from the Western countries began to relocate labour-intensive segments of the semiconductor production process to Southeast Asia—particularly to Singapore, Malaysia, and the Philippines—to take advantage of lower labour costs. Over the years, Singapore and Malaysia have indicated some movement from back-end manufacturing to higher-value design services as it attracted more foreign investments in research and product development activities. This did not happen for the Philippines, which remained pegged primarily to assembly and testing. With limited capacity to upgrade technology, the Philippines was pushed farther down the lower tiers of production and lost significant international market to China, which demonstrated technological leadership in packaging and testing operations.

2. The Philippines' Semiconductor Industry and Its Position in the Regional and Global Semiconductor Export Market

In 2006–2010, the semiconductor industry contributed an annual average of US$3 million in value added or 13 percent of the total value added in the Philippine manufacturing sector with a workforce of about 35,000 or 14 percent of the total manufacturing employment. Semiconductors remain very significant in Philippine exports although its importance has diminished in the 2000s. From 20 percent in 1991, the share of semiconductors to total exports rose to 35 percent in 1996 and peaked at 57 percent in 1999. Thereafter, the share of semiconductors to total Philippine exports experienced a general decline with a pronounced dip observed between 2007 and 2009 when the shares dropped from 47 percent to 41 percent. The slight recovery in 2010 was not sustained in 2011 with semiconductors taking only 34 percent of total exports in 2012. Although exhibiting a general decline, semiconductor exports continue to take the lion's share (88% in 1991 and 77% in 2012) in the Philippine export of electronic products.

Electronic integrated circuits (ICs) and microassemblies account for the bulk (85%) of the Philippine semiconductor exports in 2012, with the balance of 15 percent comprising diodes, transistors, and similar semiconductor devices. The latter are divided about equally between photosensitive and non-photosensitive semiconductor devices (Figure 1). One-third of electronic ICs are microprocessors, five percent are memory chips and four percent are amplifiers, and the rest categorized as other electronic ICs.

Figure 1: Composition of Philippine Semiconductor Exports, 2012

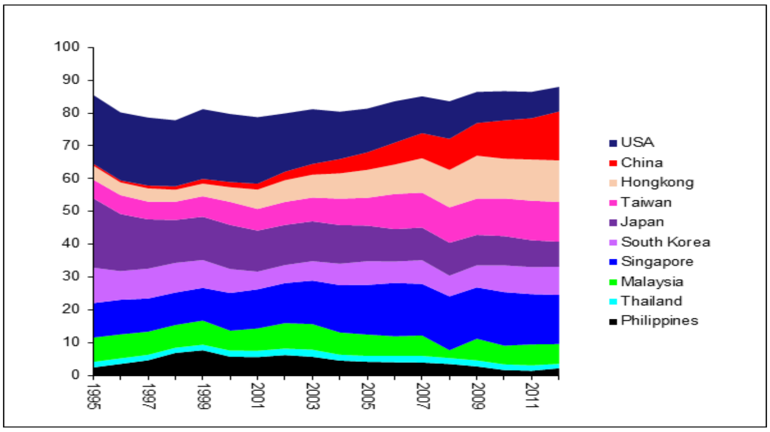


Source: Compiled United Nations Commodity Trade Statistics Database.

In the global semiconductor market, the Philippines struggled to keep afloat as it faced a rapidly dwindling share of worldwide semiconductor exports—from 7.7 percent in 1999 to 4.2 percent in 2005, and 2.5 percent in 2012 (Figure 2). While the growth of Philippine semiconductor exports has far outstripped that of the world in the second half of the 1990s (43% for the Philippines versus only 8% for the world during 1995–1999), this pattern was reversed significantly in the 2000s. World exports of semiconductors grew by an annual average of 6 percent in the period 2000–2011 while that of the Philippines declined by 6 percent. China exhibited the steepest trajectory at 28 percent annual average growth rate for the period 2000–2011, followed by Hong Kong at 16 percent, and Taiwan at 11 percent. Other Asian countries that registered high positive annual growth rates in the same period include Singapore at nine percent, South Korea at seven percent and Malaysia at six percent.

Figure 2: Percent Share to World Electronic ICs and Diodes Exports, by Country,

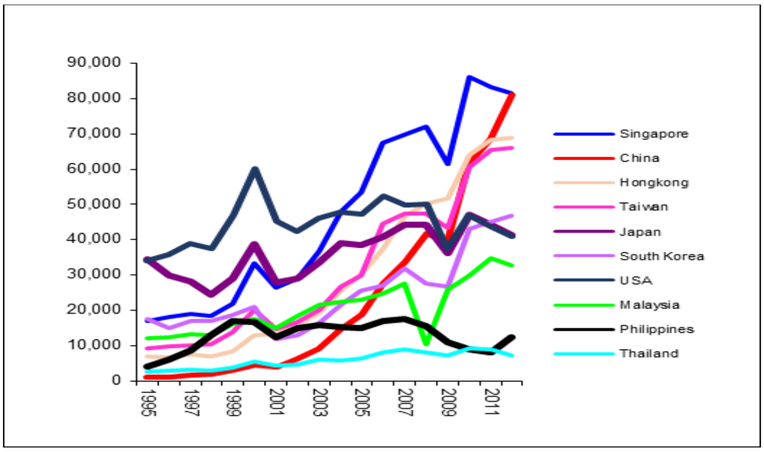
1995–2012



Source: Compiled from the UN Commodity Trade Statistics Database.

Figure 3: Value of Electronic ICs and Diodes Exports, 1995–2012

(in US$ million)



Source: Compiled from UN Commodity Trade Statistics Database.

In terms of the value of semiconductor exports, China surpassed Thailand in 2002; the Philippines in 2005; Malaysia and South Korea in 2006; Japan and the United States (US) in 2009; Taiwan in 2010; and just about converged with Singapore in 2012 (Figure 3). From a meagre 0.6 percent in 1995, the share of China in the global semiconductor market increased to 5 percent in 2005, and 15 percent in 2012. China and Hong Kong jointly captured more than a quarter (28%) of the global semiconductor market in 2012.

The semiconductor industry in the Philippines relied heavily on foreign capital, particularly from the US and Japan, making it vulnerable to trade risks faced by these countries. The intimate link is reflected in the Philippine export pattern, which mirrored the significant dips in 2001 and 2009 observed in the US and Japan, including the slight increase up to 2008 and with signs of decline after a temporary moderate rebound in 2010. The US, Japan, and a number of European countries suffered an economic slump beginning in 2001, which culminated into the global financial and economic crisis in 2008–2009 that contributed to the demand plunge for electronics and semiconductors during these periods (Rasiah et al., 2014).

Following the significant downturn in global demand for electronics and semiconductors in 2001–2002, the dominance of the US, which accounted for more than 20 percent of the global semiconductor market in the 1990s up to 2001, has waned significantly with its global share declining to 13 percent in 2005, 9 percent in 2009, and 8 percent in 2012. Likewise, Japan, which captured a larger share of the global semiconductor market than the US in 1995 at 21 percent, experienced monotonic and more pronounced declines thereafter. Japan’s share dropped by 8 percentage points from 1995 to 13 percent in 2000, and by another 6 percentage points to less than 7 percent in 2012 (Figure 2). The reverse pattern was depicted for China, Hong Kong, Taiwan, and Singapore, which captured an increasing share of the global market in the 2000s. In 2012, China and Singapore each accounted for 15 percent of the global semiconductor exports, with Hong Kong taking 13 percent, and Taiwan taking 12 percent.

Unlike the Philippines, the immediate years following the global economic crisis in 2009 depicted a quick recovery for most of the major Asian players, with sharp uptakes observed for China, Hong Kong, Taiwan, South Korea, and Singapore. Malaysia also demonstrated a swift reversal from a pronounced decline in exports in 2008. This indicated the larger extent to which the more developed ASEAN economies of Singapore and Malaysia were involved in international production network in semiconductors with Greater China and Taiwan compared to that of the Philippines, which remained tied principally to that of Japan and the US.

Philippine trade in semiconductors in the early 1990s was largely dominated by the US, which took up close to 60 percent of Philippine imports and 67 percent of

Philippine exports of electronic ICs and microassemblies in 1992 (Table 1). The prominent shares of the US in both exports and imports indicate a strong bilateral trade due to the fragmented production in the semiconductor industry and possibly involving large intra-firm transactions between US parent firms with their affiliates in the Philippines. In the 2000s, the share of the US to Philippine trade of semiconductors had diminished markedly with larger declines reflected in Philippine exports than imports. In 2012, the US accounted for 21 percent of Philippine imports of semiconductors and only 7 percent of its exports, indicating the lower likelihood of the US to purchase upstream semiconductor devices from their affiliates in the Philippines in the 2000s as compared in the 1990s, and the increasing likelihood of serving the Asian regional market.

Japan, which is the second most important trade partner of the Philippines in semiconductors in the early 1990s, significantly reduced its share of Philippine total imports in the 2000s. From 32 percent in 1995 of total Philippine semiconductor imports, Japan decreased its share to 19 percent in 2000 and 12 percent in 2012. Unlike that of the US in the 1990s, the share of Japan to Philippine exports has been much lower (at most 5%) compared to its share of imports, indicating that the semiconductor products are not sent back to serve the Japan market, but are exported to other countries in Asia.

Associated with the diminishing share of the US and Japan was an expanding Philippine trade in semiconductors with other ASEAN countries, as well as with South Korea, Taiwan, and China. South Korea and Taiwan each accounted for 18 percent of total Philippine imports in 2012—from 9 percent in 1991 for South Korea, and 2 percent in 1997 for Taiwan. While South Korea and Taiwan figured significantly in Philippine imports in the 2000s, their share of Philippine exports were much lower and exhibited some decline during 2000–2012. In 2012, South Korea and Taiwan each accounted for 18 percent of the Philippine imports of semiconductors, which is close to the 20 percent share of the US, and surpassing the 12 percent share of Japan. This reflects the strengthened presence in the Philippines of multinational corporations from Taiwan and South Korea for the assembly and test of semiconductors in the 2000s, which were exported only partially back to the parent countries and largely to the rapidly growing Asian market, particularly China.

Table 1: Percentage Distribution of Philippine Trade in Electronic ICs and Microassemblies, 1991–2012

Country	1991		1995		2000		2005		2010		2012	
	Imp	Exp	Imp	Exp	Imp	Exp	Imp	Exp	Imp	Exp	Imp	Exp
United States	**56.0**	**63.0**	**45.4**	**52.5**	**40.8**	**31.7**	**33.2**	**8.5**	**19.5**	**5.6**	**20.6**	**7.3**
Northeast Asia	**29.9**	**2.3**	**38.2**	**13.2**	**40.4**	**32.4**	**45.8**	**53.4**	**52.8**	**42.1**	**53.5**	**51.6**
Japan	20.4	0.6	31.9	5.2	18.6	9.0	13.9	5.4	9.6	1.8	11.9	1.8
South Korea	9.5	1.7	3.9	3.2	11.8	4.6	10.0	3.8	17.1	4.5	18.4	4.0
Taiwan	0.0	0.0	0.0	0.0	7.1	11.5	14.5	6.4	17.0	4.4	18.4	5.2
China	0.0	0.0	0.0	0.1	1.8	3.8	5.2	30.5	6.7	22.3	3.0	28.2
Hong Kong	0.0	0.0	2.4	4.7	1.1	3.5	2.2	7.3	2.4	9.1	1.8	12.4
Other ASEAN	**8.1**	**21.0**	**5.8**	**19.4**	**10.2**	**23.6**	**12.5**	**22.1**	**19.5**	**41.4**	**18.5**	**29.5**
Singapore	3.3	10.9	3.4	13.9	4.2	13.1	6.4	11.4	11.7	29.6	10.5	22.9
Malaysia	4.6	9.4	2.2	4.7	4.7	9.1	4.1	9.1	3.9	9.9	4.1	2.7
Thailand	0.2	0.7	0.2	0.8	1.0	1.4	1.8	1.6	3.8	1.6	3.8	2.2
Others**	0.0	0.0	0.0	0.0	0.3	0.0	0.2	0.0	0.1	0.3	0.1	1.7
Rest of World	**6.0**	**13.6**	**10.5**	**15.1**	**8.8**	**12.3**	**8.6**	**16.1**	**8.3**	**10.9**	**7.5**	**11.6**
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
N in US$ million	944	920	3,563	3,461	11,264	16,666	11,102	26,035	10,690	25,822	9,034	19,517

Note :Exp = exports, Imp = imports, ICs = integrated circuits.
** Indonesia and Viet Nam.
Source: Compiled from UN Commodity Trade Statistics Database.

China and Hong Kong jointly accounted for more than 40 percent of total Philippine exports in electronic ICs in 2012 while their combined shares in Philippine imports remain small at less than 5 percent. The meagre share suggests that the phenomenal growth of China's semiconductor industry has not translated significantly into strengthened Chinese foreign direct investment (FDI) in semiconductors in the Philippines. As China has been a major recipient in the 2000s of FDI in semiconductors, the significant shift in the destination of Philippine exports to China, given its relatively minor share of Philippine imports, may be accounted for by increased intra-firm transactions for the multiple US, Japan, South Korea, and Taiwan affiliates across countries in Asia, with China taking a disproportionate share of FDIs. In addition, the Philippine semiconductor exports to China have a high import content that is linked primarily to the US and Japan up to the mid-2000s and, thereafter, expanding to South Korea, Taiwan, and Singapore.

Over the past two decades, Philippine trade in semiconductors has expanded to more ASEAN countries that include Indonesia and Viet Nam. In the ASEAN region, Philippine trade of semiconductors is strongest with Singapore and Malaysia and has strengthened for Thailand in the late 2000s (Table 1). The share of ASEAN countries increased from 8 percent in 1991 to 19 percent in 2012 for Philippine imports of electronic ICs, and from 21 percent to 30 percent in the same period for Philippine exports. Conversely, with the US, Japan, South Korea, and Taiwan, the share of ASEAN countries to Philippine trade in semiconductors are larger for exports than imports. The pattern is similar to that of China and Hong Kong. With Hong Kong, however, the export share is minimal whereas that of the ASEAN countries is quite significant at close to a fifth of total Philippine exports in 2012, which suggests a dynamic back and forth trading in semiconductors within the ASEAN region. It could also substantiate intensive intra-firm flows by affiliates of US, Japan, South Korea, and Taiwan in the region.

