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Chapter 3: Korea and the Electronics Global Value Chain

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Acronyms

3C	Computers, Communications and Consumer Electronics
A&T	Assembly & Testing
AMOLED	Active-Matrix Organic Light-Emitting Diode
B2B	Business to Business
COGS	Cost of Goods Sold
CRT	Cathode Ray Tube
E&E	Electronics & Electrical
EDA	Electronic Design Automation
EMS	Electronic Manufacturing Services
EU	European Union
FTA	Free Trade Agreement
FYP	Five-Year Plan
GVC	Global Value Chain
HDD	Hard Disk Drives
HS	Harmonized System
IC	Integrated Circuit
IPD	Integrated Passive Devices
IT	Information Technology
IoT	Internet of Things
LCD	Liquid Crystal Display
MNC	Multinational Corporation
NPD	New Product Development
ODM	Original Design Manufacturer
OEM	Original Equipment Manufacturer
OLED	Organic Light-Emitting Diode
PCB	Printed Circuit Board
PCBA	Printed Circuit Board Assembly
PDP	Plasma Display Panel
PLC	Programmable Logic Control
PMOLED	Passive Matrix Organic Light-Emitting Diode
R&D	Research and Development
SATS	Semiconductor Assembly and Testing Services
SMT	Surface Mount Technique
STEM	Science, Technology, Engineering and Mathematics
TFT	Thin-Film Transistor
THT	Through-Hole
US	United States

3. Korea and the Electronics Global Value Chain

Since its entry into the industry in the late 1960s, Korea has established itself as a global leader in the electronics sector. At the same time, the industry has been integral to the country's economic growth over the past half century. By 1988, electronics accounted for approximately 25% of exports, making it the country's largest export category. The sector has maintained this share over the past 30 years. Today, exports from Korea are primarily key intermediate inputs including semiconductors and displays. In 2015, Korea's total electronics export were valued at US$120 billion. Korea is home to two of the top global electronics brands, Samsung and LG, and is a technology leader in the key components and subassemblies for these products, memory semiconductors (Samsung and Hynik) and displays (Samsung and LG). These firms are global household names and their brands are synonymous with innovation around the world.

Innovation in the electronics industry is driving major changes in manufacturing around the world. The electronics hardware global value chain, coupled with the broader information and communication technology (ICT) services industry, are perhaps the most dynamic and important industries to consider when discussing the future of global value chains and industry 4.0. Automation and servicification related to big data and the Internet of Things (IoT) are possible because of the development and pervasiveness of electronic components and widespread ICT infrastructure. While all industries, including electronics, will be impacted by industry 4.0 trends, electronics are also what *enable* these trends to exist. As such, Korea's participation in this GVC has implications for the country's future role in the electronics value chain, and in defining, designing, and diffusing the technologies that are enabled by electronic components.

Korea's leadership of global change, nonetheless, is limited by the current scope of the country's firms. While Korean firms hold a strong position in consumer products and key physical components, they are comparatively weak in non-consumer electronics markets (industrial, medical, aerospace and automotive) as well as in the software and programming-related service segments of the value chain. The country was the 5th global exporter of electronic components, but in other end markets, such as industrial and medical electronics, Korea is not as important, ranking 10th and 7th respectively with few globally-recognized firms. To maintain a leadership position, Korea will need to leverage existing strengths to move into these new areas.

This will require multidisciplinary interaction between manufacturing and service-related sectors, as well as expanding the workforce with skills in computational sciences. Korea's strong background in science and engineering and industrial base are strengths in this area. However, these strengths in science and manufacturing will need to be married with business-related skills to translate new technical developments into marketable products.

This report uses the Global Value Chains (GVC) framework to analyze Korea's participation and leadership in the electronics global value chain. As one of the most highly traded industries, it provides significant insight into how countries engage in global chains. As Korea's major export industry, the country's performance in the electronics GVC can provide important lessons for how Korea may be able to leverage its leadership, using Industry 4.0 trends to drive industrial transformation of its economy.

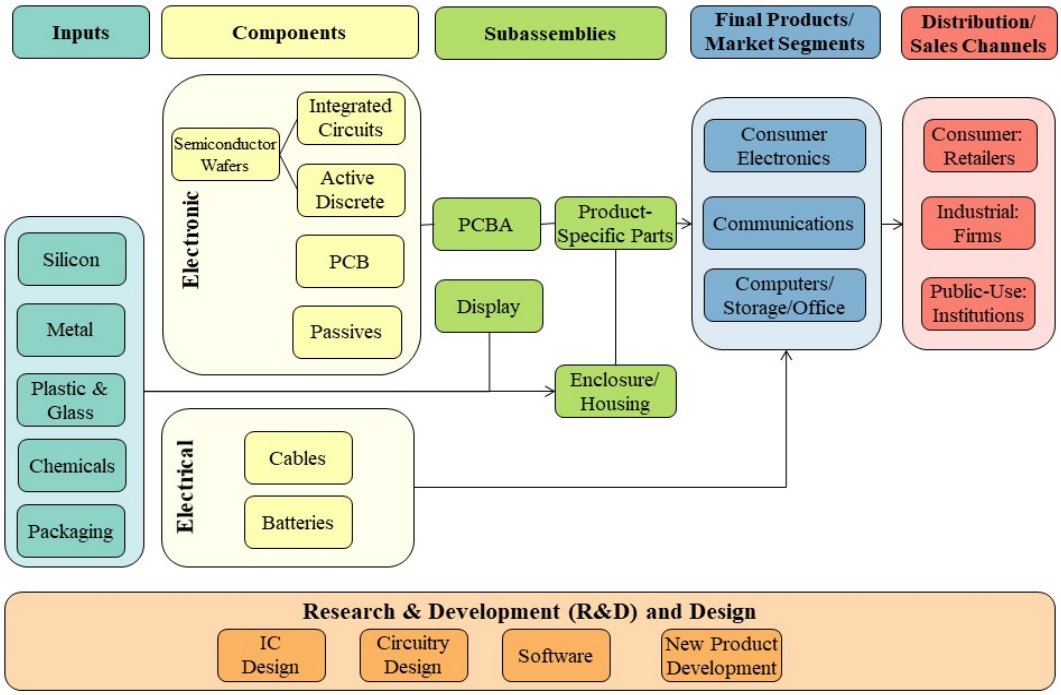
3.1. The Electronics Global Value Chain

3.1.1. Mapping the Electronics Global Value Chain

The electronics industry is comprised of electronic components, subassemblies, and final products. Electronics are capable of storing and/or processing information, which implies the product has semiconductors/integrated circuits (IC). There is an opportunity for nearly all products to perform electronic functions, the adoption rate has been faster in some areas. For example, a basic refrigerator is an electrical appliance, but a "smart refrigerator" capable of varying internal temperature or sending a message to your mobile phone is embedded with ICs and thus would be considered an electronic product as well. In the electronics industry, these non-traditional products are referred to as embedded products.

Figure 3-1 presents a map of the electronics GVC.[2] It is composed of raw materials and inputs, components, subassemblies, final product assembly for a variety of end market segments, and the ultimate buyers of final products. The value chain also includes several activities that add value to final products outside of the manufacturing process related to research, product and process development, design, marketing and after-sales services. Some of the main activities include new product development, circuitry and semiconductor design, and software. These are among the most profitable and are controlled by lead firms and leading component suppliers, and are often the last activities to be performed in offshore locations or outsourced.

Figure 3-1. Electronics "3C" Global Value Chain



Source: Frederick, 2017; 3C refers to consumer electronics, computers and communication devices.

[2] The Harmonized System (HS) codes used to define the industry is in the Appendix. This definition builds on those provided in (Frederick & Gereffi, 2013, 2016).

The **inputs and raw materials** needed to make electronic components vary by component. The materials used in semiconductor fabrication include silicon and silicon chips (for wafers), plastic (to form the layers of circuit boards), ceramics, various metals (mainly aluminum and copper, but also gold and silver), and doped chemicals and other materials. Elements boron, gallium, phosphorus, and arsenic are used in silicon chips to turn a silicon crystal from a good insulator into a viable conductor, or anything in between. Key inputs to other electronic components include various quantities of metals such as aluminum, copper, gold, and silver.