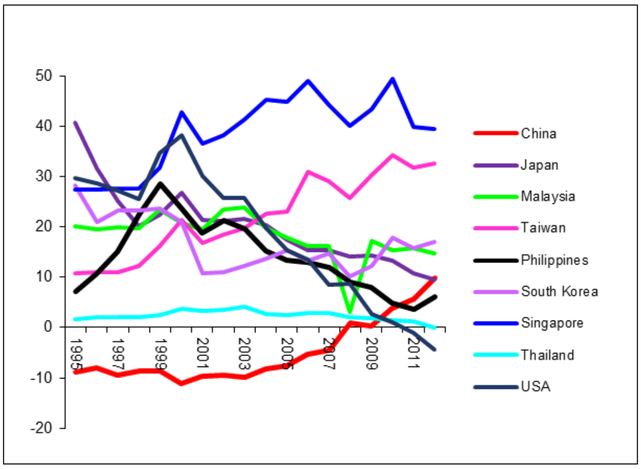
That the Philippines lost a significant market to China is also reflected in its rapidly falling normalized revealed comparative advantage (RCA)[1] in electronic ICs and diodes exports, particularly in the 2000s, alongside China's steep ascent (Figure 4). The normalized RCA value for the Philippines was among the highest at 29 in 1999 following the US (35) and Singapore (32), and higher than South Korea (24), Malaysia (23) and Japan (28). In the same year, China exhibited a relative comparative disadvantage in electronic ICs manifested by a negative RCA value while Hong Kong and Thailand each had an RCA index that was less than 3. In the 2000s, the RCA index for the Philippines dropped significantly along with that of the US and Japan while that of China demonstrated a precipitous increase. By 2008, China's disadvantaged position was reversed. A rapid rise in China's RCA value continued thereafter, surpassing that of Thailand and the US in 2010, the Philippines

[1] Yu, *et al*. (2009) improved on the Balassa (1965) RCA by constructing the normalized RCA as a deviation of the actual data from the comparative advantage neutral point. The normalized RCA avoids the shortcomings of asymmetry and incomparability across time and space of the Balassa Index. A normalized RCA value of greater than zero indicates that the country has comparative advantage in commodity j, with the larger positive value indicating greater comparative advantage.

in 2011, and Japan in 2012. The Philippines had slipped in RCA ranking from 1999, losing as well to Malaysia in 2001, to Taiwan in 2003, Hong Kong in 2004 and to South Korea in 2005. In 2012, China's RCA index was 60 percent higher than that of the Philippines.

Singapore's strong relative comparative advantage in semiconductors was sustained in the 2000s even as that of the Philippines experienced marked reductions that closely aligned with the pattern observed in Japan and the US. Although Malaysia exhibited a falling normalized RCA index, this had been much tempered compared to the sharp declines demonstrated for the Philippines. Singapore continued to take the lead in terms of the RCA index by 2012, followed closely by Taiwan and Hong Kong and then by South Korea, Malaysia, and China with the latter three countries having normalized RCA indices of less than half that of Singapore. These patterns suggest the largely concentrated involvement of the Philippines in the international semiconductor production network of Japan and the US, compared to that of Singapore and Malaysia, which appeared to have developed more diversified international linkages with newly industrializing economies in Asia, particularly with China.

Figure 4: Normalized RCA Index for Electronic ICs and Diodes, 1995–2012

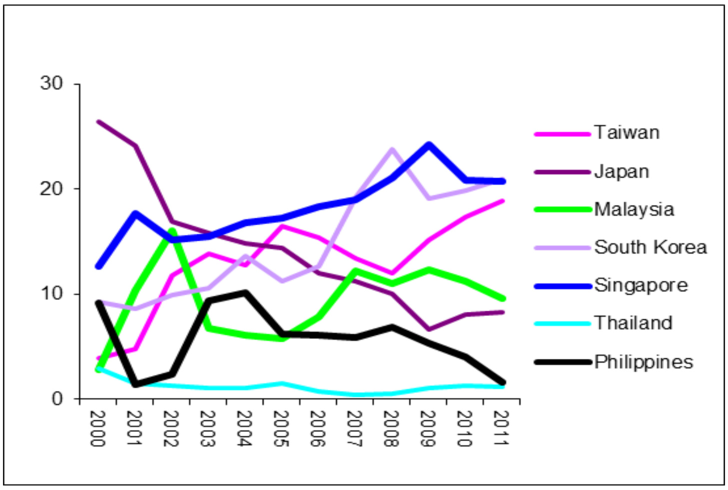


Note :RCA = revealed comparative advantage, ICs = integrated circuits.
Source: Author's calculations using data from the UN Comtrade database.

Unlike that of Singapore and Malaysia, the Philippines failed to tap into China's huge and growing market in semiconductors. China's ASEAN trading partners in semiconductors have largely been concentrated in Singapore for exports and in

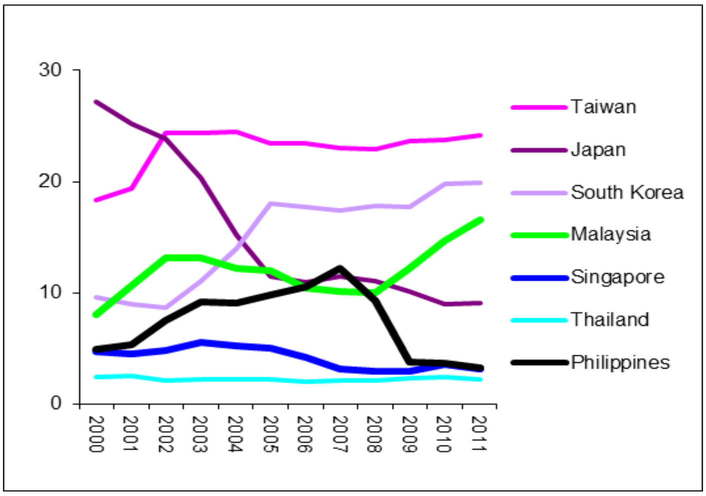
Malaysia for both imports and exports (Figures 5 and 6). Sharp declines in the Philippine share of China's exports and imports of electronic ICs were also observed following the global economic slump in 2008 and 2009. The Philippines accounted for only three percent of China's exports and less than two percent of its imports in 2011, reflecting low capital inflow and presence of Chinese transnational affiliates in the Philippine semiconductor industry. By comparison, Singapore took up 21 percent of China's exports of electronic ICs in the same year while Malaysia held 10 percent of China's exports and 16 percent of its imports.

Figure 5: China Exports of Electronic ICs and Microassemblies, by Selected Partner Country, 2000–2011 (% share)



Note :ICs = integrated circuits.
Source: Compiled from the UN Commodity Trade Statistics Database.

Figure 6: China Imports of Electronic ICs and Microassemblies, by Selected Partner Country, 2000–2011 (% share)



Note: ICs = integrated circuits.
China's total trade excludes Hong Kong and Macao.
Source: Compiled from the UN Commodity Trade Statistics Database.

Taiwan and South Korea, which are the major trading partners of China, also exhibited fast growth in semiconductor trade in 2000s, overtaking former global leaders like the US and Japan by 2011. The stronger trading with China was depicted by a rapid rise in China's share of both Taiwan's and South Korea's imports and exports of electronic ICs. From less than 1 percent in 2000, China's share increased to 16 percent of Taiwan's imports in 2012 and to 21 percent for its exports (Table 2). Likewise, its share increased from less than 3 percent to 15 percent of South Korea's imports and 33 percent of its exports.

China's vigorous trading in the 2000s with Taiwan and South Korea was associated with increased trade for Singapore but reduced trade with other ASEAN countries that were previously significant trading partners of Taiwan and South Korea, such as Malaysia and the Philippines. Singapore increased its share, particularly of Taiwan's exports, from 13 percent in 2000 to 20 percent in 2012, and of South Korea's imports from 5 percent to 14 percent in the same period. In the ASEAN region, Malaysia and the Philippines appeared to have lost the most to China in the Taiwan and South Korea semiconductor market, with the largest declines observed for Taiwan's import and South Korea's export markets. For 2000 and 2012, the Philippine share of Taiwan's semiconductor imports dropped from 9 percent to 3 percent while that of Malaysia declined from 11 percent to 5 percent. Significant declines in the Philippines' and Malaysia's share of South Korea's exports were also observed—from close to seven percent for each in 2000 to one percent for Malaysia and four percent for the Philippines in 2012.

Table 2: Percent Share of Selected Asian Countries in Taiwan and South Korea Trade in Electronic ICs and Microassemblies, 2000–2012

Partner country	Reporting country: Taiwan (%)						Reporting country: South Korea (%)					
	2000		2007		2012		2000		2007		2012	
	Imp	**Exp**	**Imp**	**Exp**	**Imp**	**Exp**	**Imp**	**Exp**	**Imp**	**Exp**	**Imp**	**Exp**
China	0.8	1.4	9.0	20.6	16.0	21.0	1.6	2.2	13.2	22.5	15.4	33.4
Singapore	8.5	13.4	6.7	9.8	12.9	20.0	5.3	12.5	16.0	13.0	14.3	11.7
Malaysia	11.0	4.0	5.3	4.0	5.0	3.3	7.1	6.6	5.2	3.7	3.6	1.3
Philippines	9.3	4.3	4.9	4.1	3.2	2.9	4.5	6.6	3.5	3.9	3.0	4.0
Thailand	2.9	1.0	3.9	3.4	1.7	1.8	1.7	1.3	2.9	0.9	1.4	0.4

Note :Exp = exports, Imp = imports, ICs = integrated circuits.
Source: United Nations Commodity Trade Statistics Database.

The Philippines also lost significantly to China in the Japan semiconductor market. Between 2000 and 2012, the increase in China's share of Japan's imports—from two percent to eight percent—was associated with the Philippines' reduced share of the same from eight percent to two percent. Malaysia's share of Japan's imports also declined significantly from 11 percent to 4 percent in the same period while that of Singapore has remained largely the same. The larger increases in China's share had been in Japan's export market from less than 5 percent in 2000 to 30 percent in 2012. This was associated with significant declines in the corresponding shares of ASEAN countries—from 13 percent to 7 percent for Singapore, from 9 percent to 5 percent for Malaysia, and from 7 percent to 4 percent for the Philippines.

While Singapore was the choice location in Southeast Asia for Japanese investments and trade in semiconductors, the US seemed to have a distinct preference for Malaysia, which captured 12 percent of the US total semiconductor trade in 2012. China has also strengthened trade with the US in the semiconductor market but not as pronounced as that of Taiwan, South Korea, and Japan. Increases in China's share were from less than two percent in 2000 to six percent in US imports in 2012, and nine percent in US exports. This was associated with an increase in Malaysia's share of US exports—from 9 percent to 12 percent—while its share of US imports has remained largely the same.

Table 3: Percent Share of ASEAN Countries in the Japan and US Trade in Electronic ICs and Microassemblies, 2000–2012

Partner country	Reporting country: Japan (%)						Reporting country: US (%)					
	2000		2007		2012		2000		2007		2012	
	Imp	**Exp**	**Imp**	**Exp**	**Imp**	**Exp**	**Imp**	**Exp**	**Imp**	**Exp**	**Imp**	**Exp**
China	2.0	4.5	7.2	24.3	8.2	29.9	1.3	1.2	6.7	14.5	6.3	9.2
Singapore	6.9	12.8	5.5	8.2	7.2	6.8	7.7	6.6	7.9	8.9	5.1	4.8
Malaysia	10.6	9.3	4.1	6.0	4.1	5.2	12.9	9.0	11.4	11.1	12.5	11.6
Philippines	8.4	6.9	6.2	4.4	2.1	3.5	12.4	8.5	9.0	8.4	4.9	5.4
Thailand	1.1	4.1	1.7	5.0	2.2	3.2	3.0	3.7	4.7	2.5	2.3	3.0

Note :Exp = exports, Imp = imports, ICs = integrated circuits.
Source: United Nations Commodity Trade Statistics Database.

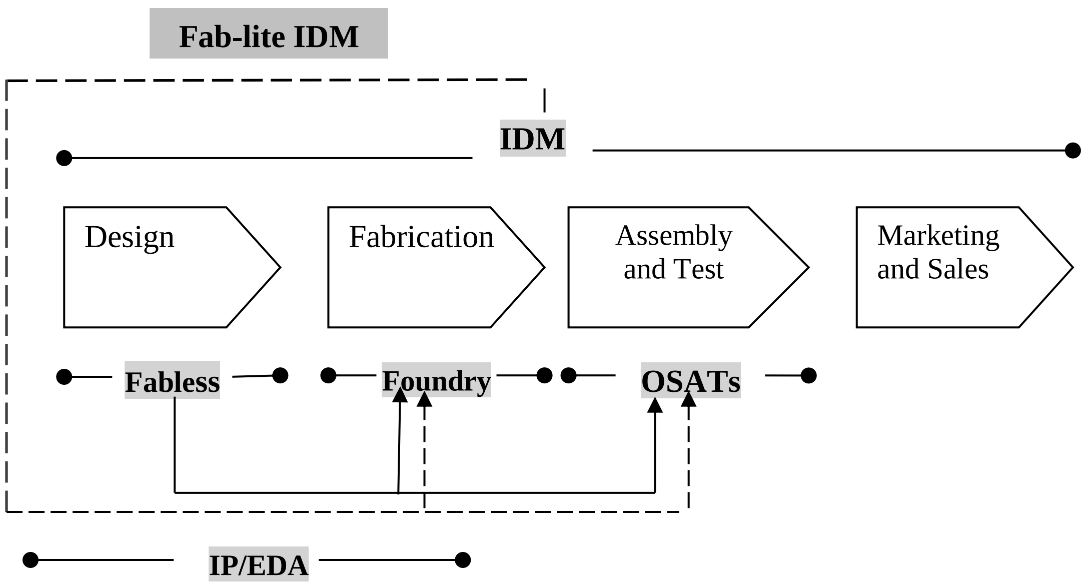
Although the Philippines was a more favoured location of US exports relative to China and Singapore in 2000, this pattern was reversed in favour of China in 2012. Furthermore, the positive bias for the Philippines relative to Singapore in the US exports was lost beginning in 2007 when the shares for both countries were about equalized. The Philippines' share, which was about the same as that of Malaysia in 2000 at 12 percent of US imports and 9 percent of US exports, dropped to 5 percent in 2012. Malaysia has sustained its share of US imports in 2012 at 12 percent and increased its share of US exports from 9 percent in 2000 to 12 percent in 2012.

3. The Global Semiconductor Value Chain

Since the invention of the transistor in the 1950s, semiconductors have become smaller and more diverse and complex, in line with Moore's law. Along with this transformation is the de-integration of the global semiconductor supply chain into four primary segments: (a) design, (b) fabrication, (c) assembly and test, and (d) marketing and sales (Figure 7). An integrated device manufacturer (IDM) is vertically integrated and handles the full range of activities in the semiconductor chain—it designs, fabricates, packages, tests, and sells IC products. The two top global semiconductor suppliers are the IDMs of Intel and Samsung, which jointly accounted for a quarter of the $299.9 billion worldwide semiconductor revenues in 2012.

Every technological innovation in ICs entails new equipment, the costs of which have grown exponentially over the years. The cost of a cutting-edge fabrication facility, which averaged $100 million in the 1980s, could now reach up to $10 billion—such as that set up by Taiwan Semiconductor Manufacturing Company (TSMC), the leading foundry worldwide. Pure-play foundries manufacture chips that other companies design. East Asia, particularly Taiwan and China, dominates the labour-intensive semiconductor manufacturing due to the advantages of a lower-cost educated labour, a substantial domestic market, and a strong government support for manufacturing investments.

Figure 7: Global Semiconductor Value Chain



Note :EDA = electronics design automation, IDM = integrated device manufacturer, IP = intellectual property, OSAT = outsourced semiconductor assembly and test.
Source: Author’s augmented version of Figure 1: Semiconductor Industry Value Chain (Macher, J., D. Mowery & T. Simcoe, 2002)

The emergence of foundries in the 1980s paved the entry of fabless companies that design chips but, unlike IDMs, do not have internal manufacturing capability.

Fabless companies established strategic linkages with pure-play foundries for chip fabrication and with outsourced semiconductor assembly and test (OSAT) companies for chip packaging assembly and tests. Advanced Micro Devices (AMD), which was among the top 20 IDMs worldwide in the early 1990s, became fabless in 2009. AMD divested its manufacturing operations to Abu Dhabi's Advanced Technology Investment Co. that owns Global Foundries. The leading fabless companies are US-based, including Qualcomm, Broadcomm, and Nvidia.

Along with the development of the 'system-on-chip' design in the 1990s came the emergence of electronics design automation (EDA) suppliers and intellectual property (IP) vendors. To keep abreast with the increasingly more complex and sophisticated IC design, semiconductor companies need strong partnerships with IP providers with expertise in developing solutions to application architecture and functionality of ICs and with EDA companies, which spun out of IDMs to focus on the development of software tools for designing ICs. The IP vendors are dominated by both the US and the United Kingdom with leading companies that include United Kingdom-based ARM Holdings and Imagination Technologies. The US companies of Cadence and Synopsis are both top EDA and IP suppliers globally.

Other than fabless companies, pure-play foundries also contract with IDMs that adopted a fab-lite business model of divesting in fabrication plants. In the past decade, a good number of leading IDMs have increasingly outsourced chip fabrication (averaging a fifth of their IC production in 2011) to pure-play foundries. Fab-lite models were first employed by leading IDMs in the US and Europe, such as Texas Instruments, Freescale, Infineon, and STMicro, with top Japanese semiconductor companies of Toshiba, Renesas, Sony, and Fujitsu immediately following in the same course.

Escalating fabrication costs led to fewer companies pursuing investments in cutting-edge fabrication facilities. The number of IDMs capable of manufacturing ICs diminished significantly with more advanced technology nodes. Of the 22 IDMs with a 130 nanometer (nm) fabrication facility, nine invested in a 45 nm facility, and only five IDMs invested in a 32/28 nm fabrication facility (Table 5). In 2012, Intel, Samsung, and IBM were the only IDMs capable of manufacturing 20 nm chips. The rest of the IDMs have resorted to outsourcing next-generation chip fabrication to pure-play foundries. The latter reduces the risk of losing out in costly investments of state-of-the art fabrication facilities by pooling demand from fab-lite IDMs and the fabless semiconductor companies.

Table 4: Top 10 IDMs with Fab-lite Strategies

Company	Year strategy announced**	Strategies/objectives
Texas Instruments (US)	2000 initially, expanded in 2007	Outsourced 25% of wafers; 75% of advanced CMOS in 2012
Toshiba (Japan)	Dec 2010	Aims to outsource 50% of SoC in 2011 and 80% by 2013
Renesas (Japan)	July 2010	Outsource all ICs with 28nm and below processes
STMicro (FR-IT)	2006	Aims to make 80% of its wafers overall and outsource about two-thirds of advanced CMOs processes
Sony (Japan)	2007	At least 30% of ICs outsourced
Infineon (DE)	2005	About 6%–7% of wafers outsourced in 2010
NXP (NL)	2007	About 25% of its production outsourced in 2010
Freescale (US)	1998 initially, reset several times	About 31% of its wafers outsourced in 2012
Fujitsu (Japan)	2009	Continues to make LSI logic down to 45nm feature sizes
Atmel (US)	2006	About 32% of its production outsourced in 2010

Note :CMOs = Complementary Metal-Oxide Semiconductor, DE = Denmark, FR-IT = France–Italy, ICs = integrated circuits, NL = Netherlands, nm = nanometer, SoC = system-on-chip, US = United States.
** IC Insights (2011).
Sources: Company profiles; IC Insights (2011).

Table 5: Foundries by IC Production Capability

IC technology node	Integrated device manufacturer (IDM)	Pure-play foundry
130nm	Intel, Samsung, IBM, ST, Panasonic, Renesas, TI, Toshiba, Fujitsu, AMD, Motorola, Infineon, Sony, Cypress Sharp, ADI, Atmel, Mitsubishi, ON Semiconductors, Rohm, Sanyo	
45nm	Intel, Samsung, IBM, ST, Panasonic, Renesas, TI, Toshiba, Fujitsu	TSMC, GlobalFoundries, UMC, SMIC
32/28nm	Intel, Samsung, IBM, ST, Panasonic	TSMC, GlobalFoundries, UMC
22/20nm	Intel, Samsung, IBM	TSMC, GlobalFoundries, UMC

Note :IC = integrated circuit, nm = nanometer, SMIC = Semiconductor Manufacturing International Corporation, TI = Texas Instruments, TSMC = Taiwan Semiconductor Manufacturing Company, UMC = United Microelectronics Corporation.
Source: IC Insights (2012).

Taiwan is the home base of the top two global foundries—Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics

Corporation (UMC)—which jointly accounted for 60 percent of the US$34.6 billion in worldwide semiconductor foundry revenues in 2012. Other leading foundries include Global Foundries (Abu Dhabi, United Arab Emirates), which accounted for 12 percent, and the China-based Semiconductor Manufacturing International Corporation (SMIC), which contributed 5 percent of foundry revenues worldwide. The strategic alliances by foundries with fab-lite IDMs and fabless companies are essential to have economies of scale, minimize underutilization of very costly manufacturing plants, and sustain profit margins.

The semiconductor industry has likewise evolved over the decades from one that was dominated by the IDMs until the 1990s, to the stronger and growing presence of pure-play foundries and fabless companies in the past two decades (Table 6). Two-thirds of the top 20 global semiconductor companies in 2012 are fab-lite IDMs or fabless companies. Leading fab-lite companies include Texas Instruments and a number of Japanese firms including Toshiba, Renesas, and Sony. US-based companies like Qualcomm, Broadcom, AMD, and Nvidia led the fabless semiconductor industry while Taiwan's TSMC and UMC took the lion's share of the foundry market. The top 20 semiconductor companies contributed $211.5 billion in revenues or 70 percent of worldwide semiconductor revenues in 2012. Of this market share, 44 percent were contributed by the IDMs, 28 percent by fab-lite companies, 16 percent by fabless companies, and 11 percent by foundries.

The past two decades also witnessed major shifts in global leadership in semiconductors. The 1990s reflected the leadership dominance of Japan, which had at least 5 out of the 10 leading semiconductor companies worldwide and which held the top three spots in 1990. The year 2005 saw the resurgence of the US semiconductor industry led by Intel, which alone accounted for 15 percent, and jointly with five other leading US-based companies captured 27 percent of the $237 billion in worldwide revenues for that year. By comparison, NEC and Toshiba slipped down in global ranking from first and second in 1990 to fourth and ninth in 2005. The top seven Japanese companies contributed 16 percent of worldwide semiconductor revenues in 2005. By 2012, only three Japanese companies entered the top 20 list, namely, Toshiba, Renesas, and Sony, which jointly contributed nine percent of the almost $300 billion worldwide semiconductor revenues. This is way below the corresponding share of 46 percent by the leading Japanese-based semiconductor companies in the top 20 list in 1990. Japan’s diminishing leadership was associated with the revival of US-based pioneering semiconductor IDMs which, along with the leading fabless companies in the top 20 list, accounted for 33 percent of worldwide semiconductor revenues in 2012. Japan also lost significant spots in 2012 to South Korea and Taiwan with the South Korean–based IDMs Samsung and SK Hynix capturing 16 percent, while that of Taiwan foundry giants TSMC and UMC, as well as fabless leader Media Tek, jointly accounted for 24 percent of the worldwide revenues (Table 6).

As a strategic move to improve competitive advantage, US-based IDMs began offshoring in the 1960s the most labour intensive portion of the chip supply chain, namely, assembly and test (Brown and Linden, 2005). Majority of these assembly plants were put up in Asian countries with positive foreign investment policies and lower-cost, less-skilled labour.

Table 6: Top 20 Semiconductor Companies Worldwide, 1990, 1995, 2005, and 2012

Rank	Company	Business model	1990 Revenue US$M		Company	Business model	1995 Revenue US$ M
1	NEC (Japan)	IDM	4,322		Intel (US)	IDM	13,172
2	Toshiba (Japan)	IDM	4,202		NEC (Japan)	IDM	11,314
3	Hitachi (Japan)	IDM	3,539		Toshiba (Japan)	IDM	10,077
4	Motorola (US)	IDM	3,516		Hitachi (Japan)	IDM	9,137
5	Intel (US)	IDM	3,171		Motorola (US)	IDM	8,732
6	Fujitsu (Japan)	IDM	2,599		Samsung (S. Korea)	IDM	8,329
7	TI (US)	IDM	2,574		TI (US)	IDM	7,831
8	Mitsubishi (Japan)	IDM	2,108		Fujitsu (Japan)	IDM	5,538
9	Philips (NL)	IDM	1,955		Mitsubishi (Japan)	IDM	5,272
10	Matsushita (Japan)	IDM	1,826		Hyundai (S. Korea)	IDM	4,132
11	National Semicon (US)	IDM	1,653		Philips (NL)	IDM	3,901
12	SGS-Thomson (FR-IT)	IDM	1,441		IBM (US)	IDM	3,522
13	Samsung (KR)	IDM	1,315		Matsushita (Japan)	IDM	3,476
14	Siemens (DE)	IDM	1,204		SGS-Thomson (FR–IT)	IDM	3,554
15	Sanyo (Japan)	IDM	1,196		Siemens (DE)	IDM	3,062
16	Sharp (Japan)	IDM	1,194		LG (S. Korea)	IDM	2,863
17	AMD (US)	IDM	1,053		Sanyo (Japan)	IDM	2,714
18	Sony (Japan)	IDM	1,010		Micron (US	IDM	2,601
19	OKI (Japan)	IDM	954		Sharp (Japan)	IDM	2,592
20	Harris (US)	IDM	800		National Semicon (US)	IDM	2,408

Rank	Company	Business model	2005 Revenue US$M		Company		2012 Revenue US$ M
1	Intel (US)	IDM	35,466		Intel (US)	IDM	49,370
2	Samsung (S. Korea)	IDM	17,210		Samsung (S. Korea)	IDM	30,425
3	TI (US)	IDM	10,745		TSMC (Taiwan)	Foundry	17,022
4	Toshiba (Japan)	IDM	9,077		Qualcomm (US)	Fabless	12,807
5	STMicro (FR–IT)**	IDM	8,881		TI (US)	Fab-lite	12,063
6	Renesas (Japan)**	IDM	8,310		Toshiba (Japan)	Fab-lite	11,075
7	Infineon (DE)**	IDM	8,266		Renesas (Japan)**	Fab-lite	9,839
8	TSMC (Taiwan)	Foundry	8,217		SK Hynix (S. Korea)**	IDM	8,802
9	NEC (Japan)	IDM	5,710		STMicro (FR-IT)	Fab-lite	8,654
10	Philips (NL)	IDM	5,646		Broadcom (US)	Fabless	8,384
11	Freescale (US)**	IDM	5,598		Micron (US)**	IDM	7,740
12	Hynix (S. Korea)**	IDM	5,560		Sony (Japan)	Fab-lite	6,245
13	Micron (US)	IDM	4,775		AMD (US)	Fabless	5,423
14	Sony (Japan)	IDM	4,574		Infineon (DE)**	Fab-lite	4,984
15	Matsushita (Japan)	IDM	4,131		GlobalFoundries (UAE)	Foundry	4,560
16	AMD (US)	IDM	3,917		NXP (NL)**	Fab-lite	4,397
17	Qualcomm (US)	Fabless	3,457		Nvidia (US)	Fabless	4,300
18	Sharp (Japan)	IDM	3,266		Freescale (US)**	Fab-lite	4,274
19	UMC (Taiwan)	Foundry	3,259		UMC (Taiwan)	Foundry	3,787
20	Rohm (Japan)	IDM	2,909		Media Tek (Taiwan)	Fabless	3,734

Note: DE = Denmark, FR = France, IDM = integrated device manufacturer, IT = Italy, NL = Netherlands, TI = Texas Instruments, UAE = United Arab Emirates, UMC = United Microelectronics Corporation, US = United States.
**Infineon was a spin-off from Siemens; Renesas was a merger of Mitsubishi and Hitachi; Freescale was a spin-off from Motorola; Micron Technology acquired in 2012 Elpida Memory, which was a merger of NEC and Hitachi; SK Hynix was formerly LG; STMicroelectronics was formerly SGS-Thomson; ON Semiconductor was a spin-off from Motorola; NXP Semiconductors was formerly Philips Semiconductors.
Sources: IC Insights (2012); Gartner (2013).

With the large and growing market share of Asia for semiconductors, final testing and shipment to Asian customers were added to these assembly facilities in the 1980s, which was also a period of increasing automation in semiconductor back-end processes. Over the years, the IDMs' offshoring of chip assembly led to the emergence of contract companies that are dedicated to investing in leading-edge package and test solutions. These companies, mostly based in Asia, offered contract assembly and test services to IDMs, fabless companies, and foundries located in Asia.

The global industry for assembly and testing is segmented dually into the sector comprising of a handful of highly technologically advanced companies and the majority of players with traditional packaging capability and doing the low-end, price-driven products. IC packaging needed to keep pace with the advancement in chip performance towards further miniaturization, as well as faster and lower-cost products. Only a few OSAT companies would have the capability to undertake large investments in R&D for packaging and test solutions, which evolved with the advance in chip technology. In 2011 and 2012, four OSAT companies accounted for 45 percent of the OSAT revenue markets. Advanced Semiconductor Engineering has retained the lead spot, capturing close to a fifth of the $24.5 billion worldwide revenues for assembly and test services in 2012. Amkor Technology came in second with a market share of 11 percent, followed closely by Siliconware Precision Industries Co. with a market share of nine percent, and STATSChipPAC Ltd. with a share of seven percent (Gartner, 2013).

These four leading OSAT companies generated positive market growth from undertaking heavy investments in advanced packaging technologies, such as flip chip and advanced wafer level packaging technologies. Advanced Semiconductor Engineering, for example, increased its investment in advanced packaging technologies from $90 million in 2011 to $200 million in 2012 (Molnar, 2012). Packaging comprises 80.5 percent of the revenue of Advanced Semiconductor Engineering, which totalled $4.4 billion in 2012 and 90 percent of Siliconware Precision Industries' revenue of $2.2 billion (Gartner, 2013).

4. The Philippines' Position in the Global Semiconductor Value Chain

Increased trade liberalization and fiercer competition in the international markets have induced semiconductor companies to engage in production fragmentation to be more cost efficient. This involves dividing different activities in the production chain across different subsidiaries of a company in different locations. International production networks foster the link between developed economies and developing countries. The Philippines participates in the global value chain primarily through semiconductor exports by multinational companies that import the intermediates from the parent country.

4.1. IDMs and Fabless Semiconductor Companies

The Philippine semiconductor industry began in the early 1970s when leading IDMs in the US established assembly and test facilities in Southeast Asia to take advantage of its low labour cost and sustain cost-competitiveness in the global trade. The semiconductor industry in the Philippines has been primarily at the back-end process of the value chain and comprises largely of small subcontractors for assembly and testing that have limited research and development (R&D) investments and innovation and, hence, have narrow prospects for sustained positive growth.