The next stage in the value chain is components. **Electronic components** are electronic elements with two or more connecting leads or metallic pads intended to be connected, usually by soldering to a printed circuit board (PCB), to create an electronic circuit (IBISWorld, 2015b). They can be categorized as passive or active, where active components amplify voltage and control the flow of electric current in a circuit. Semiconductors and passives are configured together in an electronic subsystem, the most common type being a printed circuit board assembly (PCBA), for incorporation into a complete electronic subassembly (Freedonia, 2012). Integrated circuits (or semiconductors) are the most expensive components, and the most important given these are what enable a product to process and/or store information. There are multiple types of ICs, including memory, logic, microprocessors, and microcontrollers.

Electronic subassemblies vary by final product; however, circuit boards are found in most electronic products. A circuit board is put into a plastic or metal enclosure (also called casing or housing) to form a subassembly. Manufacturers at this stage may be responsible for creating the PCBA and/or putting it in its casing; the manufacturer may take on the responsibility of sourcing raw materials or perform the operations on a contract or consignment basis for another firm. The electro-mechanical assembly process involves enclosure fabrication, installation of subassemblies and components, and installation and routing of cables. A term used by industry to refer to this stage is “box-build” or systems integration, which means assembly work other than just PCBA.[3] The final assembled product is then a “product-specific” part, indicating it is ready to go into a definable final product.

Displays are another common subassembly in consumer electronics, and if included, is often the most expensive intermediate input. The two main types today are: liquid crystal displays (LCD) and organic light emitting diode (OLED); prior technologies included plasma display panels (PDP), while the earliest displays were from cathode ray tubes (CRT). LCD and OLED markets are broken up based on size (large versus small; TV versus computers/phones) and types. For example, within OLED there is active-matrix OLED (AMOLED) and passive matrix OLED (PMOLED). As OLED technology is introduced, the size of the LCD market overall going down (based on value), however as of 2016, the LCD market is still much larger than OLED ($85 versus $15 billion)(IHS, 2016).

The **distribution and sales** methods for electronics components vary by type and the relative value of the part. Passive electronic component manufacturers (other than semiconductors) sell over half of their products via distributors (Ulama, 2015). Semiconductor and PCB companies are more likely to sell their products directly to electronic product manufacturers (IBISWorld, 2012). How finished ICs are sold to downstream manufacturers depends on a combination of

[3] https://www.ventureoutsource.com/contract-manufacturing/information-center/terms-and-definitions

product type and scale. Customized products are sold directly to specific buyers whereas standard products go through distributors; large buyers receive direct shipments whereas smaller buyers source from distributors. Regardless of how the product is sold, the components may be shipped from the Assembly and Testing (A&T) facility to the main distribution center of the semiconductor, distributor, or assembly company in the region (in Asia, these are primarily in Singapore, Taiwan, and Hong Kong), even if the purchasing firm is physically in the same country as the A&T facility.

Final products are destined to a growing range of end markets, from computers and consumer electronics, to appliances, cars, medical equipment and devices, industrial equipment, and aerospace and defense (A&D) products. In this report, the three principal end markets, or the "3Cs" -- computers, consumer electronics, and communications and networking (or cell phones) -- are analyzed (Table 3-1). These markets, starting with consumer electronics, and followed by computers and communication devices, were the original products capable of storing and processing information, and the entire output of these industries is included in this analysis. In the 3Cs, the lead firms are electronic specialists with technical expertise in the industry. These are all primarily consumer market products produced in high volumes with declining unit values as product replacement cycles are less than five years (and less than two years in several markets and product categories). Communication devices (cell phones) are the only segment to increase in value and volume. Compared to consumer electronics and computers, they are higher volume, lower value products. Of the 3C categories, they accounted for 62% of volume, but only 43% of value in 2015 (Table 3-1).

Table 3-1. 3C Electronics, Volume (Units) and Value (US$), 2007-2015

Segment	2015, millions		Change (%), 2007-15		Unit Value	Share, 2015	
	Vol	Value	Vol	Value	2015	Vol	Value
3C Total	**2,583**	**683,971**	**26%**	**17%**	**$257**		
Consumer Electronics	537	**206,849**	-35%	-25%	$346	21%	30%
Computers	446	180,565	53%	9%	$405	17%	26%
Cell Phones	1,600	296,557	72%	107%	$185	62%	43%

Source: Euromonitor (2016); Note: volume data not available for video game hardware (part of consumer electronics); shares for volume and unit values do not include video game hardware, however shares based on value include video game hardware.

The division between what is considered a computer compared to a consumer electronic or communication device (particularly cell phones) is increasingly blurry which causes some issues in directly comparing data across sources. The growth of smaller portable devices, including laptops, tablets, and mobile phones, which increasingly have the same capabilities as in-home devices, is decreasing the need to have individual units by function. Furthermore, most visual and audio media is now available via the Internet, and physical discs (which required the use of a video/DVD player or a portable audio player) are no longer needed. This greatly reduces the 'tangible output,' and will also result in a decline in exports (with a corresponding increase in service-related trade in software). This convergence in technological capabilities also makes it difficult to accurately segment consumer electronics into comparable categories across sources.[4]

[4] For example, Pegatron, a contract manufacturer, includes tablets, game consoles, LCD TVs, e-readers, and multimedia players (MP3) as consumer electronics (Pegatron, 2015). However, tablets and e-readers are classified as computers in other sources (e.g., trade data).

Table 3-2. Market Share of 3C Categories, 2007-2015 and Number of Firms

Country	Market Share (%)								Number of Firms (2015)			
	Consumer Electronics		Computers		Cell Phones		Video Games		Consumer Electronics	Computers	Cell Phones	Video Games
	2007	2015	2007	2015	2007	2015	2007	2015				
Korea	12%	21%	9%	12%	22%	27%	--	0%	2	2	2	1
Japan	33%	26%	14%	8%	2%	2%	71%	57%	13	8	3	2
US	11%	11%	33%	34%	54%	18%	14%	28%	8	12	3	4
Europe	5%	4%	1%	1%			--	--	2	3	2	--
China	4%	9%	5%	10%	3%	27%	0%	0%	9	10	11	1
Taiwan	--	--	10%	12%	2%	2%	--	--		4	2	--
Share Known	67%	72%	73%	77%	82%	80%	84%	85%	34	~40	20	8

Source: based on market data from Euromonitor (2016); represent volumes except video games.

Computers: This segment, which also includes storage devices, servers and office equipment, is comprised of consumer products as well as enterprise or commercial products purchased by businesses. Computers for personal use (i.e., laptops/notebooks, desktops) are the main consumer product. These are produced in large volume and have experienced tremendous growth in the last decade, but has stagnated due to the growth of smaller, more handheld electronics with similar capabilities such as smartphones. Manufacturing of most top computer brands is by contract manufacturers who have the global scale to produce for this high-volume market. This segment also includes printers, scanners, copiers, fax machines (and combinations thereof), as well as parts of computer systems sold individually (keyboard, display, mouse, etc.), however these account for a relatively small share of the overall value.

Products in the enterprise segment include computer systems, servers and storage devices;[5] this is a smaller, but growing market due to companies and individuals saving more data and the trend towards cloud computing rather than saving all data locally on a device. The lead firms in this segment differ from those in the personal computer segment and align more with the communication and networking end market.

Of the 3C markets, computers are the smallest based on value and volume. In 2015, this market value was $181 billion with 446 million units sold (Euromonitor, 2016) for an average unit value of $405. Overall volume and to a lesser extent value have increased.

Computer companies/brands have two significant groupings; the top four, which accounted for 44% of retail volume in 2015, and the top 7 (60%). There is a significant drop in volume after this point. Over the last eight years, US firms have maintained the top position with approximately one-third of the market, while Asian firms in Korea, Taiwan and particularly China have increased market share at the expense of Japanese firms. At the firm-level, growth has been driven by Apple (US), Lenovo, the Chinese firm that acquired IBM's computer business in 2005, Asus (Taiwan), and Samsung (Korea).

[5] Storage devices are components of personal computers and industrial computers as well as standalone products.

Contract manufacturing is the dominate production model in the computer segment. For notebook PCs, the top five ODM/EMS companies accounted for three-quarters of global shipments in 2014 (131 of 172 million units)(Pegatron, 2015). Of the top five computer brands, only Samsung and Lenovo have in-house manufacturing.

Consumer Electronics: this group is broken into in-home products (TVs, DVD players, home audio and video), digital cameras, portable players, and video game hardware. Consumer electronics were still the largest of the '3C' categories in 2015, but significance is falling in terms of value and volume (Table 3-3). In 2015, 537 million units were sold (not including video game hardware) with a market value of **$207 billion** (video game hardware included). The number of units and the value have declined in all product categories (except TV volume, which has slightly increased by 4% between 2007 and 2015). The largest segment is TVs, accounting for 64% (based on value) and 41% (based on volume) in 2015.