The few giant semiconductor companies in the Philippines in 2012 are largely US based. Of the 12 leading IDMs that made it to the top 20 semiconductor companies worldwide in 2012, only four companies have manufacturing facilities in the Philippines, including Texas Instruments, STMicro, NXP, and Samsung Electro-Mechanics, which is a subsidiary of Samsung Electronics (Table 7). Other IDMs that have put up manufacturing capabilities in the Philippines are mainly US-based companies, such as Analog Devices Inc., Cypress Semiconductor, ON Semiconductor, and Maxim Integrated.

While the Philippines may have been favoured by a handful of leading semiconductor IDMs as a location for their back-end manufacturing operations, it is not a preferred site for R&D. Most of the leading vertically integrated semiconductor companies have set up design centres in China and India, and a significant number have done so in Japan, South Korea, and Taiwan. In Southeast Asia, Singapore and Malaysia are the top chosen destinations for setting up engineering capabilities among the leading IDMs.

Malaysia, which developed its semiconductor industry at about the same time as that of the Philippines in the early 1970s, is by far a more preferred location in 2012 than the Philippines, with 8 out of the 12 leading IDMs—including the chipmaker giant Intel— establishing both manufacturing and R&D capabilities in Malaysia. Singapore is also a choice destination with 6 of the 12 leading IDMs establishing affiliate companies in Singapore. Underpinned by a substantial and growing consumer base and a positive policy environment for FDI, China has attracted all global semiconductor giants to set up manufacturing plants in China and with many leading IDMs also setting up their design centres there, such as Intel, Samsung, Texas Instruments, and Renesas (Tables 7).

The dominance of China is also indicated by the preference of leading fabless semiconductor companies to establish affiliates in China. Of the top 25 fabless companies, 22 have established manufacturing presence in China, including Qualcomm, Broadcom, AMD, Nvidia, Marvell, and Media Tek (Table 8). China has also two local companies that made it to the top 25 list in 2011. China-based Spreadtrum posted the highest growth in revenues, which increased from US$105 million in 2009 to US$674 million in 2011. Taiwan, which is intimately linked with China in the international production network, is the home base of five fabless companies with Taiwan-based MStar and Novatek recording very high growth rates of 21 percent between 2009 and 2011.

The Philippines is way below from making the grade as a regional centre for R&D in chip design. Of the top 25 fabless companies in 2011, none have product design operations in the Philippines. Singapore is the home base of Avago, which is among the leading fabless semiconductor company worldwide. Along with Malaysia, Singapore tops the list as a favoured location for setting up of affiliates by US- and Europe-based global fabless companies. Semiconductor EDA suppliers and IP core vendors have also established R&D operations in China, India, Japan, South Korea, and Taiwan and, to some extent, in Singapore and Malaysia, but not in the Philippines (Table 9).

Table 7: Locations in Asia for Leading Semiconductor IDMs, 2012

Company	Headquarters	Locations in Asia
Intel	United States	R&D: China, India, Malaysia Manufacturing: China, India, Malaysia, Viet Nam
Samsung Electronics	South Korea	R&D centres: South Korea, China, India, Japan, Taiwan Manufacturing: South Korea, China
Samsung Electro-Mechanics	South Korea	R&D: South Korea Manufacturing: South Korea, China, Thailand, Philippines
Texas Instruments	United States	R& D: India, China, Japan Manufacturing: China, Japan, Malaysia, Philippines, Taiwan
Toshiba	Japan	R&D: Japan, China Manufacturing: Thailand
Renesas Electronics	Japan	Design centres: Japan, China, Malaysia, Viet Nam Manufacturing & Engineering services: Japan, China, Singapore, Malaysia
SK Hynix	South Korea	R&D: South Korea, Taiwan Manufacturing: South Korea, China, Taiwan
STMicro	France–Italy	R&D: Singapore, India Manufacturing: China, Malaysia, Philippines, Singapore
Micron	United States	R&D: China, Japan, South Korea Manufacturing: Singapore, China, Taiwan, Japan, Malaysia, Singapore
Sony	Japan	R&D: China, India, Japan, Singapore
AMD	United States	R&D: China, Taiwan Manufacturing: China, Malaysia, Singapore
Infineon	Germany	R&D: China, India, Singapore, Taiwan Manufacturing: Malaysia,
NXP	Netherlands	Design centres: China, India, Hong Kong, Singapore, Manufacturing: China, Malaysia, Philippines, Singapore, Taiwan, Thailand
Freescale	United States	Design centres: China, India, Malaysia Manufacturing: China, Malaysia
Rohm	Japan	Design centres: China, South Korea, Taiwan, Philippines (Rohm LSI Design) Manufacturing: China, South Korea, Malaysia, Philippines, Thailand,
Analog Devices Inc.	United States	Engineering offices: China, India, Japan, Philippines Manufacturing: Philippines
ON Semiconductor	United States	Design and solution engineering centres: China, India, Japan, South Korea, Philippines, Taiwan Manufacturing: China, Japan, Malaysia, Philippines, Viet Nam
Fairchild Semiconductors	United States	R&D, design centres: China, India, South Korea, Taiwan Manufacturing: China, South Korea, Malaysia, Philippines
Maxim Integrated	United States	Design centres: India, China, South Korea, Taiwan Manufacturing: Philippines, Thailand
Cypress Semiconductor	United States	R&D: China, India, Philippines Manufacturing: China, Philippines

Note :IDMs = integrated device manufacturers, R&D = research and development.
Sources: Company profiles.

Table 8: Location in Asia for the Top 2011 25 Fabless Semiconductor Companies in the World

Name of company	Headquarters	Locations in Asia
Qualcomm	United States	China, India, South Korea
Broadcom	United States	China, India, Japan, South Korea, Singapore, Taiwan
AMD	United States	China, Taiwan
Nvidia	United States	China, India, Japan, South Korea, Taiwan
Marvell Technology	United States	China, Hong Kong, India, Japan, South Korea, Malaysia, Singapore, Taiwan
Media Tek	Taiwan	China, India, Japan, South Korea, Singapore, Taiwan
Xilinx	United States	Corporate offices: China (Hong Kong), India, Japan, Singapore Research laboratory: India
Altera	United States	Corporate offices: China (Hong Kong), Japan, Malaysia
LSI Group	United States	China, India, Japan
Avago	Singapore	Singapore
MStar	Taiwan	China, South Korea, Japan, Taiwan
Novatek	Taiwan	China, Japan, Hong Kong, Taiwan
CSR	Europe	China, India, Japan, South Korea, Singapore, Taiwan
ST-Ericsson	Europe	China, India, Japan, South Korea, Singapore, Taiwan
Realtek	Taiwan	China, Japan, Taiwan
HiSilicon	China	China
Spreadtrum	China	China, India, South Korea, Taiwan
PMC-Sierra	United States	China, India
Himax	Taiwan	China, Japan, South Korea
Lantiq	Europe	China, India, Singapore, Taiwan
Dialog Semiconductor	Europe	China (Hong Kong), Japan, South Korea, Singapore, Taiwan
Silicon Labs	United States	Singapore
Mega Chips	United States	China, India, Taiwan
Semtech	United States	China, India, Japan, South Korea, Malaysia, Philippines, Taiwan
SMSC	United States	China, India, Japan, South Korea, Taiwan

Sources: Company profiles.

Table 9: Location in Asia for Semiconductor IP Core Suppliers

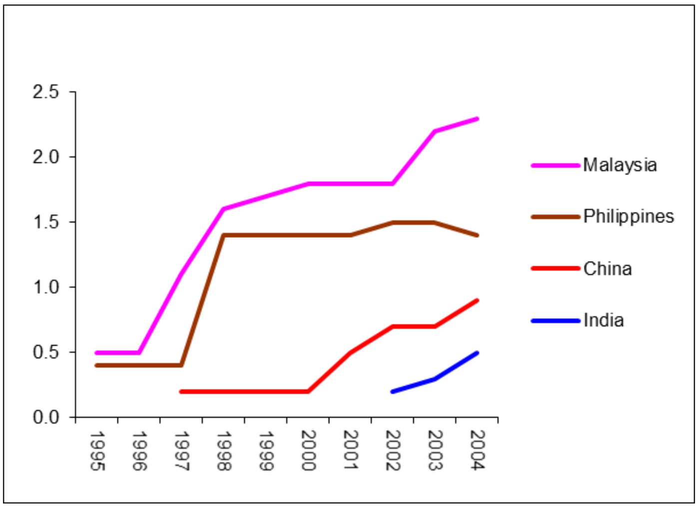
Name of company	Headquarters	Locations in Asia
ARM Holdings	United Kingdom	China, India, Japan, South Korea, Taiwan
Cadence Design System	United States	China, India, Japan, South Korea, Singapore, Taiwan
Imagination Technologies	United Kingdom	China, India, Japan, South Korea, Taiwan
Synopsys	United States	China, India, Japan, South Korea, Malaysia, Singapore, Taiwan
CEVA	United States	China, Japan, South Korea, Taiwan
EnSilica	United Kingdom	India
Dolphin Integration	France	China

Note: IP = intellectual property.
Sources: Company profiles.

There is some indication that the Philippines had regressed from successfully competing in global semiconductor trade and knowledge-intensive FDI. In 2009, the world's leading semiconductor company, Intel, closed its assembly and test plant in the Philippines which it established in 1974 after it launched a similar plant in Malaysia. In 1995, Intel's plants in the Philippines and Malaysia occupied an area of 431,000 square feet (ft^2) and 531,000, ft^2 respectively (Figure 8). In the next decades, Intel not only expanded manufacturing operations but also established a research and product development centre in Malaysia in 1999.

Although it has strengthened its manufacturing capabilities in the Philippines with a more-than-triple increase in facility area to 1.3 million ft^2 by 1998, Intel did not establish an R&D centre in the country. In 2004, the Intel facility area in the Philippines was largely the same as it was in 1998 while that in Malaysia increased further to 2.3 million ft^2. Intel's assembly and test operations in Asia, which were largely concentrated in Malaysia and the Philippines in the 1990s, expanded to China where facility size almost tripled from 187,000 ft^2 in 2000 to 513,000 ft^2 in 2001. By 2002, Intel had established a research and product development centre in China and India.

Figure 8: Facility Size (million ft^2)**, Intel, 1995–2004**



Source: Company profiles.

When China began to emerge as a strong player in the 2000s, the Philippines struggled to weather the fierce competition from China, along with China's neighbouring countries, which have less innovative capacity but offer cheaper labour costs. After Intel closed its assembly plant in the Philippines in 2009, it opened a 500,000 ft^2 assembly and test facility in Viet Nam the following year. The transfer was made despite the advantage of the Philippines over Viet Nam in terms of educated manpower and engineering talent. To develop its manpower resource in Viet Nam, Intel implemented a scholarship programme for bright engineering Vietnamese students to complete a bachelor of science degree in electrical or mechanical engineering and supply and logistics management in Portland State University, conditional on their commitment to work for at least three years at Intel's facility in Viet Nam after graduation.

Intel's manufacturing investment appeared to have a huge positive impact in Viet Nam's semiconductor industry as the latter's semiconductor exports surged by an annual average of 58 percent between 2006 and 2012. By comparison, Intel's closure of its manufacturing plant in the Philippines may have contributed to the decline in the Philippine semiconductor exports from an annual average of about US$16.7 billion for the pre-Intel closure period of 2006-2008 to US$9.8 billion annual average between 2010 and 2012. The value of Viet Nam's semiconductor exports was only less than 1percent that of the Philippines in 2006 but increased to 17 percent by 2012.

Figure 9: Value of Electronic ICs and Diodes Exports, Philippines and Vietnam

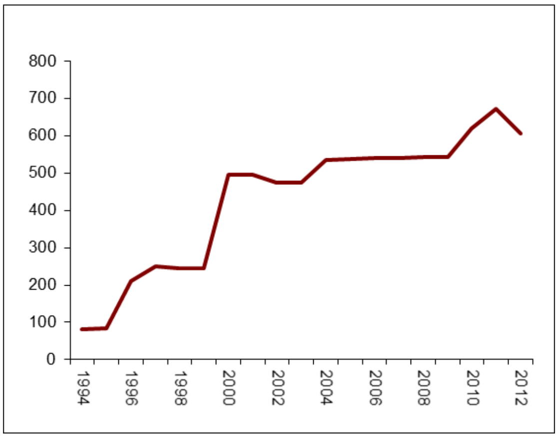
(in million US$)

Source: Compiled from the UN Commodity Trade Statistics Database.

The establishment of an Intel affiliate in the early 1970s stimulated the stream of back-end manufacturing outsourcing by pioneering US-based semiconductor companies to Southeast Asia, including the Philippines. In 1979, Texas Instruments (TI) established its first assembly and test plant in the Philippines. With a revenue of US$12 billion, TI occupies the fifth lead spot of semiconductors worldwide in 2012, next to IDM leaders Intel and Samsung, and following foundry giant TSMC and fabless company Qualcomm. Analogue semiconductors and embedded processors are the primary products of TI. Analogue semiconductors account for 55 percent of its revenue and comprise 18 percent of the worldwide market for analogue semiconductors in 2012. Embedded processing products account for 15 percent of its revenue and 12 percent of the worldwide market for embedded processors. While Intel folded up its assembly and test facility in the Philippines in 2009, TI opened its second manufacturing plant with leading-edge packaging technologies in the Clark Freeport Zone spanning 780,000 ft^2. Both TI plants earned a Leadership in Energy and Environmental Design (LEED) certification, with its 280,000 ft^2 plant in Baguio City being the first LEED-certified facility in the Philippines and the newer facility in Clark, Pampanga as the first LEED gold-certified semiconductor fabrication plant in the world.

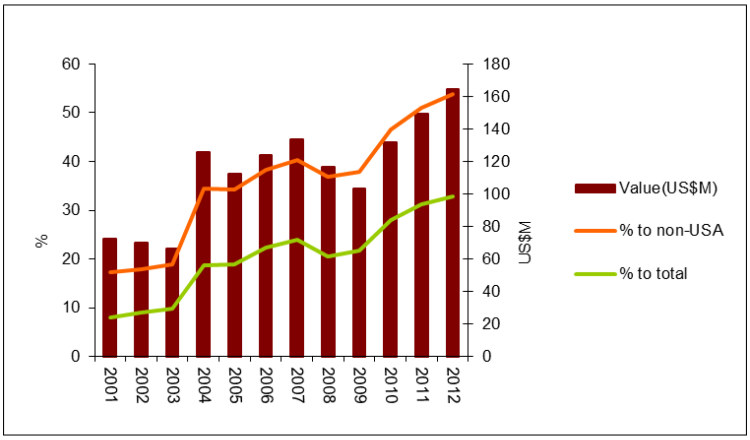
A strong competitor of TI in the analogue product segment is the US-based Analog Devices Inc. (ADI), the leading global supplier of data converter and high-performance amplifiers with a total revenue of US$2.7 billion in 2012. The 605,000 ft^2 Philippine facility is the largest manufacturing facility of ADI and performs wafer probe and testing. The Philippines is among the three of ADI's product and failure analysis regional centres, along with that in Ireland and in Massachusetts. The continuous expansion of ADI's manufacturing capabilities in the Philippines is reflected in the large increases in Philippine facility size and investments in property and equipment from 1994 to 2012 (Figures 10 and 11). A sharp uptake in investments was observed in 2000 when the company opened a new plant in Gateway Business Park, Cavite. In 2003, the company's facility in Manila transitioned from assembly to higher-value test of more complex products with the product assembly outsourced to subcontractors. The Philippines benefited from a disproportionate share of the company's investments in physical capital. By 2012, the value of ADI's Philippine facility is estimated at US$165 million and accounted for one-third of ADI's total property and equipment assets and more than half of physical assets in their foreign locations.