Japanese firms still hold the largest market share (26%), but it is declining as Korean (21%) and Chinese (9%) firms increase market share. US firms' volume has decreased, but it has maintained market share. European firms have not been prominent in this segment. As demand has decreased, the industry has become more concentrated at the firm level. The share held by the top three firms has increased (26% to 32%). In video game hardware, Japanese and US firms dominate the (85% of 2015 market value). In the in-home segment, Samsung, LG, and Sony are the top firms. They accounted for 41% in 2015; up from 31% in 2007 (for TVs only, the shares increased from 33 to 43%).

Table 3-3. World Consumer Electronics, Market Size, Top Firms, Shares, and Change, 2015

Category	2015 (millions)		Change % (2007-15)		Top 3 Firms/Brands, 2015 (Volume)	Top 3 Share	Unit Value
	Volume	Value	Vol	Value		2015	2015
Total Consumer Electronics	**537**	**206,849**	**-35%**	**-25%**	Samsung, LG, Sony	**32%**	--
(1) In-Home	353	155,542	-20%	-14%	Samsung, LG, Sony	41%	$440
TVs	222	133,325	4%	-5%	Samsung, LG, Sony	43%	$602
Home Audio/Cinema	86	17,836	-19%	-26%	Sony, Samsung, Philips	36%	$207
Video Players	45	4,381	-63%	-73%	Samsung, Sony, LG	48%	$96
(2) Imaging Devices	62	18,748	-68%	-59%	Canon, Nikon, Sony	53%	$302
(3) Portable Players	122	11,787	-36%	-51%	Apple, Sony, Amazon	35%	$97
(4) Video Game Hardware	--	20,773	--	-15%	Sony, Microsoft, Nintendo	80%	--

Source: Euromonitor (2016); Values are based on RSP. Note: volume data for video game hardware is not available.

The unique features of this segment are that (1) most firms own manufacturing facilities rather than use contract manufacturers; and (2) they are also at least quasi-vertically integrated for key components. For example, for LCD televisions, Samsung and LG outsource less than 15% of final production. However, even though they own manufacturing, essentially all production is offshore (98%+ in 2014). Until 2010, Sony followed a similar model, but dramatically increased outsourcing after the economic crisis (which is now around 75%). Chinese firms, except Haier, also primarily manufacture in-house (TCL, HiSense, Skyworth and Konka).

The imaging devices (digital cameras) the market was valued at $18.7 billion in 2015. Since 2007, the segment has seen the greatest volume decline of all the consumer electronics categories (-68% from 2007 to 2015), yet unit values increased from $239 to $302 (Euromonitor, 2016). Mobile phones have taken away the need for separate cameras, but there is still a niche market for higher-end models. The market is concentrated; just eight firms accounted for 87% of the global market in 2015 (by volume), and is dominated by Japanese firms (78%); the top five firms -- Canon, Nikon, Sony, FujiFilm and Panasonic -- are all Japanese (Euromonitor, 2016). The only company to increase production volume between 2007 and 2015 was GoPro (US).

Portable players, which includes e-readers and portable media players, is the smallest category based on retail value (6%), but made up 23% by volume in 2015. The average unit value in 2015 was $97. The top three companies accounted for 35% of the market (based on volume in 2015). The top companies and brands are Apple (iPod, Beats), Sony and Amazon (Kindle). US companies dominate in this segment.

Video game hardware is highly concentrated with the top three companies accounting for 80% of sales in 2015. These are Sony (42%), Microsoft (23%) and Nintendo (15%) (Euromonitor, 2016). The market value was $21 billion in 2015; down from $28 billion in 2008.

Cell Phones: Overall volume is increasing in this segment. Between 2007 and 2015, only one of the top brands (Samsung) maintained its position in the top three. The other two (Nokia and Motorola) were both absorbed by other companies (Microsoft and Lenovo). The top three companies in 2015 were Samsung, Apple and Huawei (40% share based on volume). The most notable changes between the two years are the emergence of Apple and Chinese firms/brands. Apple went from less than 1% market share to 13% and Chinese firms from 3% to 27% (with six of the top 10 firms being Chinese). Samsung also doubled market share (Euromonitor, 2016). Outside of Apple however, US/European firms saw their market share decline by more than half; from 54% to 18% (Motorola went from being a US to a Chinese firm over this time period) (Euromonitor, 2016). While Korean firms have been able to maintain market share in cell phones, the rapid growth of Chinese producers suggests they will likely out-produce Korean firms within the next two years (at least based on volume). Both countries accounted for approximately 27% in 2015, however Korea had 22% in 2007 whereas China was only 3%.

A variety of production models are used in this segment. Korean firms manufacture in-house (but offshore), Chinese firms are mixed (Huawei, Xiaomi outsource, Lenovo and ZTE have a mixed strategy; TCL is in-house); the two US firms, Apple outsources while Motorola manufacturers in-house, but offshore (Vietnam).

Software is a key service-related segment of the electronics value chain, and is composed, for the most part, of a different set of firms than those engaged in manufacturing and differs based on the market. The *video game software* industry is much larger than video game hardware and is composed of a different group of companies. In 2015, video game software had a value of $78.5 billion. While still smaller than the major hardware segments (phones, computers and TVs), it is growing and offers opportunities for smaller firms. The top five based on value in 2015 only held 15% of the market. The top three positions are US firms, but a variety of Asian companies from China, Japan and Korea also participate (Euromonitor, 2016).

In computers, Microsoft dominates software (combined with Intel microprocessors).
In mobile phones, Google playing a leading role in the development of the Android open-source operating system and Qualcomm dominates the design of microprocessors for smartphones. In the first quarter of 2016, 84% of smartphones were based on the Android OS, with approximately 15% from Apple's iOS use only in its own products (Sun & Grimes, 2016). The other two OS each have less than 1% of the market: Research in Motion (Blackberry) and Microsoft (Windows Phone).

3.1.2. Geographic Distribution (global supply and demand)

Global trade in the electronics industry has shifted from developed markets and towards Asia, in terms of both demand and supply. While the shift of production towards the region has been steady because of lower costs and access to raw materials, more recently the rapid growth of the Asian consumer market has also made the region important on the demand side. This section examines these changes, analyzing the main countries participating (exporting and importing) in the different segments of the GVC, including key end markets.

Global supply is represented by both the countries that export components (parts and product-specific subassemblies), and those that assemble and export final products that incorporate them. Table 3-4 lists world exports by value chain stage and the final product/subassembly categories identifiable using trade statistics: computers/storage devices/office equipment, consumer electronics, and communication equipment.

Exports of final 3C electronic products were US$1 trillion in 2014 (Table 3-4). Computers were the largest category in 2014; however mobile devices surpassed computers in 2015 (UNComtrade, 2017a).

Table 3-4. World Electronics Exports, 2000, 2007 and 2014

Category/Share	Export Value ($US, B)			Share of Total (%)			Change (%)	
	2000	2007	2014	2000	2007	2014	2000-14	2007-14
World Total	**1,150**	**1,792**	**2,285**				**99%**	**27%**
Communication Equipment	116	218	389	10%	12%	17%	236%	78%
Computers/Storage Devices/Office Equipment	217	315	417	19%	18%	18%	92%	33%
Consumer Electronics	100	214	200	9%	12%	9%	99%	-7%
Industrial Final	43	85	113	4%	5%	5%	163%	32%
Medical Final	17	42	52	1%	2%	2%	203%	25%
3C Subassemblies	255	316	327	22%	18%	14%	29%	4%
Industrial Subassemblies	12	23	31	1%	1%	1%	158%	38%
Electronic Components	390	580	756	34%	32%	33%	94%	30%
By VC Stage								
Final	493	874	1,170	43%	49%	51%	137%	34%
Subassembly	267	338	359	23%	19%	16%	34%	6%
Components	390	580	756	34%	32%	33%	94%	30%
Final 3C Total	433	747	1,006	38%	42%	44%	132%	35%

Source: UNComtrade (2017a); HS96

China has maintained its lead in the final assembly stage over the past decade, representing 40% of final product exports in 2014 (Table 3-5). Export growth has also been strong for Vietnam, Thailand, the United Arab Emirates (UAE), and to a lesser extent, Mexico. In terms of export share, other top exporters have remained stable (US, EU-15, Korea, Malaysia and Singapore) or declined (Japan and Taiwan).