Figure 10: Facility Size of Analog Devices Inc., Philippines, 1994–2012 ('000 ft^2)



Source: Company profiles.

Figure 11: Value of Property, Equipment, and Land of Philippine Facility and Percentage to Foreign and Total Property Value, Analog Devices Inc. 2001–2012 (US$ million)

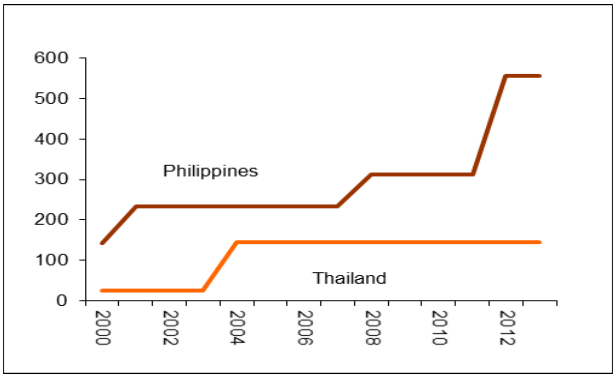


Source: Company profiles.

Maxim Integrated Products Inc. (Maxim) is a US-based company that designs, manufactures, and sells analogue ICs with a total revenue of US$2.44 billion by the end of June 2013. In the first half of the 2000s, the final testing of the majority of Maxim's products typically assembled by Asian subcontractors were performed in its Philippine facility before shipment to the end-customer. Maxim put up another testing facility in Thailand in 2004 and set up a new module assembly plant in Batangas, Philippines in 2007. By June 2013, Maxim performed virtually all of its wafer sorting, final testing, and shipping activities at both the Philippine and Thailand facilities, with the Philippine facilities performing about two-thirds of the operation. Maxim's manufacturing capability in the Philippines has grown over the past decade with a marked increase observed in 2012 (Figures 12 and 13). The two Philippine facilities occupies a total area of 557,000 ft^2 while Maxim's Thailand facility spans 144,000 ft^2. In June 2013, the net value of long-lived assets in Maxim's Philippine facility was US$184 million and represents 13 percent of the company's total net long-lived assets and 60 percent of that in foreign locations.

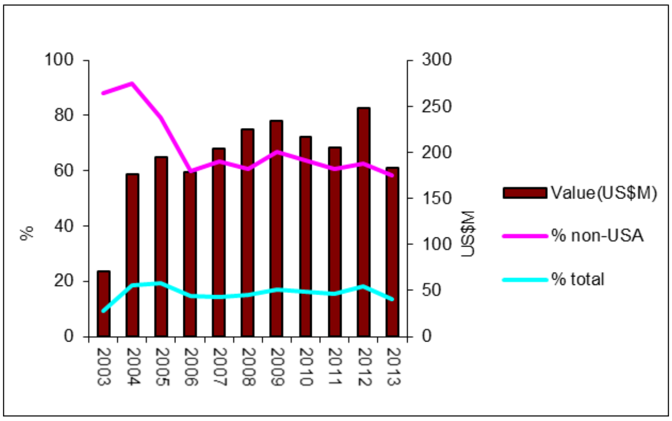
A couple of IDMs have established their design centres in the Philippines, namely, ON Semiconductor Corporation and Cypress Semiconductor Corporation. ON Semiconductor Corporation had a total revenue of US$2.9 billion in 2012 from sales of its wide array of analogue component products. In 2011, ON Semiconductor acquired the Japan-based Sanyo Semiconductor Inc., and expanded further its range of products to include microcontrollers and custom ASICs, integrated power modules, and motor control devices. ON Semiconductor's manufacturing operations are largely in Asia with assembly and test facilities in the Philippines, China, Viet Nam, Japan, and Malaysia, and with the latter two also performing front-end manufacturing processes. Both the Philippines and Malaysia perform wafer probe in addition to assembly and test.

Figure 12: Facility Size of Maxim Integrated Products Inc.
June 2000–June 2013 ('000 ft^2)



Sources: Company profiles.

Figure 13: Value of Property, Equipment, and Land of Philippine Facility and Percentage to Foreign and Total Assets, Maxim
June 2003– June 2013 (US$ million)

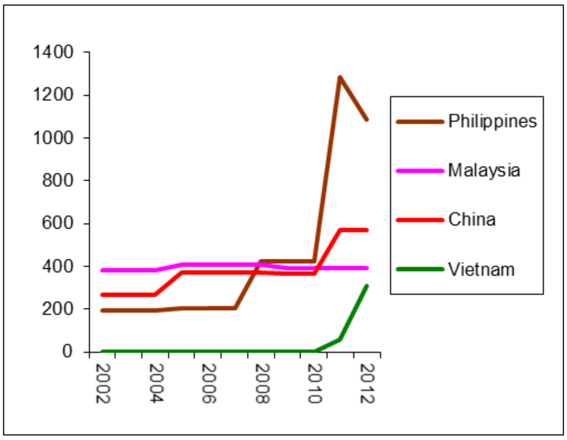


Sources: Company profiles.

ON Semiconductor's manufacturing capability in the Philippines in terms of facility size has been on an upward trend since 2007 with a marked increase observed in 2011 upon its acquisition of Sanyo Semiconductor's Philippine facilities (Figure 14). The company's property, land, and equipment were valued in 2012 at close to US$190 each for the Philippines and Malaysia (Figure 12). The corresponding values for China and Viet Nam were US$104 million and US$35 million, respectively. Apart from the US, Canada, and some European countries, ON Semiconductor also has design operations in China, India, Japan, South Korea, and the Philippines. About US$368 million or 13 percent of its total revenue in 2012 was allocated to R&D with focus on power management solutions. This R&D budget represents a US$120 million increase from the corresponding level in 2010.

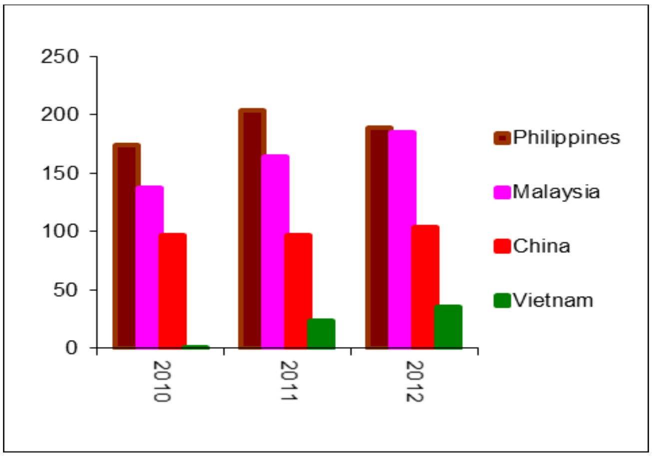
Figure 14: Facility Size, ON Semiconductor, Selected Asian Countries, 2002–2012

('000 ft^2)



Sources: Company profiles.

Figure 15: Value of Property, Land, and Equipment of ON Semiconductor Selected Asian Countries, 2002–2012 (US$ million)

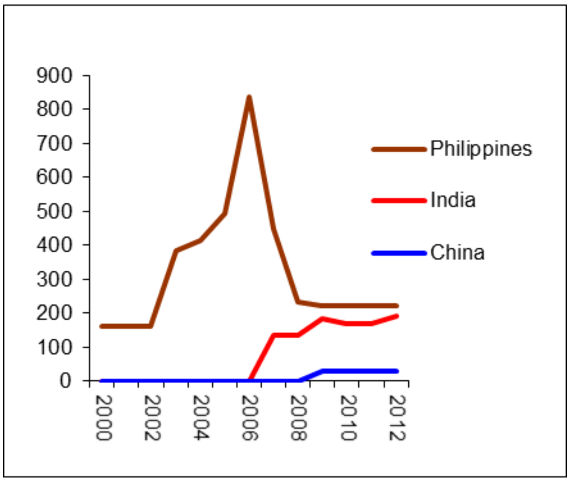


Sources: Company profiles.

Cypress Semiconductor had also put up research capabilities in the Philippines. Its revenue in 2012 was US$769.7 million and is the leading global provider of universal bus controllers (USB) and high-performance static random access memory (SRAM) products. It invented the programmable system-on-chip in 2000 and continues to introduce innovations in low-power, high-performance programmable system-on-chip products and touch screen chips. Cypress Semiconductor established a highly automated facility in the Philippines that manufactures high-volume products and packages and accounted for 36 percent of the company's total assembly and test output in 2012. Apart from the Philippines, the Asian locations of the company's research and product development centres are China and India. From US$176.8 million in 2010, Cypress Semiconductor increased its R&D investments to an annual average of US$190 million in 2011 and 2012. The company's long-lived assets in the Philippines were valued at US$73 million in 2012 or 27 percent of its total long-lived assets and close to 80 percent that of its foreign locations (Figures 12 and 13).

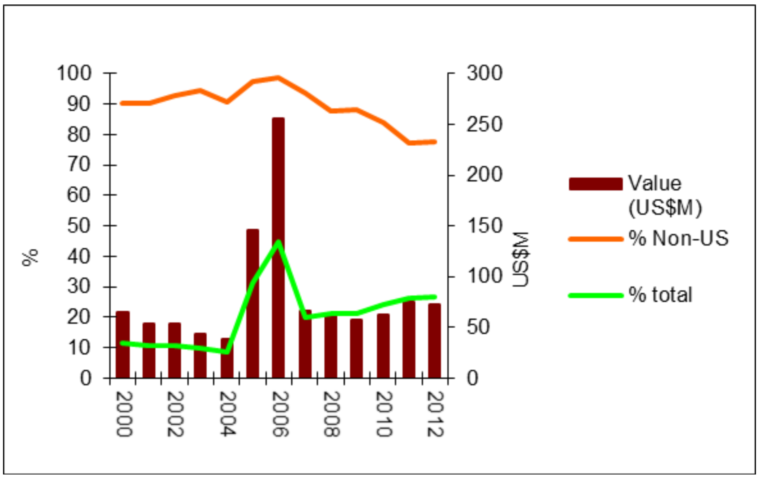
Manufacturing and engineering activities of Cypress Semiconductor in Asia were concentrated largely in the Philippines, before the establishment of a design centre in India in 2007 and in China in 2009. The company acquired additional properties in the Philippines between 2003 and 2006, most of which were leased to its subsidiary, SunPower Corporation, a vertically integrated company for high-performance solar electric power technologies. In 2008, SunPower Corporation purchased the previously leased manufacturing facilities from Cypress Semiconductor.

Figure 16: Facility Size, Cypress Semiconductor, 2002–2012 (‘000 ft^2)



Sources: Company profiles.

Figure 17: Value of Property, Land, and Equipment in the Philippines, Cypress Semiconductor 2002–2012 (US$ million)



Sources: Company profiles.

Another majority-owned and fully independent subsidiary of Cypress Semiconductor, the Deca Technologies, was launched in 2011 and established engineering capabilities in the Philippines. Deca Technogies is a global provider of advanced electronic interconnect solutions. It recently introduced its proprietary solution for die alignment issues in embedded packaging through adaptive patterning. It also offers wafer-level chip scale packaging services through a process that is less costly and has shorter manufacturing cycle time.

Finally, Lattice Semiconductor Corporation had established an engineering development centre in the Philippines in 2011 to consolidate its R&D operations. It is a US-based fabless semiconductor company that designs and markets high-performance programmable logic devices and has a revenue of US$279 million in 2012. With product development centres in the US, China, and the Philippines, the company's investment in R&D activities increased from US$60 million in 2010, US$72 million in 2011, to US$77 million in 2012. Apart from putting up an R&D centre in the Philippines, the company also transferred the supply chain support activities from its headquarters in Oregon to its operations centre in Singapore and in Manila, Philippines. The company's wafer fabrication is performed by foundry partners in Japan, Taiwan, and Singapore while the assembly and test operations are outsourced to subcontractors in Indonesia, Malaysia, and the Philippines.

4.2. Outsourced Semiconductor Assembly and Test Companies

China and Taiwan are the favoured locations for OSAT companies, which thrive in areas of high foundry concentration. Foundries manufacture the chips that OSATs package and test before these are shipped to the end-customer. Relative to the foundries, the OSATs are more dedicated to undertake innovations in packaging and testing solutions, allowing them to offer a wider range of differentiated service and product options across a broader set of end-market applications and achieve scale economy. OSATs also possess the manpower expertise that allows for a shorter cycle from packaging to product market shipment.

Of the top 15 OSAT companies in the world, only Amkor Technology has an assembly and test plant in the Philippines (Table 10). Taiwan is the home base of 7 out of 15 leading OSAT companies, including the top-notch Advanced Semiconductor Engineering. China houses 11 of the top 15 OSAT companies in the world, including its own Jiangsu Electronics Technology, which ranked eighth in terms of worldwide OSAT revenues in 2011. Singapore is the home base for STATSChipPac and United Test and Assembly Center, the fourth and sixth leading OSATs worldwide, and it lodges three other top OSAT companies. Five OSAT companies in the top 15 are located in Malaysia in 2011, including two of its own company—Unisem and Carsem.

Table 10: Location in Asia for the 2011 Top 15 OSATs in the World

Name of company	Headquarters	Locations in Asia
1. Advanced Semiconductor Engineering, Inc.	Taiwan	China, Japan, South Korea, Malaysia, Singapore, Taiwan
2. Amkor Technology	United States	Philippines, China, Japan, South Korea, Singapore, Taiwan
3. Siliconware Precision Industries Co.	Taiwan	China, Taiwan
4. STATS ChipPAC	Singapore	China, South Korea, Malaysia, Singapore, Thailand, Taiwan
5. Powertech Technology	Taiwan	China, South Korea, Malaysia, Singapore, Thailand, Taiwan
6. United Test and Assembly Center	Singapore	China, Singapore, Thailand, Taiwan
7. ChipMOS	Taiwan	China, Taiwan
8. Jiangsu Changjiang Electronics Technology Co	China	China
9. J-Devices Co.	Japan	Japan
10. King Yuan Electronics Co	Taiwan	China, Taiwan
11. Chipbond Technology Co	Taiwan	Taiwan
12. STS Semiconductor	South Korea	South Korea
13. Formosa Advanced Technologies	Taiwan	Taiwan
14. Unisem	Malaysia	China, Indonesia, Malaysia
15. Carsem	Malaysia	China, Malaysia

Sources: Company profiles.

Costly investments in advanced packaging technologies by OSAT companies can be offset by a high volume demand from global foundry leaders. Taiwan dominates the market for both semiconductor front-end and back-end manufacturing. It holds monopoly power in the foundry market with the two Taiwan-based giant foundries of TSMC and UMC, jointly taking the lion's share (60%) of the US$34.6.worldwide semiconductor foundry revenues in 2012. Taiwan also retains the leading position in the semiconductor assembly and test services market, with its five leading OSAT companies generating a combined revenue of US$8.7 billion or 36 percent of the worldwide OSAT market in 2011. The revenue of the Taiwan-based Advanced Semiconductor Taiwan for IC packaging and test was over US$13 billion annually since 2010, representing 55 percent of worldwide revenues. IC packaging revenues in Taiwan was over US$9 billion annually since 2010 or about 70 percent of IC packaging assembly and test services revenues. For Taiwan's leading high-technology OSATs—Advanced Semiconductor Engineering and Siliconware Precision Industries Co.—IC packaging accounted for a much higher share of over 80 percent of total revenues in 2012 (Gartner, 2013).

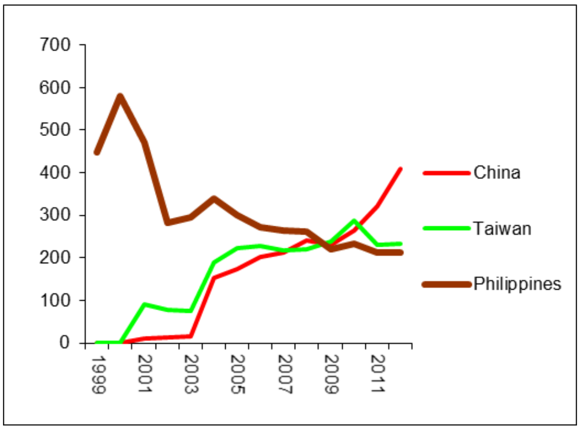
China itself has infused large investments in semiconductor fabrication plants in the past decade. According to PricewaterhouseCooper's report (2012), China's growth in wafer fabrication net capacity of nine percent between 2010 and 2011 has far outstripped that of the world, which was at four percent. With its 163 wafer fabrication plants in 2011, China's semiconductor manufacturing capacity increased its share of worldwide wafer fabrication capacity from 1.5 percent in 2001 to 10.8 percent in 2011.

In the semiconductor assembly and test services market, China increased its share of the global value of production from 28 percent in 2010 to 31 percent in 2011. There are 109 semiconductor assembly and test facilities in China in 2011, accounting for 20 percent of total facilities worldwide (PricewaterhouseCooper's, 2012). This is comparable with that of Taiwan and higher than that of Japan at 17 percent. China also takes the largest share (23 percent) of worldwide employment in the semiconductor assembly and test services, surpassing that of Taiwan (17 percent) and Malaysia (16 percent). China-based Jiangsu Changjiang Electronics Technology advanced to the top 10 ranking with its revenue of US$611 million or 2.5 percent of worldwide OSAT revenues in 2011.

Capitalizing on the fast growth of wafer fabrication capacity, as well as the strong presence of the top fabless and vertically integrated semiconductor companies in China, the leading OSAT companies expanded and strengthened the back-end manufacturing capabilities of their affiliates in China. Amkor Technology, which is the only OSAT in the top 10 that located in the Philippines, has expanded manufacturing operations in China as it diminished its capabilities in the Philippines.

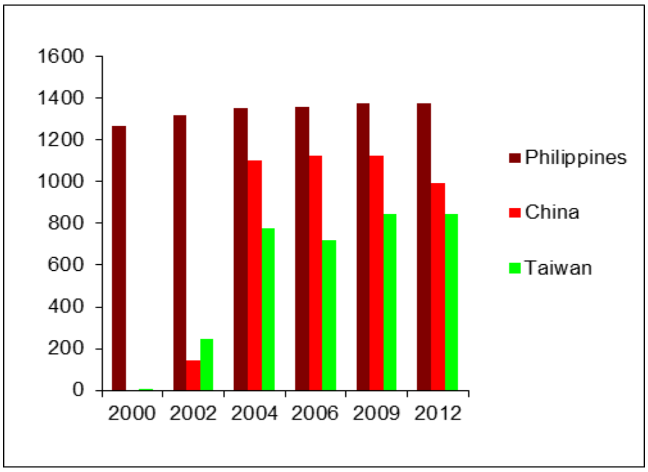
Before 2001, Amkor Technology had virtually all of its assembly and testing services conducted in its four manufacturing plants in the Philippines. By 2004, Amkor Technology had put up three manufacturing plants in Taiwan and two in China. While the factory size (in square feet) has remained largely the same in these three countries since 2004, the value of the property and equipment depicted a continuous decline for the Philippines and a rise for China, with larger uptakes for China than for Taiwan (Figures 18 and 19). Following the global recession of 2009, the Philippines bore the greater brunt of the labour reduction measures of Amkor Technology in their manufacturing operations outside of Greater China, laying off 1,050 employees in the Philippines in 2011; 60 employees in South Korea; and 120 employees in Japan in 2012.

Figure 18: Value of Property, Land and Equipment, Packaging and Test Facilities, Amkor Technology, 1999–2012 (US$ million)



Sources: Company profiles.

Figure 19: Factory Size, Amkor Technology (‘000 ft^2)



Sources: Company profiles.

Two Filipino-owned companies stood out in the OSAT market—the PSi Technologies and Cirtek Electronics Corporation. PSi Technologies is traded on the US Nasdaq stock market and provides comprehensive back-end services of assembly, test, and drop shipment primarily for power conversion and power management semiconductors. Its annual average revenues increased from US$42 million in the late 1990s to US$85 million during 2000–2005 and US91.6 million during 2006–2007. In 2010, Filipino-owned Integrated Microelectronics Inc., a global provider of electronics manufacturing services, acquired 56 percent share of PSi Technologies. The latter’s contribution to the revenues of Integrated Microelectronics Inc. was US$74 million in 2011 and US$45.6 million in 2012. PSi Technologies has proprietary rights for PowerQFN (Quad Flat-No Leads) packages that utilize a unique solder die attach process in combination with clip-leads, resulting in lower thermal resistance, inductance, and capacitance.

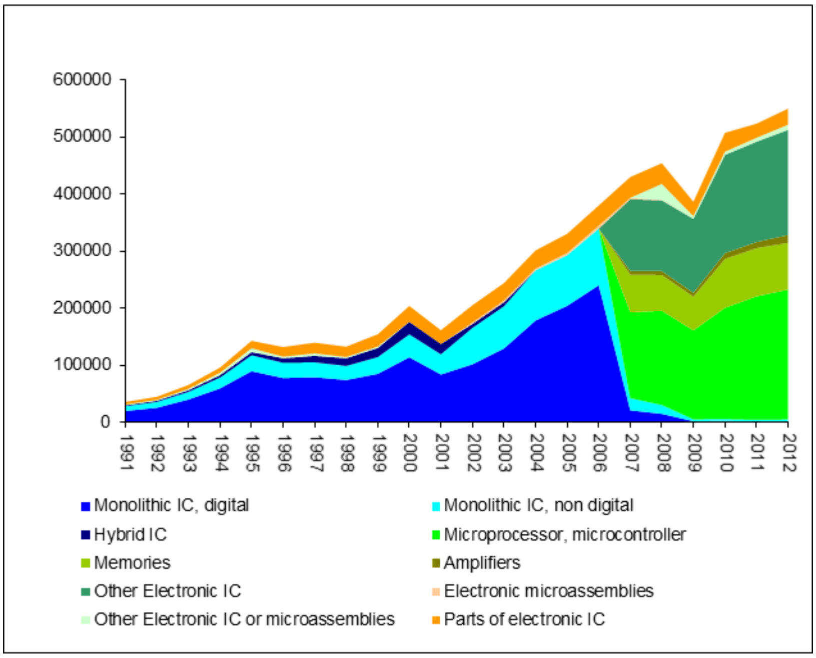
Cirtek Electronics Corporation is an assembly and test provider of largely customized high-performance multi-chip packages for telecommunications and automotive industries. The company developed the air cavity ceramic packages and high-transistor plastic packages for high-power applications in telecommunications. It uses die attach film technology or wafer backside coating in multi-chip packages for shorter processing times and silver alloy wire bonding as an alternative to the more costly gold wires to ensure package reliability and cost-competitiveness. The company’s revenue has been on a fast upward trend from US$23.9 million in 2009 to US$34.4 million in 2010, and US$40.6 million in 2012.

In Southeast Asia, the Philippine semiconductor assembly and test service is bested not only by Singapore—which is a leading global supplier of assembly, packaging, and test services—but also by Malaysia, which has also established strong local capabilities in this market. Malaysia is the home base of OSAT companies Unisem and Carsem, each garnering revenues of more than US$300 million in 2011. Unisem has proprietary technology in etched leadless package and taped leadframe package while Carsem introduced an extremely thin micro leadframe package for thermal voltage suppression diode applications.

5. Declining Technological Intensity of the Philippine Semiconductor Industry

Rapid advances in chip technology can render simpler variants of chips to become obsolete in shorter periods as more complex and sophisticated forms are developed at increasing speed. Foreign trade statistics have made corresponding adjustments in classifying semiconductor items with monolithic ICs replaced in the latter part of 2000s by microprocessors, which are among the most advanced ICs that could incorporate billions of transistors in a single chip (Figure 20).

Figure 20: World Imports of Electronic ICs and Microassemblies, by Type 1991–2012 (US$ million)



Source: Compiled from the UN Commodity Trade Statistics Database.

There are some indications that the Philippines had failed to keep pace with the rapid technological advancement in semiconductors. These include (a) the value of Philippine exports for more advanced ICs, such as microprocessors and microcontrollers, have posted negative growth against the high positive growth for the world; (b) the normalized RCA index in semiconductors for the country have shrank quite rapidly after reaching a peak in 1999, and continued to decline in the latter part of the 2000s; and (c) the country's low investments in semiconductor machinery equipment and R&D relative to China, Singapore, and Malaysia.

The Philippines has one of the highest recorded growth rates in the exports of monolithic ICs in the 1990s and into the first half of 2000s. In 1995, the Philippines captured only 2.5 percent of the world market for monolithic ICs compared to Singapore's share of 7 percent, and 8 percent for Malaysia (Table 11). After posting rapid growth in exports in the last half of the 1990s, the Philippines had almost caught up with Singapore and Malaysia as it accounted for six percent of the global share by 2000. For the period 2000–2006, the Philippines, Malaysia, and Singapore had each registered an average growth rate of 16 percent—17 percent in the exports of monolithic ICs, surpassing that of the world. While both Singapore and Malaysia have sustained rapid growth in the second half of the 2000s for the more advanced microprocessors, the Philippines had recorded a substantial decline. Exports of microprocessors grew by 9 percent for the world in 2007–2012, 11 percent for China, 15 percent for Malaysia, and 8 percent for Singapore, while that for the Philippines declined by 18 percent.

Table 11: Growth Rate in the Value of Exports for Monolithic ICs and Microprocessors, by Selected ASEAN Countries and China, 1995–2012

	Share to world exports (%)			Growth rate (%)		
	Monolithic ICs		Microprocessor & microcontrollers	Monolithic ICs		Microprocessor & microcontrollers
Country	1995	2000	2007	1995–1999	2000–2006	2007–2012
China	0.3	1.2	8.9	36.2	56.4	11.2
Singapore	6.9	6.7	6.5	-4.1	16.5	8.0
Malaysia	8.1	7.8	10.7	-2.2	16.0	15.4
Philippines	2.7	6.3	11.3	20.1	16.7	-17.8
Thailand	1.9	1.6	1.8	-3.7	20.6	0.3
World	100.0	100.0	100.0	-0.7	14.1	8.7

Note: ICs = integrated circuits.
Source: Author's calculations using the UN Comtrade database.

The Philippines has not maintained its strong comparative advantage in semiconductors in the 1990s, and the very rapid declines in RCA value observed all throughout the 2000s had more than offset the gains achieved in the latter half of the 1990s (Table 12). The Philippine RCA value increased at an average of 30 percent annually in 1995–1999 but declined at an average of 9 percent in 2000–2006 and 2007–2012. This indicates the rapidly waning relative comparative advantage for the Philippines with increasing technological sophistication of ICs. In contrast, the phenomenal growth of semiconductor exports in China led to the reversal of its disadvantaged position by 2008. In 2012, China's RCA value was way above that of Thailand and the Philippines and just about equal that of Malaysia. Singapore has sustained very strong relative comparative advantage in semiconductors from the 1990s and throughout the 2000s.

Table 12: Normalized RCA Index for Electronic ICs and Diodes, by Selected ASEAN Countries and China

Country	Normalized RCA value			Annual rate of change (%) in RCA value		
	1995	2000	2012	1995–1999	2000–2007	2008–2012
China	-8.7	-11.2	9.8	-0.6	-12.0†	79.8
Singapore	27.4	42.8	39.5	3.6	0.5	-0.4
Malaysia	20.2	20.7	14.8	3.8	-3.5	47.6
Philippines	7.2	23.7	6.1	41.0	-9.5	-9.3
Thailand	1.7	3.7	0.1	10.1	-3.0	-57.4

Note: † = refers to declining negative RCA value, RCA = revealed comparative advantage.
Source: Author's calculations using UN Comtrade data base.

To be competitive, semiconductor companies need to strengthen technological capability through large investments in R&D, and in the state-of-the-art capital equipment. Countries that are fast to adopt sophisticated solutions and upgraded machinery to support the advancement in chip technology capture the market majority.

The previous section provided some evidence of the lack of capital inflow to the Philippines in knowledge-intensive activities as outsourcing to the country by leading semiconductor companies remained largely limited to assembly operations. This was not the case for China, Malaysia, and Singapore, which were preferred locations, along with Taiwan and India, for research and product development capabilities.

The lack of investments in the Philippines for replacing and upgrading semiconductor machinery equipment may have also stymied the quick transition to manufacturing more technologically sophisticated chips. Semiconductor machinery equipment are categorized primarily into two—equipment for front-end manufacturing (e.g., manufacture of wafers, electronic ICs, and semiconductor devices) and equipment for back-end manufacturing (assembly, packaging, and testing equipment). Investments in equipment for front-end manufacturing are usually larger than those for back-end manufacturing as these are costlier and add more value to production. The value of world exports in front-end manufacturing equipment to China and Singapore were six to eight times larger than that in back-end manufacturing equipment. The corresponding figure for Taiwan, which is the global leader in wafer fabrication, is 13 times larger for front-end manufacturing machinery compared to back-end manufacturing. For the Philippines and Malaysia, the value of imported front-end manufacturing equipment was twice that of back-end manufacturing equipment (Table 13).

Table 13: Average Annual Value of World Exports of Semiconductor Machinery, 2007–2012, by Selected Partner ASEAN Countries, Taiwan, and China (in US$ million)

	Machines used solely or principally for the			
Partner country	**manufacture of wafers, semiconductor devices, ICs**	**manufacturing and repair of masks and reticles, assembling, handling, loading of semiconductor devices and ICs**	**Machine parts and accessories**	**Total**
China	5,843.5	761.9	724.3	7,329.7
Taiwan	7,914.4	572.8	1,405.1	9,892.3
Singapore	1,307.2	214.9	520.3	2,042.4
Malaysia	286.7	135.0	200.7	622.5
Philippines	147.4	76.0	66.2	289.2
Thailand	97.0	71.5	50.8	219.3

Source: Author's calculations using UN Comtrade data base.