Table 3-5. Top 10 World Exporters of Electronic 3C Final Products, 2000, 2007 and 2014

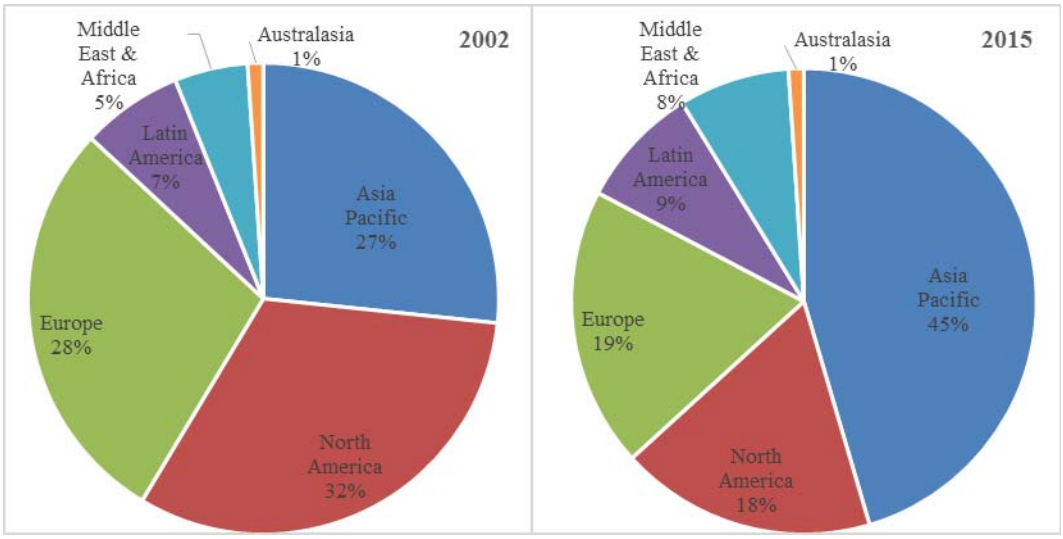
Reporter	Export Value ($, US Billions)			Country Share of World Exports (%)			Change (%)
	2000	2007	2014	2000	2007	2014	2000-14
World	**433**	**747**	**1,006**				**132%**
China	28	228	405	6%	31%	40%	1339%
EU-15	143	165	139	33%	22%	14%	-3%
US	53	54	74	12%	7%	7%	41%
Hong Kong	18	38	65	4%	5%	6%	259%
Mexico	25	42	53	6%	6%	5%	113%
UAE	n/a	3	31	n/a	0%	3%	n/a
Vietnam	0	1	30	0%	0%	3%	52189%
Korea	21	34	24	5%	5%	2%	19%
Thailand	5	17	21	1%	2%	2%	299%
Singapore	25	22	21	6%	3%	2%	-17%
Japan	40	24	12	9%	3%	1%	-70%
Other Asia, nes	21	11	13	5%	1%	1%	-39%
Malaysia	19	26	19	4%	4%	2%	3%
Top 10 (in given year)	**393**		**865**	**91%**		**86%**	**120%**

Source: UNComtrade (2017a); top exporters based on export value.

Global demand is represented by the top importers of final products and retail data. The main consumers in both 2007 and 2014 were the EU-15, US, China/Hong Kong, and Japan. However, demand for 3C final products is becoming less dependent on the US and the EU-15. In 2000, these two markets accounted for 62% of world imports, however this was down to 47% in 2014 (UNComtrade, 2017b). Using the same groups as below, Asia-Pacific increased from 21% to 26% between 2000 and 2014 and the Middle East and Africa went from 1% to 6%.

Based on retail volume, the Asia-Pacific region increased its share of demand for consumer electronics from 27% in 2002 to 45% in 2015, surpassing North America to become the largest market in 2004. Growth has been primarily driven by China, which accounted for half of that demand. While demand has grown in North America and Western Europe, this has been at a much slower pace than in Asia (Euromonitor, 2016).

Figure 3-2. World Consumer Electronics Demand, by Retail Volume & Region, 2002-15



Source: Euromonitor (2016). Australasia: Australia and New Zealand; North America: USA and Canada; Middle East/Africa (includes UAE, Saudi Arabia and South Africa); Europe (incl. Russia); Latin America (incl. Mexico).

3.1.3. Key Firms and Segments in the Electronics GVC

The electronics industry is comprised of three main groups of actors: **lead firms, Tier 1 suppliers and contract manufacturers, and component suppliers**.[6] Many other entities play important roles in the broader industry, including software developers, production equipment manufacturers, distributors, and producers of more generic components and subsystems, but understanding how these three firm-level actors interact provides the most important insights into economic development opportunities. The share of the total value captured by the most powerful firms in GVCs – in this case, lead firms and component suppliers with strong "platform leadership" - can be extremely high (Sturgeon & Kawakami, 2010). These actors control product and technology development that are crucial for competing in the final product market, while the introduction of new applications and better-engineered components drives growth in the chain.

Lead firms concentrate their activities in the highest value stages for final products; these activities include marketing, branding, research, design, and product development. Some lead firms still assemble products in-house, but outsourcing final product and subassembly activities to contract manufacturers has been a strong trend over the past three decades (Sturgeon & Kawakami, 2011). This enables them to focus on the highest 'intangible' value-adding activities listed above without having to also focus on achieving production efficiencies. Production and logistics activities require a different set of skills and tasks than inventing and marketing final goods, so dividing the chain in this way enables the different actors to each develop a more specialized set of core competencies.

[6] The term "Tier 1" is used in end markets in which the final product is not typically considered an "electronic." For example, in the automotive industry, lead firms are motor vehicle manufacturers (e.g., Ford, Mazda, or Toyota), however the primary electronic suppliers (such as those listed in the table) are considered Tier 1. In most cases the Tier 1 engages in manufacturing, but it is also possible for the Tier 1 to outsource to an EMS contract manufacturer. This is an important distinction because the distance between the contract manufacturer and the lead firm is further removed in these end markets.

The outsourcing of manufacturing functions and services by lead firms gave rise to the emergence of large supplier firms of varying degrees of sophistication and business models. Production services in the electronics industry include activities such as component purchasing, PCBA, final product assembly, and testing. In the industry, this is referred to as electronics manufacturing services (EMS). In addition to manufacturing, some contract manufacturers also provide design services; contractors that provide manufacturing plus product design services are known collectively as original design manufacturers (ODM).

A few of the largest cater to large volumes for the computer, communication, and consumer electronics. Others, particularly those beyond the top 15, are specialists in automotive, medical or other niche markets. Some specialize in products with short life-cycles; others in products with longer life-cycles. A few also do design work (and thus resemble original design manufacturers)(van Liemt, 2016).

Contract manufacturers establish their own global production networks to produce products and/or provide design services on behalf of lead firms for a specified period of time.[7] The popularity of contract manufacturing in the electronics industry is enabled by value chain modularity, which enables a clear technical division of labor between design and manufacturing at multiple points in the value chain, most notably between the design and assembly of final products and the design and fabrication of integrated circuits (Sturgeon & Kawakami, 2011).

EMS firms have become significant players in the industry as standardized operations allowed them to serve multiple customers, achieve high capital utilization rates and leverage economies of scale. Contract manufacturers account for a majority share of assembly operations in the more mature 3Cs markets and an increasing share in others. In 2014, contract manufacturing services in electronics accounted for between US$406 and US$490 billion (Buetow, 2015; IDC, 2015; NVR, 2015). Most of the EMS business is in PCBA, for which manufacturing processes and technologies are relatively generic. EMS providers can thus serve lead firms in a variety of end markets, which provides a large pool of potential customers. Yet, this limits the market power of EMS providers because their services are highly substitutable. Design expertise, on the other hand, is more sector-specific, which limits the potential for end market upgrading but does enable the firm to engage in higher-value activities.

Table 3-6 lists the top global EMS and ODM providers in 2014 based on industry revenue. The contract manufacturing sector is fairly concentrated with the top company, Foxconn, accounting for approximately 30% of industry revenue in 2014 and the top 10 accounting for approximately 65% (Buetow, 2015). All the top 15 global contract manufacturers in electronics have production locations in China.

Contract manufacturers are responsible for some input sourcing, but this is largely only in lower value components. Purchase contracts for the more expensive components such as microprocessors or displays are negotiated directly by the lead firms and the component companies (this is discussed further below). The global prices for the other generic electronic

[7] Most large ODM contract manufacturers are based in Taiwan where they host their design functions, while their manufacturing operations are concentrated in mainland China.

and electrical components are typically low and are often purchased through global distributors. EMS providers profit margins typically range between 2 and 10% (Rammohan, 2011).