Although Taiwan has sustained global leadership in semiconductor manufacturing operations in the 2000s, China has emerged as a tough competitor in back-end manufacturing as it dedicated heavy investments for leading-edge packaging and test technologies. During 2007–2012, the value of world exports to Asian countries in machinery for wafer fabrication averaged every year US$8 billion for Taiwan, US$6 billion for China, and US$1.3 billion for Singapore. The corresponding figure for Malaysia was US$287 million; for the Philippines, US$147 million; and Thailand, US$97 million.

China has larger investments in imported machinery for back-end manufacturing than Taiwan, averaging US$762 million annually compared to US$573 billion for Taiwan. In Southeast Asia, Singapore tops the list with machinery imports for assembling semiconductor devices and ICs that were about three times more than those of the Philippines and Thailand, and 1.6 times more than those of Malaysia. The Philippines' total value of imports of semiconductor machinery equipment during 2007–2012 was only 3 percent–4 percent that of Taiwan and China, 14 percent that of Singapore, and less than half that of Malaysia.

6. Discussion and Policy Recommendations

Almost four decades since the establishment of the first semiconductor assembly and test plant in the Philippines in the mid-1970s, the country remains locked into back-end manufacturing processes that heavily depend on foreign investments. In the 2000s, the Philippines struggled to keep afloat as it faced fierce competition from China in the same market segment of assembly–packaging and test services of semiconductor devices and ICs. China's rapid economic growth after its accession in world trade in 2001 provided the necessary capital endowment for upgrading its technological capacities and to build a strong local semiconductor industry in back-end manufacturing. Bolstered by a burgeoning domestic electronics market, along with a relatively inexpensive labour and a positive investment policy climate, China became the preferred destination of the leading semiconductor companies from the US, Western Europe, Japan, and South Korea to establish both manufacturing and research capabilities in the country.

The Philippines cannot compete with China in the back-end manufacturing processes unless it is prepared to constantly infuse large capital investments for leading-edge manufacturing technologies. Singapore and Malaysia, which have developed higher technological capabilities and have attracted knowledge-intensive foreign technologies, have also succeeded in building a more competitive local industry in back-end manufacturing and have optimized international production network and increased trade intensity with China. Malaysia's share of the global market in 1999 was about the same as that of the Philippines at 7 percent, and while this was largely sustained by Malaysia in 2012, that of the Philippines had shrunk to 2.5 percent. Singapore's market share had increased from 10 percent to 17 percent in the same period.

The annual increases in minimum wages in the Philippines have also rendered ASEAN countries that are geographically in closer proximity to China more attractive as alternative sources for global semiconductor production. This includes Viet Nam, which has lower technological capacity but relatively much cheaper labour than the Philippines. The average factory worker's base salary in the Philippines is comparable with that of Malaysia and Thailand but twice or three times as much as in Viet Nam (Table 14). In addition to rising wage rates, the Philippine investment climate may have also been affected adversely by the high cost of power. The Philippines' electricity rate is the second highest in Asia next to Japan, and is more than twice as much compared to that of China; Taiwan; Bangalore, India; and the ASEAN countries of Viet Nam, Indonesia, Malaysia, and Thailand.

Table 14: Wage Indicators and Electricity Rates in Selected Asian Countries, 2011

Country	Monthly minimum wage (US$)	Factory worker's monthly base salary (US$)	Electricity rate per kWh (US$)
China (Beijing)	199	538	0.08
China (Guangzhou)	206	352	0.10
China (Shenzhen)	237	317	0.11
China (Hong Kong)	578	1,384	0.14
India (Mumbai)	103	403	0.13
India (Bangalore)	84	320	0.07
Indonesia (Jakarta)	167	209	0.08
Japan (Nagoya)	1,555	3804	0.26
South Korea (Seoul)	646	1,696	0.07
Malaysia (Kuala Lumpur)	_	344	0.11
Philippines (Manila)	153	325	0.25
Philippines (Cebu)	139	195	0.24
Singapore	_	1,285	0.23
Taiwan (Taipei)	621	1,008	0.12
Thailand (Bangkok)	136	286	0.11
Viet Nam (Hanoi)	95	111	0.08
Viet Nam (Ho Chi Minh)	95	130	0.08

Note : kWh = kilowatt-hour.
Source: Japan External Trade Organization (2012).

The Philippines cannot stay long in competition unless it is able to transition to higher-value and more knowledge-intensive chip and package design. Unlike the manufacturing segment, which was dominated by Taiwan in the 2000s and with China also stepping forward as a major player, the market for semiconductor design is more differentiated by a wide range of product applications and more widely spread across smaller companies specializing on certain products.

The Philippines should identify a niche in the semiconductor design market and then build long-term capability for introducing proprietary product and process innovations. Digital semiconductor products take a dominant share in the semiconductor design industry of India and China. The Philippines might look into the analogue segment, which displayed more stable profit margins in recent years. As university training is concentrated in digital semiconductors, which take the lion's share (more than 80 percent) of the semiconductor market, there is a short supply of engineering talent with expertise in analogue and mixed-signal devices. Analogue devices fit in a wider breadth of product applications (e.g., automotive and consumer electronics, medical care, solar energy, etc.) and have a broader array of requirements for performance and efficiency. For example, Texas Instruments, which is the largest supplier of analogue ICs, offers more than 42,000 analogue products (Petrov Group, 2012).

The Philippines has a strong potential to position itself as a major player for analogue design and mixed-signal devices. Four out of the five leading analogue IC companies worldwide have set up manufacturing capabilities in the Philippines, such as Texas Instruments, STMicroelectronics, Analog Devices Inc., and Maxim Integrated. Both Analog Devices Inc. and Maxim Integrated have established design centres in the Philippines indicating the presence of a pool of Filipino analogue engineering talent. As it takes longer years of experience (5–10 years) to make pioneering analogue engineers, the Philippines can optimize its existing knowledge base to facilitate the development of a critical mass of analogue engineering talent through a strong mentoring process by the more experienced analogue engineers in the industry and the academe. The top global supplier of analogue devices—Texas Instruments—has established major manufacturing capabilities in the Philippines and its presence can be leveraged further through strong partnerships with Philippine universities and the government for the development of a strong IC design industry for analogue and mixed-signal devices.

The Philippines produced an annual average of more than 50,000 engineering graduates during 2005–2011, five times more than that in the United Kingdom.

However, this is less than half the number of engineering graduates in the US (with an annual average of 127,192 during 2005–2010) and way below the corresponding figures in India (with an annual average of 271, 861 graduates in a four-year engineering course in 2005–2010). To build an engineering talent that creates proprietary technologies, the Philippines needs to produce engineers with master of arts and doctoral degrees. In 2004, Filipino engineering graduates with advanced degrees comprise less than one percent of total graduates. By comparison, of the 160,000 employed in India's semiconductor design industry in 2010, 19 percent had a master's degree and 1 percent with a doctorate degree (Government of India, 2011). In the US, 38 percent of engineering graduates in 2010 obtained a master's degree and close to 9 percent had a doctorate degree. The number of master's degrees in Engineering awarded in the US higher education institutions increased from 25,738 in 2000 to 41,282 in 2011 (National Science Board, 2014). In Singapore, of the 29,482 research scientists and engineers in 2011, 24 percent have a master's degree and 26 percent, with a doctorate degree.

A more pressing challenge for the Philippines is how to reverse the extensive diaspora of Filipino engineering talent to more developed countries, including Singapore, the United Kingdom, Japan, North America, Taiwan, and South Korea. In the global competitiveness index ranking, the Philippines bested India and China in tertiary education, but fared poorly in regard to availability of scientists and engineers and the country's capacity to retain or attract talents (Table 15). While the Philippines has a significant number of engineering graduates, they are not all available for work in the Philippines. Existing government programmes to reverse the labour migration outflow and to lure seasoned Filipino engineers working overseas to return to the country have not been as successful as those in India, China, Malaysia, and Singapore. The Philippine ranking is better than China in terms of the overall quality of the educational system but is way below that of the other four Asian countries in terms of the quality of math and science education and the quality of scientific research institutions. The Philippines also rated poorly in innovation capacity and related indicators, such as R&D investments, university–industry research partnership, and intellectual property creation and protection.

Table 15: Global Competitiveness Index, Rank for Selected Indicators, and Asian Countries, 2013–2014

Indicator	GCI Ranking (with 1 as the highest rank out of 148)				
	Philippines	**India**	**China**	**Malaysia**	**Singapore**
Tertiary education	81	98	83	62	20
Availability of scientists and engineers	87	15	44	19	14
Country capacity to retain talent	71	50	31	20	8
Country capacity to attract talent	86	54	26	22	2
Quality of the educational system	40	33	54	19	3
Quality of math and science education	96	32	48	27	1
Quality of scientific research institutions	91	37	41	27	11
Company spending on R&D	51	39	22	17	8
University–industry collaboration R&D	69	47	33	16	4
Capacity for innovation	48	41	30	15	18
PCT patents, applications/million population	84	64	36	31	13
Intellectual property protection	78	71	53	30	2

Note :GCI = global competitiveness index, PCT = Patent Cooperation Treaty
Source: World Economic Forum (2013).

Notwithstanding the country's current limitation in manpower resource development and technological intensity, the remarkable economic growth of the Philippines, which is among the highest in the world at 6.8 percent in 2012 and 7.2 percent in 2013, is expected to augur well for a larger domestic market in electronic products that could attract leading semiconductor companies worldwide to establish or expand operations in the country. A robust economy also implies increased capital endowment for higher investments in research and product development that fosters technological innovation.

There is a need to formulate a comprehensive policy and a long-term development plan to establish the Philippines as a major ASEAN centre for IC design. The following are some of the suggested measures:

(1) Invest more heavily in R&D as a long-term strategy to increase proprietary breakthroughs. The overall R&D expenditure (in million current Purchasing Power Parity [PPP]) in 2011 was highest in the US at US$415 billion, followed by China at US$208 billion, and Japan at US$147 billion (OECD, 2012). The corresponding figures in other Asian countries for 2011 are US$60 billion in South Korea, US$36 billion in India, US$26 billion in Taiwan, and US$7 billion

in Singapore; and for 2010, the figures are US$2.7 billion in Malaysia, $1.5 billion in Thailand, $0.79 billion in Indonesia, and $0.52 billion in Viet Nam. In the Philippines, R&D spending was estimated at PPP US$0.34 billion in 2007. This represents a miniscule 0.11 percent of the country's gross domestic product (GDP) and way below the percentage share of R&D expenditures to GDP in other Asian countries in 2011, which were 3.7 percent in Japan and South Korea, 2.3 percent in Taiwan, 2.2 percent in Singapore, 2 percent in China, and 1.1 percent in Malaysia.

(2) Build up intellectual capacity for technological innovation in microelectronics through a long-term manpower resource programme. As there is a worldwide shortage of analogue engineers, Philippine universities can be equipped to develop a critical mass of engineers with expertise in both analogue and mixed-signal devices.

2.1 Develop a scholarship programme to create a large pool of world-class engineering talent with specialization in analogue and mixed-signal microelectronics. Provide financial support for Filipino engineering top talents to pursue higher education up to a post-doctorate level in microelectronics with strong expertise in both digital and analogue engineering in leading global universities and technological institutes, and to require the scholars upon completion of their graduate education to engage in R&D in local institutions for a period of time equivalent, for example, to at least twice the duration of the scholarship.

The Engineering Research and Development for Technology Program of the Philippine Department of Science and Technology provides scholarship grants for master's and doctorate degrees in engineering in eight member universities. The privileges include free tuition, a monthly stipend, transport and book allowance, and a thesis/research grant. Scholarships for master's and doctorate degrees in science and technology are also provided under the Accelerated Science and Technology Human Resource Development Program. As of March 2013, the number of scholarship recipients for master's degree totalled 604 and 104 for doctorate in engineering programmes, while there were 669 scholars for master's degree and 181 doctorate scholars for science and technology programmes.

By comparison, Malaysia implemented the MyBrain15 Sponsorship programme, which aims to produce 60,000 Malaysian doctorate holders by 2020. The programme provides financial assistance for three types of programme—a master's degree, a doctorate, and an industrial doctorate for industry practitioners. The master's degree scholarship programme provides a scholarship of up to RM10,000 in tuition fees for a maximum of 24 months and a thesis support of up to RM3,000. For full-time doctorate students, the scholarship includes tuition fees of up to RM24,000; a monthly allowance of RM2,300; a journal allowance of RM1,500; and a thesis allowance of RM3,000. Finally, Malaysia's doctorate programme for industrial practitioners provides up to RM50,000 funding for a study period of up to 48 months with the industry partner shouldering the cost of the research project.

The Singapore Economic Development Board allocated US$16 million for the Integrated Circuit Design Postgraduate Scholarship Program intended for graduate schooling at Singapore's two main universities, Nanyang Technological University and the National University of Singapore. Of the IC designers, some 150 were expected to benefit from this programme between 2009 and 2014.

Apart from scholarships for doctorate programmes in Singapore's top universities, the Singapore Agency for Science, Technology and Research (A*STAR) also has a number of scholarship programmes for Singaporean talents to study in top universities in the world from college to postdoctoral levels, and thereafter to engage in research work in Singapore for six years. The three scholarship programmes for a doctorate education overseas are the National Science Scholarship for Biomedical Sciences, Physical Sciences and Engineering programmes; the National Science Scholarship programme for the medical fields; and the A*STAR Graduate Scholarship for any doctorate programme. Financial support includes full tuition fees; monthly sustenance allowance; and book, computer, conference, thesis, and other miscellaneous allowances.

Under India's Innovation in Science Pursuit for Inspired Research (INSPIRE) Program, 1,127 students have been granted fellowships for postgraduate education during 2012–2013, of whom 666 were enrolled in the doctorate programme. In addition, 177 thesis/research grants were provided to doctorate candidate faculty members. Outstanding Indian scientists and engineers can also avail of the JC Bose Fellowship for those working in India, and the Ramanujan National Fellowships for those working overseas and who want to take scientific research positions in India. In 2012, 13 outstanding Indian scientists and engineers received a JC Bose fellowship and 29 were granted a Ramanujan national fellowship. Fellows are entitled to a monthly bursary of Rs25,000 and a research grant of Rs10 lakh per annum for the JC Bose Fellowship, and up to a monthly bursary of Rs75,000 and a research grant of Rs5 lakh per annum for up to five years.

2.2 Provide research grants in microelectronics, especially in analogue and mixed-signal devices, and confer national recognition to top innovations and innovators.

The Philippine Engineering Research and Development for Technology Program provides a thesis/research grant of PhP230,000—PhP460,000 (US$5,260–US$10,520) for scholarship recipients in all engineering fields.

By comparison, public expenditure in Singapore for R&D in electronics increased from US$617.7 million in 2010 to US$705.8 million in 2011, representing an annual growth of 14.3 percent (Agency for Science, Technology and Research, 2012). In the US, the National Science Foundation and the Nanoelectronics Research Initiative jointly provided grants amounting to US$20 million in 2011 for innovative research in nanoelectronics to accredited institutions.