Table 3-6. Top 15 Electronics Contract Manufacturers (EMS & ODM), 2014

Rank	Contract Manufacturers	Global HQ	Main Service	Year Est.	Revenue (US$, B)	Emp. ('000)	Markets	Manufacturing Locations
1	Foxconn/Hon Hai	Taiwan	EMS	1974	$135	1,061	3C	China, Mexico, Brazil, USA, Czech Rep., Hungary, Slovakia, Turkey, Malaysia
2	Pegatron	Taiwan	ODM	2007	$33	7	3C	China, Mexico, Taiwan, Czech Rep.
3	Quanta Computer	Taiwan	ODM	1988	$29	105	Computer	China, USA, Germany
4	Compal Electronics	Taiwan	ODM	1987	$27	70	3C, Auto	China, Vietnam, Taiwan, Brazil, Poland
5	Flextronics+	Singapore	EMS	1969	$27	150	All	China, Malaysia, Mexico, Brazil, Hungary, Israel, Poland, Romania, Ukraine, India
6	Wistron	Taiwan	ODM	2001	$19	70	3C	China, Mexico, Taiwan, Czech Rep., Malaysia
7	Jabil Circuit	USA; FL	EMS	1966	$17	142	All	China, Malaysia, Singapore, Vietnam, India, USA, Mexico, Brazil, Hungary, Ireland, Poland, Ukraine
8	Inventec	Taiwan	ODM	1975	$14	--	3C	China, UK, Taiwan, Czech Rep., USA, Mexico
9	TPV Technology	Taiwan; Hong Kong	EMS	1998	$12	32	Computer Consumer	China, Mexico, Poland, Russia, Brazil, Argentina
10	Celestica	Canada	EMS	1997	$6	27	All	China, Malaysia, Thailand, Singapore, Laos, Canada, USA, Mexico, Ireland, Spain, Romania
11	Cal-Comp Electronics*	Thailand	EMS	1989	$5	247	Computer Telecom	China, Thailand, Philippines
12	Sanmina-SCI	USA; CA	EMS	1980	$5	43	All	China, Singapore, Malaysia, Israel, Finland, USA, Mexico, Hungary
13	Universal Scientific Industrial (USI)	Taiwan	EMS	2003	$4	--		China, Taiwan, Mexico
14	Benchmark Electronics	USA; TX	EMS	1979	$3	10	Industrial Telecom Computer Medical	USA, Thailand, Mexico, Malaysia, China, Singapore, Netherlands, Romania, Brazil
15	BYD Electronic	Hong Kong	EMS	2002	$3	60	Consumer (Mobile)	China, Hungary
Total/Top 15					**$490/69%**			

Sources: Authors. Compiled from: Buetow (2015), firm websites and MarketLine profiles. Additional maps here.

While electronics assembly firms are mostly headquartered in Asia, key components are still controlled by developed country firms. The world's largest electronic component companies are headquartered in the US, Japan, Korea, Taiwan and countries in Western Europe with

manufacturing facilities in low-cost countries (such as China). In some cases, these facilities are owned by the parent company or companies might outsource some of their production or specific steps, particularly semiconductor assembly and test activities (SATS) to contract manufacturers also located in low-cost countries.

Semiconductors, including discretes, ICs, and optoelectronics, are among the most critical and expensive components in electronic products. Given the technological importance and share of the cost of the final product, semiconductor companies often deal directly with lead firms and work in conjunction with them on R&D and NPD of final products (in some cases lead firms have IC and final product divisions). Top semiconductor companies are listed in Table 3-7.

Table 3-7. Top 10 Semiconductor Firms by Revenue in 2010 and 2014

Firm	HQ	Revenue ($US, B)		Types	Activities	Mfg. Locations	Year Est.
		2010	2014	2013			
Intel	US (CA)	40.0	51.4	Microprocessor (51%), Logic (49%)	Wafer, A&T	US, Ireland, Israel, China	1968
Samsung Electronics	Korea	28.1	37.8	Memory (84%), Logic	Wafer, A&T	Korea (3), US (1), China (2)	1969
TSMC	Taiwan	--	25.0	--	Wafer	Taiwan (8), China, US	1987
Qualcomm	US (CA)	7.2	19.3	--	IC Design	Fabless	1985
Micron Technology (acquired Elpida 2012)	US (ID)	8.9	16.7	Memory (76%), Logic (24%)	Wafer, A&T	Japan, Singapore, US	1978
SK Hynik; Hynix Semiconductor (2001-11)	Korea	10.6	16.3	Memory (100%)	Wafer, A&T	Korea, China (1)	1983
Texas Instruments	US (TX)	13.0	12.2	Analog (87%), Logic (13%)	Wafer, A&T	US (6), China (1), Japan (1), Germany (1), Scotland (1)	1951
Toshiba	Japan	13.1	11.0	Memory (78%), Logic, Discrete, Analog	Wafer, A&T	Japan	1875
Broadcom Ltd. (acquired by Avago Technologies 2016)	Singapore/ US	--	8.4	--	IC Design	Fabless	1991/ 1961/ 2016
STMicroelectronics	Switzerland	10.3	7.4	Discrete (68%), Logic (26%), Analog (7%)	Wafer, A&T	France (4), Italy (2), Singapore (2)	1987
Renesas Electronics (merged with NEC 2010)	Japan	11.8	--	Logic (45%), MC (25%), Discrete & Analog (29%)	Wafer, A&T		2002/ 2003/ 2010
Elpida Memory	Japan	6.9	--				
Top 10		**131.1**	**205.5**				1997

Sources: Zino (2011, 2015); Source's sources: 2010: company reports; iSuppli; 2014: IC Insights. Additional maps and tables are provided here.

The display market is fairly concentrated in terms of companies and countries. The top country for LCD and OLED technologies is Korea, based on headquarters and production capacity, however China and Taiwan are very close for LCD production capacity. Korea edges ahead due to their dominance in OLED. Overall, Korean firms control 97% of the OLED market (based on

value, 2016). LCD is more divided; Korea still leads with approximately 37% followed by China (27%), Taiwan (24%) and Japan (10%). Of the Korean firms, LG Display is focused on large screen OLED whereas Samsung Display is focused on small and medium (computers, phones). Top consumer electronics manufacturers that own manufacturing also tend to be at least partially vertically integrated (e.g., Samsung, LG, Sony and Sharp/Foxconn).

Countries positions in the industry can also be generalized by the characteristics of most firms with operations in the country, and compared by tiers based on sales volume and market orientation. From a geographic market standpoint, manufacturers physically located in Mexico and Eastern Europe primarily supply the US and Western Europe, whereas "global" providers are all Asian based, more specifically in East and Southeast Asia. Table 3-8 gives an overview of the roles played by the main country participants in electronics.

Table 3-8. Segments of the Electronics GVC with Country Examples

Categories	Capabilities/Tiers	Countries	End Markets
Production Equipment	--	Japan, Europe, US	--
Component suppliers: Semiconductors	A&T	Philippines, Malaysia, Thailand, Taiwan (esp. SATS)	--
	Wafer fabrication; IC design and/or R&D	Taiwan, Singapore, China, Korea, US, Malaysia	--
Displays		Korea, China	--
HDD		Singapore, Philippines	--
EMS/ Tier 1 MNC Branch Plants	Regional	For US: Mexico For Western EU: Hungary, Poland, Czech Republic, Germany, Romania For China: China	All
	Global: Tier 3	Laos, Myanmar (very recent) Indonesia (entered 1990s) Philippines (entered 1970s)	-- Consumer, Industrial Storage/Office, Automotive
	Global: Tier 2	Vietnam (entered 2000s) Thailand (entered 1980s) Malaysia (entered 1970s)	Cell Phones, Computers Computers/Storage Computers, Consumer
	Global: Tier 1	China	3C, All
ODM	Design and NPD	China	Computers Communications Consumer Electronics
		US, Taiwan, Singapore	
Global Lead Firm (OBM)	Global brand owners; marketing, branding and manufacturing (for some)	Western Europe US Japan Korea China	Automotive (Germany, Japan) Medical (UK, Ireland, Germany) Industrial (Europe, US) A&D (US) Communications (Korea, US) Consumer Electronics (Japan, Korea, China) Computers/Office (US, Taiwan, China, Korea, Japan (office))

Source: updated from Frederick and Gereffi (2016); based on trade data, market reports, and global locations of top Tier 1/EMS/ODM companies.