The India National Science and Engineering Research Board approved more than 5,500 research grants for 2012–2013 (Government of India, 2013). The R&D grants for the Electrical, Electronics and Computer Engineering Programme resulted in more than 200 publications in national and international peer-reviewed journals in 2012–2013. In 2012, out of 600 innovation entries in the field of life sciences, electronics and communications, information technology (IT), energy and engineering technologies, India selected the top five innovations and three innovators for national recognition and awards on the basis of technical feasibility; market potential of the innovation; and impact on industry, society, and the environment.

2.3 Develop a long-term strategy for attracting experienced Filipino engineers to return and work in the Philippines. Reestablish the Transfer of Knowledge through Expatriate Nationals (TOKTEN) programme of the United Nations Development Programme (UNDP) in collaboration with the Philippine Department of Foreign Affairs to bring in seasoned Filipino analogue engineers working overseas in a mentoring programme with young Filipino engineers towards creating novel solutions. The Philippine TOKTEN programme, which operated for a decade and ended in 1999, can be extended to include a longer-term engagement of the returning expatriate. The programme should engage the active participation of the Philippine industry and the academe in selecting and hosting the expatriate beneficiaries. An important objective of the programme is for the seasoned expatriate to be part of a core engineering team in a Philippine industry or academe conducting design analysis in analogue and mixed-signal devices. The TOKTEN programme can be consolidated with the Diasporas to Development Program (D2D) of the Commission on Filipino Overseas and the Balik Scientist Program of the Department of Science and Technology. The D2D Program has important features, such as providing entrepreneurial assistance through the development of business plans and linkages. The Business Advisory Circle of the D2D Program can be strengthened to include partnership with the few Philippine-based IC design houses—such as BiTMICRO Networks International, Blue Chip Designs Inc., and Xynix—to encourage start-ups in the semiconductor design business.

Expand the Balik Scientist Program of the Department of Science and Technology to include Filipino engineering talents working in leading global semiconductor IDMs and design companies and provide them higher incentives to work in the Philippines and help develop a world-class semiconductor design industry in the country. The Philippines can learn from Malaysia’s programme of providing tax incentives for returning experts and from Germany’s collaborative programme with developing countries in granting information and financial assistance to foreign professionals who wish to return to their home countries.

The Philippines can learn from a number of successful programmes in other countries to lure global talents. China’s Recruitment Program of Global Experts, also known as the Thousand Talents Programs, was launched in 2008 to attract thousands of professional expatriates to work in the next 5–10 years in China and promote technological innovation. Benefits include a research initiating fund of at least RMB5 million (US$820,700) in the field of science and engineering, at least RMB1 million (US$164,000) for settling in allowances, an annual salary of at least RMB5 million, and housing provisions. Other similar programmes of China include the Chang Jiang Scholars Program for distinguished professors, the Recruitment Program of Global Young Experts, the Hundred Talents Recruitment Program, and the Excellent Overseas Talents Program.

In the Returning Expert Program of Malaysia, qualified individuals or experts are entitled to a reduced income tax rate of 15 percent in their employment income for five years, 100 percent tax exemption for all personal effects brought into Malaysia, and permanent resident status eligibility for foreign spouse and children.

It is interesting to note that the German Federal Ministry for Economic Cooperation and Development, through the Centre for International Migration (CIM) and Development, has a Returning Expert Program to support highly qualified foreign professionals from developing countries who are currently living in Germany and who wish to return to their home countries. The benefits of qualified individuals under Germany's CIM programme for returning experts includes (a) information on job markets in the country of origin and counselling services for career plan development; (b) internship support in the home country equivalent to €300 monthly for the cost of living for up to six months; (c) travel subsidies of €400 for job interviews in the home country; and (d) relocation package back to home country, including €1,000 per family member, salary topping of up to €1,600 for two years, up to €10,000 for workplace equipment, €1,000 for travel support for participation in conferences and trainings, and lifetime annual support of €100 for media programme for books and magazines.

2.4 Establish world-class research infrastructure and centres of excellence in engineering, science, and technology that will support technological innovation, particularly in microelectronics.

The University of the Philippines Electrical and Electronics Engineering Institute had set up the Microelectronics and Microprocessors Laboratory (MICROLAB) for building capability in IC design with focus on analogue and mixed-signal design, radio-frequency IC design, and low-power RISC microprocessor design. For 2000–2010, MICROLAB had designed and implemented 17 integrated test chips, including 40 master's thesis projects and over 100 undergraduate thesis projects. MICROLAB has four full-time professors and four other faculty members on study leave.

By comparison, the Singapore's Institute of Microelectronics, established in 1991, aims to build strong capabilities in IC design, silicon process technologies, and advanced packaging and test solutions. It has cutting-edge facilities that include a fully integrated line of 300-millimeter manufacturing systems, advanced package laboratory, IC design laboratory, high-frequency characterization laboratory, optoelectronics and photonics laboratory, and a bioelectronics laboratory. The Singapore Institute of Microelectronics has 350 employees, 56 percent of whom have advanced graduate degrees, and more than 90 international researchers.

The Singapore Economic Development Board established the IC Design Centre of Excellence in 2010 at Nanyang Technological University, which aims to train at least 100 postgraduate students in analogue and mixed-signal IC design. Annual enrolment at the university's School of Electrical and Electronic Engineering averaged 3,500 for the undergraduate level and 1,200 for the graduate level. The Singapore University of Technology and Design, another public-funded university, will put up a S$148 million international design centre in partnership with the Massachusetts Institute of Technology for novel technological solutions. The university targets 4,000 undergraduate students and 2,000 graduate students.

(3) The Philippines needs to improve its climate for investments in R&D activities geared specifically for product and process innovation. More incentives directed to value creation are needed to encourage start-ups in local IC design houses, and to attract semiconductor IDM giants and leading fabless and IP companies to establish design capabilities in the country. As the Philippines becomes a choice destination for top semiconductor companies producing in large volumes, OSAT players that have the capability to develop cutting-edge package and test solutions will also be drawn to locate themselves in the country to take advantage of the sizeable base of customers for back-end process outsourcing. Existing semiconductor facilities should be provided incentives to continually upgrade the technical content of their manufacturing operations.

In the present Philippine policy, R&D expenditures may be treated as a current expense deductible at 100 percent or as a deferred expense distributed within 60 months. The policy does not have a clear definition of R&D activities. Corporations are subject to an income tax rate of 30 percent unless they are duly recognized by the Board of Investments as a regional operating headquarters engaged in product development services, in which case they are granted a reduced corporate income tax of 10 percent. In addition, enterprises engaged in R&D activities that qualify for registration with the Board of Investments are entitled to a four-year income tax holiday and other incentives.

By comparison, Singapore defines R&D activities as 'any systematic, investigative and experimental study that involves novelty or technical risk carried out in the field of science or technology with the object of acquiring new knowledge or using the results of the study for the production or improvement of materials, devices, products, produce, or processes, but does not include certain activities'. Singapore grants a tax deduction of 400 percent of actual R&D expenditure on the first SGD$400,000 (US$32,000) incurred within the years of assessment period (e.g., 2011 to 2015) and a tax deduction of 150 percent of actual expenditure in excess of SGD$400,000. Additional tax deductions are granted for costs related to the registration of intellectual property rights (IPR) and can be claimed by companies that own the legal and economic rights of the IPR for at least one year from the date of filing of IPR to the date of disposal of IPR. More specifically, a tax deduction of 400 percent of actual registration of IPR expenses (e.g., patenting costs) may be claimed on the first SGD$400,000 incurred within the years of assessment period, and a tax deduction of 100 percent on the remainder. For companies that own the IPR for at least five years from the date of acquisition of IPR to the date of disposal of IPR, an enhanced tax deduction of 400 percent of expenditures in acquiring the IPR may be claimed on the first SGD$400,000 incurred within the assessment period, and a tax deduction of 100 percent on expenditures beyond the SGD$400,000. Subject to some conditions, the unutilized deductions may be carried forward indefinitely. In Malaysia, R&D is defined as 'any systematic or intensive study undertaken in the field of science or technology with the object of using the results of the study for the production or improvement of materials, devices, products, produce or processes' excluding research in social sciences, humanities, and business management. R&D companies that are granted pioneer status may claim a tax exemption on 100 percent of statutory income for five years and, where applicable, may be extended for another five years for those that reinvest in R&D activities post tax relief period. R&D companies eligible for an investment tax allowance incentive may claim up to 100 percent tax allowance of qualifying capital expenditure incurred within 10 years and, where applicable, can be extended for another 10 years for those that reinvest in R&D activities post tax relief period. Any unutilized investment tax allowance may be carried forward indefinitely. Companies undertaking approved research projects or that made cash contributions or donations to approved research institutes are also entitled to a 200 percent tax deduction for R&D revenue non-capital expenditure (e.g., raw materials and manpower used in research; technical services procured; travel costs; maintenance; and rental of motor vehicles, buildings, and equipment). Researchers who commercialize the findings of approved research projects are entitled to a tax exemption on 50 percent of the income received from the commercialization of their research findings for five years. Malaysia also provides an industrial building allowance where qualified companies are granted an initial allowance of 10 percent and an annual allowance of 3 percent for capital expenditure on the construction or purchase of a building that is used for R&D purposes.

India defines scientific research as ‘activities for extending knowledge in the field of natural or applied science’ including the ‘development of new technologies, design and engineering, process/product/design improvements, developing new methods of analysis and testing; research for increased efficiency in use of resources’. R&D expenditure are defined as those ‘incurred for prosecution, or the provision of facilities for the prosecution, of scientific research, but does not include expenditure incurred in the acquisition of rights in, or arising out of, scientific research’. India provides a tax deduction of 200 percent for expenditures of approved scientific research (excluding cost of land and building) and a tax deduction of 100 percent for building expenditures. Income tax benefits are also provided for approved companies located in the special economic zones, namely, a 100 tax benefit on eligible profits for the first five years of operation and a 50 percent tax benefit on eligible profits for the succeeding five years of operation. Companies that made donations for use in approved scientific research projects may claim a 200 percent tax deduction of donations paid if the donations were made to national universities or Indian institutes of technology, and a 175 percent tax deduction if paid to other scientific research institutions.

India’s special incentive package scheme provides 20–25 percent subsidy for capital expenditures covering a wide range of products, including consumer and industrial electronics, nanoelectronics, semiconductor chips, and chip components. Reimbursements of excise for capital equipment and fabrication facilities are also provided. Incentives not exceeding Rs10,000 crores (US$1.6 billion) are likewise granted for projects that lead to the establishment of an indigenous manufacturing ecosystem for semiconductors and electronics

(4) Enforce adequate protection of IPR and effective enforcement of Republic Act 9150 of 2001 or An Act Providing for the Protection of Layout-Designs (Topographies) of Integrated Circuits. Building an environment that highly values the generation and protection of intellectual capital is expected to attract both foreign and local investments in microelectronics R&D and fosters the local production of intellectual property.

A number of countries have enacted copyright laws specifically for semiconductors earlier on. The US pioneered the protection of IPR for semiconductors through the Semiconductor Chip Protection Act of 1984. Equivalent laws were passed in other countries, such as the Japanese Circuit Layout Right Act of 1985, the Treaty on Intellectual Property in Respect of Integrated Circuits of 1989 by member states of the European Union, the Integrated Circuit Topography Act of 1990 in Canada, the 1999 Layout-Designs of Integrated Circuits Act in Singapore, the Layout-Design of Integrated Circuits Act of 2000 in Malaysia, and the 2000 Semiconductor Integrated Circuit Layout-Design Act in India. The Philippines remains to be in the IPR violation watch list of the US in 2013 due to, among others, the lack of implementing rules and regulations especially those which clarify the protection of technological protection measures, and the inadequate criminal enforcement of violation of IPR (Marantis, 2013). The delayed enactment of IPR protection laws on IC layout design relative to other countries and weak enforcement of IPR policies in general may have cost the Philippines much desired investments in microelectronics R&D.

(5) Strengthen university–industry–government partnerships to expedite the commercialization of new technologies. The academe and research institutes would gain from strategic collaborations with leading semiconductor companies in both the development and commercialization of innovations.

Finally, there is a lot to gain from an ASEAN integration of the semiconductor industry with stronger linkages forged among its member countries across the value chain of design, manufacturing, package assembly and test, and shipment of the final product to the end- customer.

Conclusion

While the Philippines benefited from the fragmentation of semiconductor production, it is not able to leverage this early advantage to secure a consistently significant share of the global market. From capturing 7.5 percent of the global semiconductor market in 1999, the Philippines lost substantial market to China in the 2000s even as it intensified trade with other ASEAN countries. By 2012, the share of the Philippines plunged to 2.5 percent. From a very strong position of relative comparative advantage in semiconductors in 1999, with a normalized RCA value that is at par with Japan and South Korea and following the US and Singapore, the Philippines experienced dramatic downturns in RCA value that was surpassed by China in 2011. Along with the erosion of the Philippine share in the global semiconductor market is the ascent of China. From a disadvantaged position in the 1990s, China emerged as a major supplier of semiconductors capturing 17 percent of the global market and with an RCA index that is thrice as much as that of the Philippines by 2012.

The declining Philippine comparative advantage and global market share in the labour-intensive assembly, packaging, and test segment may be attributed to a number of factors. The Philippines failed to attract more diversified FDI compared to Singapore and Malaysia, which have gained most from China's investments in the ASEAN region. Having relied heavily on the US and Japan for semiconductor trade and investment, the Philippines suffered from the significant downslide in semiconductor trade during the global economic slump that affected the US, Europe, and Japan in 2001 and again in 2008–2009. China maintained relatively high economic growth at 9 percent–10 percent annually for 2008 and 2009, and the stronger integration of Singapore and Malaysia in international production network with China had offset the negative impact of the contraction in demand from the West and Japan. The Philippine share of China's trade in semiconductors was less than 4 percent in 2011, compared to Singapore, which held 21 percent of China's exports in the same year; and Malaysia, which held 10 percent of China's exports and 16 percent of its imports.

There has been some reconfiguration of Philippine semiconductor imports over the past two decades that reflects a diminishing share of the US and Japan, together with an expanding portion taken by South Korea, Taiwan, and the ASEAN countries, particularly Singapore. This suggests increased capital inflows from South Korea and Taiwan, which alongside an increased economic interdependence within the ASEAN region has mitigated the dampening effect on the global financial crisis on the semiconductor trade.

Another factor is the failure of the Philippines to develop its technological capacity to keep pace with the rapid advance in chip technology, which are reflected in the following:

(a) The Philippine spending in R&D comprise only 0.11 percent of its GDP while the corresponding figures in other Asian countries are 3.7 percent in Japan and South Korea, 2.3 percent in Taiwan, 2.2 percent in Singapore, 2 percent in China, and 1.1 percent in Malaysia.

(b) Low investments for replacing and upgrading semiconductor machinery equipment have likewise disadvantaged the Philippines from competing with the rapid modernization of China's semiconductor industry, particularly in the packaging and test operations. For the period 2007–2012, the total value of imports of semiconductor machinery equipment for the Philippines was only less than 5 percent of that of Taiwan and China, 14 percent of that of Singapore, and less than half of that of Malaysia.

(c) Unlike China, Singapore, and Malaysia, the Philippines had not been a choice location for leading semiconductor companies to set up research and product development capabilities.

This paper recommends policy reforms for the Philippines to transition from back-end manufacturing services—for which it is rapidly losing comparative advantage—to higher-value and more knowledge-intensive chip and package design.

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