3.1.4. Standards and Institutions

The proliferation of product standards and the wide-spread adoption of process standards have enabled the codification of this very complex supply chain. This modularity, in turn, has facilitated the electronics industry's rapid development. Standardization has both enabled the growth in the number of products and end markets that incorporate electronic components and the transferability of at least some components among multiple products and brands.

Standard-Setting Organizations

There are several bodies involved in setting electronics standards and platforms. At the global level, the International Electrotechnical Commission (IEC) is the standards organization that prepares and publishes international standards for all electrical, electronic and related technologies – collectively known as "electrotechnology." ISO standards are published by the International Organization for Standardization (ISO) and are available through national standard bodies. The IEC works with the ISO and the International Telecommunications Union (ITU), in some cases developing joint standards. The IEC is composed of one national committee per country. These members help develop the standards as well as conformity assessments.

Process Standards

Quality standards are very important in the electronics industry and the ability to manufacture with low defect rates and quick turnaround times are necessities. As a result, maintaining certifications for international standards is of the utmost importance. Certification is important for firms throughout the supply chain from component suppliers to final product manufacturers.

The ISO 9000 family of standards covers quality management systems and how products are produced rather than the product itself. These standards provide guidance and tools for firms who want to ensure that their products and services consistently meet customer requirements, and that quality is consistently improved. Companies are certified through accredited certification organizations and must renew the certification at regular intervals, typically every three years. ISO 9001 was first released in 1987, and has been through four versions with 2008 being the most recent. All requirements are generic and intended to apply to all organizations, regardless of size, industry, or products provided. Most companies obtain an ISO 9001 certification.

Several industries have more specific quality management standards that expand on ISO 9001 to cater to their market's needs, many of which are applicable to electronic and electrical product manufacturers. Lead firms often require suppliers to be certified, and firms wishing to sell into multiple end markets must obtain certifications for each industry. Tier 1 and EMS providers are required to get industry-specific certifications and ensure the latest version is implemented. In some cases, these certification requirements can be a constraint or even a barrier to entry for new firms, SMEs, or those in developing countries due to the costs required to meet the qualifications of the standard and to become and maintain certification. Given the critical nature of products for the automotive, A&D, and medical markets, quality requirements are more stringent than those for consumer electronics.

Beyond quality management, there are several other ISO standards that pertain to maintaining operational or environmental efficiencies. The most common is the ISO 14000 family of standards which focuses on environmental management and helps companies minimize their environmental impact. For capital-intensive manufacturing, ISO 50001 is important to ensure energy efficiency. The table provides a list of the main standards and certifications relevant for the electronics and electrical industries.

Table 3-9. Important Standards in the Electronics GVC

Standard	Description	Certification/ Audit Frequency	End Markets
Quality Management			
ISO 9001	Industry neutral standard	Valid: 3 years	All
ISO/IEC 17025: 2005	Certification would signal functional upgrading to service activities.		Testing and Calibration Laboratories
TL 9000	Specific to the telecommunications industry; developed by the telecom industry group QuEST Forum. It also includes standardized product measurements for benchmarking.		Telecommunications
Business Operations/Environment			
ISO 50001:2011	Improvement of energy performance, including energy efficiency, energy use and consumption.	Valid: 3 years	All (Energy Management)
ISO 14000		Valid: 3 years Audits: annual	All (Environmental Management)
RoHS	Impacts sales to the EU market		All
WEEE	Impacts sales to the EU market		All
Product			
Interconnect Standards (i.e., 2G, 3G, 4G)	National standards are set within international standards.		Telecommunications (Mobile)

Sources: updated from Frederick and Gereffi (2016)

Product Standards

There are also numerous product standards, most of which can be found on the IEC's database of standards. Adoption of IEC standards is voluntary, although they are often referenced in national laws or regulations around the world.

Standards are particularly important in enabling *digitalization*. General interconnect standards are set by the International Telecommunications Union (ITU), an international standard setting body based in Geneva. The ITU organizes study groups to produce draft recommendations on international specifications for each generation of mobile telephony (1G-5G), and these broad standards are then approved, modified, or rejected by world telecommunications standardization conferences that include representatives from member states, industry associations, and firms. How companies meet these standards in specific terms is up to them to propose to the ITU, but since interoperability is needed to allow equipment such as mobile phone handsets and wireless infrastructure (towers, base stations, and network switching equipment) to interact, the strongest players, often collaborate to propose their own standards, and submit these for approval to ensure that they meet the requirements of the general standard.

Environmental Standards

There are also environmental standards and waste regulations for electronic products in many countries, particularly in the EU market. Since late 2006, products sold in the EU must comply with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC (and now also RoHS Directive 2011/65/EU (RoHS2), effective January 2013) which restricts the use of six heavy metals (lead, mercury, cadmium, hexavalent chromium, and other flame retardant materials) found in electronics. The EU also promotes collection and recycling of electronic equipment under the Waste from Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC. All applicable products in the EU market must pass WEEE compliance and carry the "Wheelie Bin" sticker. WEEE encourages manufacturers to design electronic products with end of life recycling and recovery in mind. RoHS assists in this process by requiring the use of safer materials via restricting the amount of hazardous chemicals (European Commisson, 2015).

Tariffs and Trade Agreements

Import tariffs for electronics and electrical products tend to be low due to the WTO Information Technology Agreement (ITA). The ITA was reached through a Ministerial Declaration on Trade in Information Technology Products at the first WTO Ministerial Conference, held in Singapore in 1996. The original ITA had 29 participants, however, the number has grown to 81, representing about 97% of world trade in IT products. The ITA requires each participant to eliminate and bind customs duties at zero for all products specified. During 2015, the ITA was expanded to cover an additional 201 products. At the time of writing, 54 members have agreed to the expansion, covering 90% of world trade in IT products. Participants must develop a schedule to eliminate tariffs on most new products over the course of three years (2016-2018) (WTO, 2016a).[8] Another objective of the ITA is to eliminate non-tariff barriers (NTB) in IT trade (WTO, 2016b). As such, free trade agreements (FTAs) are not widely used compared to other manufacturing industries.

3.1.5. Human Capital and Workforce Development

Most workers in manufacturing establishments are production workers including operators and technicians. Workers at these levels typically have at least primary education as well as secondary education and some additional technical/vocational school at the technician level. Non-production workers include research scientists, product developers, process developers, managers, supervisors, and administrative staff. These employees typically have a four-year university degree in engineering or a business administration field. Firms employ a range of engineers that focus on various aspects of process and product development, including process and systems engineers, component and machine design, field applications, and quality control.[9]

The highest-level workers are scientists who engage in research related to theory and conceptual development of new ideas for technologies that will enable new processes and products. Scientists typically have a Doctor of Philosophy (PhD) in basic sciences, engineering, or a

[8] Participants: https://www.wto.org/english/tratop_e/inftec_e/itscheds_e.htm (includes all top importers and exporters except Mexico).

[9] This section draws on fieldwork conducted on the E&E industry as part of this project (Frederick & Gereffi, 2016), and two previous studies (Frederick & Gereffi, 2013; Metha & Frederick, 2015).

degree that combines aspects of the two. After an idea is generated, product developers with a strong background in engineering principles work to create a new or improved product or prototype. Product developers have a Master of Science (M.S.) degree in an engineering-related field, or a Bachelor of Science (B.S.) combined with many years of experience in the field. Process developers look at the results of current operations to determine how production can be modified to improve productivity and reduce cost. These activities are more repetitive and less innovative than product development, and positions are typically held by employees with a B.S. in engineering. Related to process development, mechanical engineers are also involved in areas related to manufacturing equipment. Industrial engineers are often involved in activities related to inventory and supply chain management. Employees with a background in business are engaged in scheduling, procurement, marketing, and other administrative roles. Table 3-10 provides the typical workforce profile of an electronics manufacturing firm.

The most common engineering degrees vary by company, but popular fields include electrical or electronic, mechanical, and industrial. Increasingly firms are looking for employees that have cross-disciplinary skills across two or more fields within engineering (e.g., electromechanical, industrial design) or more often in engineering and business. These positions are particularly important in areas where employees need to be able to communicate the benefits of their technology in a way that someone outside of the engineering field can understand such as customers, investors, and government officials. Similarly, employees with these qualifications are also well-suited for management positions or to start their own companies. Technology management degree programs are gaining in popularity where coursework is divided between business classes and a specific scientific or industrial area.

A different workforce profile is required for firms to move beyond manufacturing into sourcing, distribution, and sales. Employees include production-level workers in distribution centers, receiving, and shipping, and university-level employees in fields related to business management to work in procurement, supply chain management, and sourcing. To move into technical research, design, and product development, advanced science, engineering, and analytical skills are needed; for marketing, branding, and retail, workers need soft skills related to communication and business development. Growing and advancing to higher value-added activities requires a large supply of workers with sufficient technical skills to cover the full range of key supply chain functions.

Table 3-10. Employee Profile for the Electronics Manufacturing Global Value Chain

Position	Share	Education	Job Characteristics
Operators	30%	Mostly primary education	Production line workers; majority of training is on the job
Technicians	50%	Secondary education, technical high school, vocational training	Some specific technical or industry-specific skills required
Engineers	14%	Tertiary; university degree in engineering	Process engineering; systems optimization, quality control
Administrative	6%	Tertiary; university degree in business	Sales, finance, customer service, supervisors, management

Source: Frederick and Gereffi (2013)

Given the capital-intensive nature of this industry, labor/wages account for a relatively small share of industry costs. The average estimate for labor costs is 12%, with material costs making up the bulk of expenses at an average of 65% (IBISWorld, 2015a, 2015b, 2015 (October); JETRO, 2014). Labor costs have fallen as a percentage of revenue since 2010 due to the standardization of components, improved supply chain management, increased use of automation, and the transfer of production from high-wage to low-wage countries.

3.1.6. Upgrading Trajectories

Upgrading is broadly defined as moving to higher-value activities in GVCs to increase the benefits (e.g. security, profits, skill, technology or knowledge transfer) from participating in global production. Upgrading can take place in many forms; firms can make better products, make them more efficiently, take on more manufacturing stages, move into more skill-intensive activities, or change who products are made for. Countries often initially compete by performing labor-intensive work at low costs, however rising labor costs will eventually cause much of this low-value work to shift to a cheaper location, and the economy will need to transition to higher-value activities to differentiate itself and continue growth. The following presents each type of upgrading in the electronics industry.

Table 3-11. Types of Upgrading in the Electronics GVC

Upgrading Type	Description
Functional (Moving into Services)	Final product manufacturers acquire responsibility for more value-adding activities; a switch from manufacturer to service provider often occurs over time: Categories: Assembly→EMS→ODM→Lead Firm Activities: Assembly→Sourcing/Distribution→Development/Design→Marketing
Supply Chain Linkages	Establish backward (or forward) manufacturing linkages within the supply chain; related to vertical integration: Inputs →Components→ Subassemblies→ Final Products This can also be extended all the way back to production equipment.
End Market	Market diversification: serving new buyers or markets often in emerging domestic or regional markets (new geographic destinations or distribution/market channels) Geographic: exporting only to the US and now to Mexico as well Market Sector: consumer electronics to medical
Product	Shift to customized products, use of higher quality inputs, or other additions that increase the value of the product or otherwise provide a competitive edge
Process	Reduce cost, increase productivity and improve flexibility by investing in new or better machinery or logistics technology. Specific steps within a stage (for example, components): Assembly→Metal Fabrication→Stamping→Finishing→Testing

Source: updated from Frederick and Gereffi (2013)

3.2. The Asian Electronics Regional Value Chain

Electronics trade fully supports the trend of the reorientation towards Asia. Asia has consolidated its position as the center of the electronics GVC over the last 15 years by increasing its share of global demand and supply (see global section) and in inter-industry trade along the chain, which is further discussed here. More and more trade in electronics is now among Asian economies and between Asia and other regions.

The analysis of intra-regional trade flows in electronics shows the growing centrality of China, both in finished and intermediate goods. It also shows the declining significance of non-China

trade, exemplified by the declining trade ties among Korea, Japan and Taiwan. Some countries like Korea and Taiwan are still key exporters, but just shifted their export linkages to China, whereas Japan, is now mostly just on importer side.

3.2.1. Regional Dynamics and Trends

Asia's share of 3C final products, subassemblies and electronic components exports has increased from 51% to 73% between 2000 and 2015. In all three segments the increase has been driven by East Asian countries, particularly China, within the Asian region. This has been at the expense of exports from Europe across all three segments, and for North America in intermediates (subassemblies and components).

Intra-regional trade in Asia has also grown significantly, particularly in intermediates, indicating the presence of strong regional production networks. Growing exports of both finished products from Asia to emerging countries and regions including India, Mexico, the UAE and Russia) is indicative of the growing consumer markets in these regions. In contrast, non-Asian trade ties declined. For example, trade ties within Europe and North America weakened in both finished and intermediate electronic goods.

Among Asian countries, China and Hong Kong dominate exports of both finished and intermediate goods, overall accounting for 59% of Asia's exports in 2015 with a higher share in final products than intermediates (75% vs. 46%). Among Asian exporters, since 2007, Japan's export value has significantly declined, Malaysia, the Philippines Singapore and Thailand have remained fairly stable (change between 2007 and 2015 was between -13% and 11%), while Korea, Taiwan, China/Hong Kong, and Vietnam have increased by over 20%. Especially notable is Vietnam, whose electronics exports skyrocketed from a mere $1 billion in 2002 to nearly $50 billion in 2015, accounting for 3% of Asia's exports in the three stages combined in 2015.

In intermediates, China/Hong Kong are also the top exporters, followed by Taiwan, Singapore and Korea, each accounting for approximately 11% of Asia's intermediate exports in 2015. These five countries account for 82% of Asia's intermediate exports in 2015.

Intra-Asian trade flows of intermediate goods highlight the central role of China. Hong Kong was by far the largest importer of China's electronics components, followed by Japan, Korea, Singapore and Taiwan. Among the major intermediates exporters to China, Taiwan led in 2014, and Korea doubled its exports to China. Notable is the weakening of Northeastern trade among Korea, Japan and Taiwan. In 2008, all trade linkages among the three exceeded the one-percent threshold, however, in 2014 only Taiwan's exports to Korea and Japan stayed above one percent. Taiwan and Korea expanded exports to China, indicating the gravity of their trade networks shifted toward China over the last several years.[10]

3.2.2. Cooperation and Competition in Asian RVCs

Trade ties in the electronics sector among Asian countries has been facilitated by offshoring and outsourcing at the regional level. It has given rise to robust Asian regional value chains (RVCs)

[10] For this analysis, electronic intermediate goods are represented by SITC 759, 764, 776 using UNComtrade data.

in the electronics industry. The presence of the strong regional production networks and supplier bases plays a key role in not only raising the competitiveness of Asian electronics firms against Western firms but also attracting non-Asian firms to relocated operations to the region. These firms initially moved production but now increasingly R&D and other upstream and downstream activities, to take advantage of the resources and capabilities embedded in the networks.

While the analysis of trade networks above shows a dynamic trend in Asian electronics RVCs, it provides a partial picture of various forms of cooperation and competition among countries and firms in the regional chains. It needs to be complemented by a firm-level analysis.

Multinational enterprises play a key role in organizing global and regional value chains and affecting patterns of trade, investment and production. Through FDI and offshore outsourcing, they facilitate the trade of intermediate goods as well as that of finished goods across Asia and beyond. To a great extent the trade pattern presented above reflects MNEs' changing strategies of organizing their value chains on the regional level. FDI induces the import of inputs from a MNE's home country and other foreign sourcing locations as well as the export of finished goods back to the home country and other regional markets. Moreover, FDI and related factory relocations by MNEs often involve a similar move by suppliers, particularly more capable ones, which leads to a pattern of co-location. For instance, as Korean electronics giants like Samsung Electronics and LG Electronics move abroad, some of their suppliers also move, generating more complex trade linkages between the home and host countries and beyond. Offshore outsourcing also creates complex networks of production, which may involve various firms from multiple countries that take care of component production and final assembly.

Therefore, in a contemporary world of global and regional value chains, a country's exports are not simply from its own domestic firms, but often from locally based, foreign-owned firms that use a mix of local and imported inputs. Therefore, an exported product is considered as the outcome of a regional production network, not a single country, challenging the conventional notion of country-of-origin in international trade (OECD, 2013; UNCTAD, 2013).

The rising centrality of China in intra-Asian trade networks, for instance, does not necessarily mean that Chinese firms play a central role in the country's expanding regional exports. It can be because more foreign firms in China, from neighboring Asia and other parts of the world, contributed more to the country's exports, or because these firms' suppliers based in China, either local or foreign-owned, increased exports to the MNE's global markets. As shown below, while most Apple products are produced and exported from China, and therefore count towards China's exports, they are assembled in Taiwanese-owned factories of contract manufacturers and most of the manufacturing-related added-value is attributable to Korea, Japan and other countries that supply core components. China's domestic value-added is much lower compared to others (Kraemer et al., 2011; Xing & Dert, 2010).

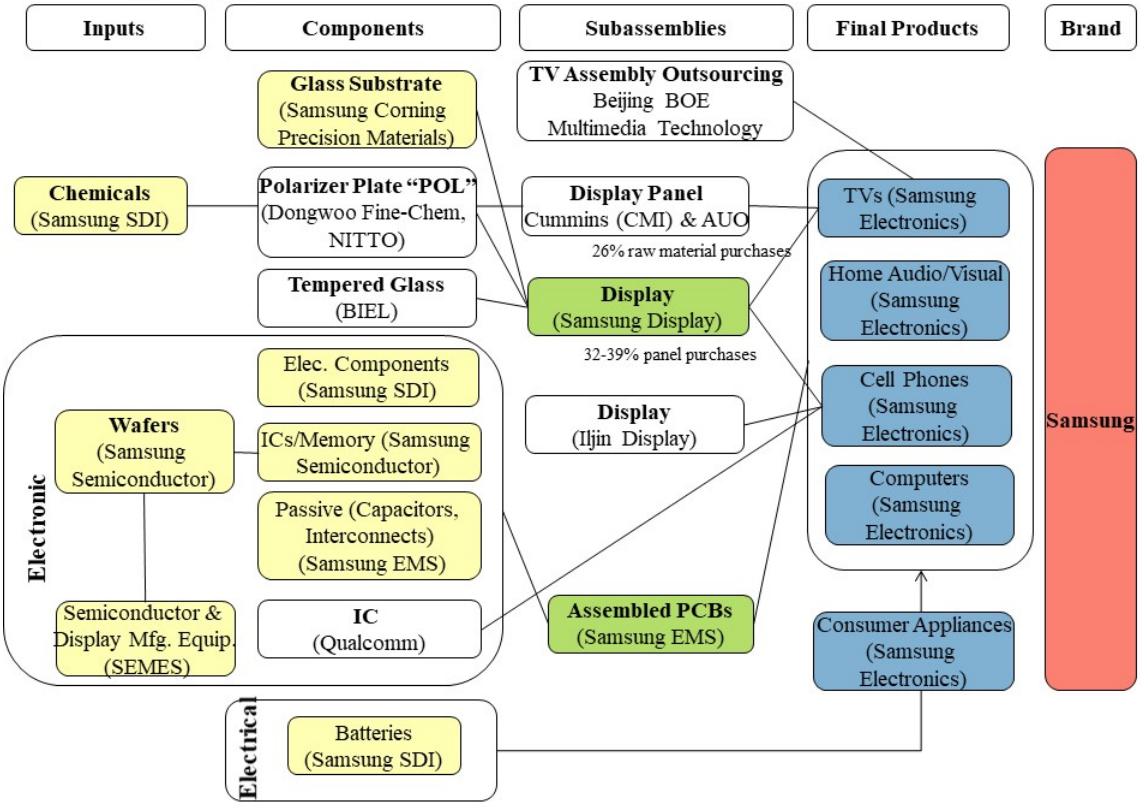
Focusing on the case of mobile phones, the following examples illustrate how the dynamics of cooperation and competition unfold in Asian electronics RVCs.[11]

(1) Samsung Electronics ("Samsung") had over one-fifth of the world's sales of mobile phones in 2016 (Gartner, 2017). Its production network is characterized by a great degree

[11] See also Lee and Lim (2016)

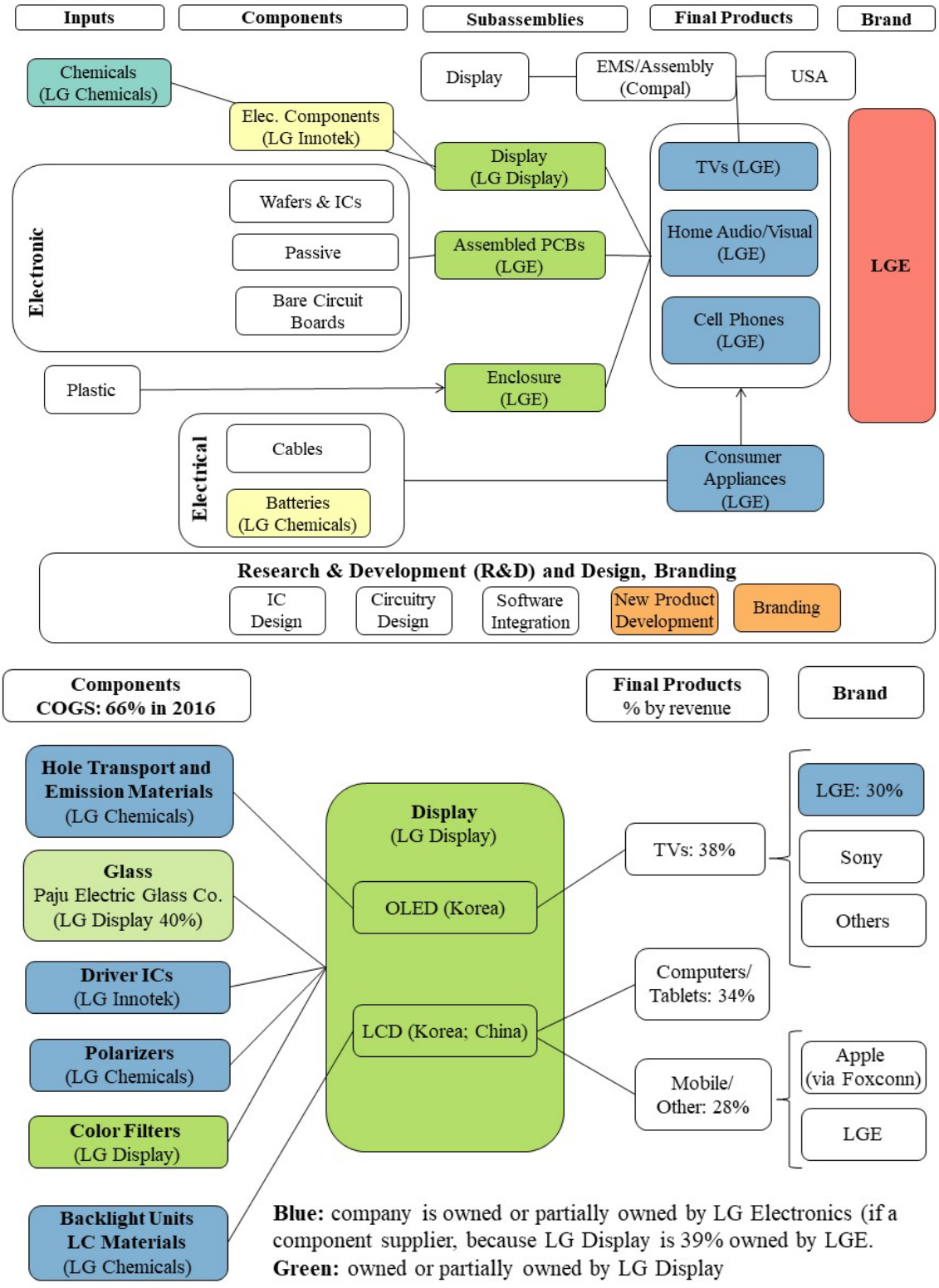
of internalization. Many key components, such as display panels, memory chips and processors, are sourced from other divisions of the diversified electronics firm or its related firms (Figure 3-3; includes other consumer electronics in addition to phones.). Samsung assembles phones in its own factories, however its production network has expanded geographically over the last decade. In the early days of offshore production, China played a key role as Samsung established factories in Tianjin, Shenzhen and Huizhou in 2001-2007. In 2008, China accounted for 54% of the company's mobile phone production, surpassing Korea (41%). Recently, production shifted to Vietnam with two new factories near Hanoi. In 2014, Vietnam took over as the leading location representing 46% of total mobile phone production capacity (H.-H. Lee, 2015). The rise of Vietnam as an electronics final product exporter has strengthened trade ties with Korea. In 2013, Vietnam became the second largest importer of phone parts from Korea, only after China, showing the impact of the presence of Samsung on the growth of trade flows between the countries. LG Electronics and LG Display have a similar production model, further contributing to Korea's relationship with Vietnam (Figure 3-4).

Figure 3-3. Samsung's Electronics Value Chain



Source: Frederick, 2017. Display panel data: (Samsung Electronics, 2016)

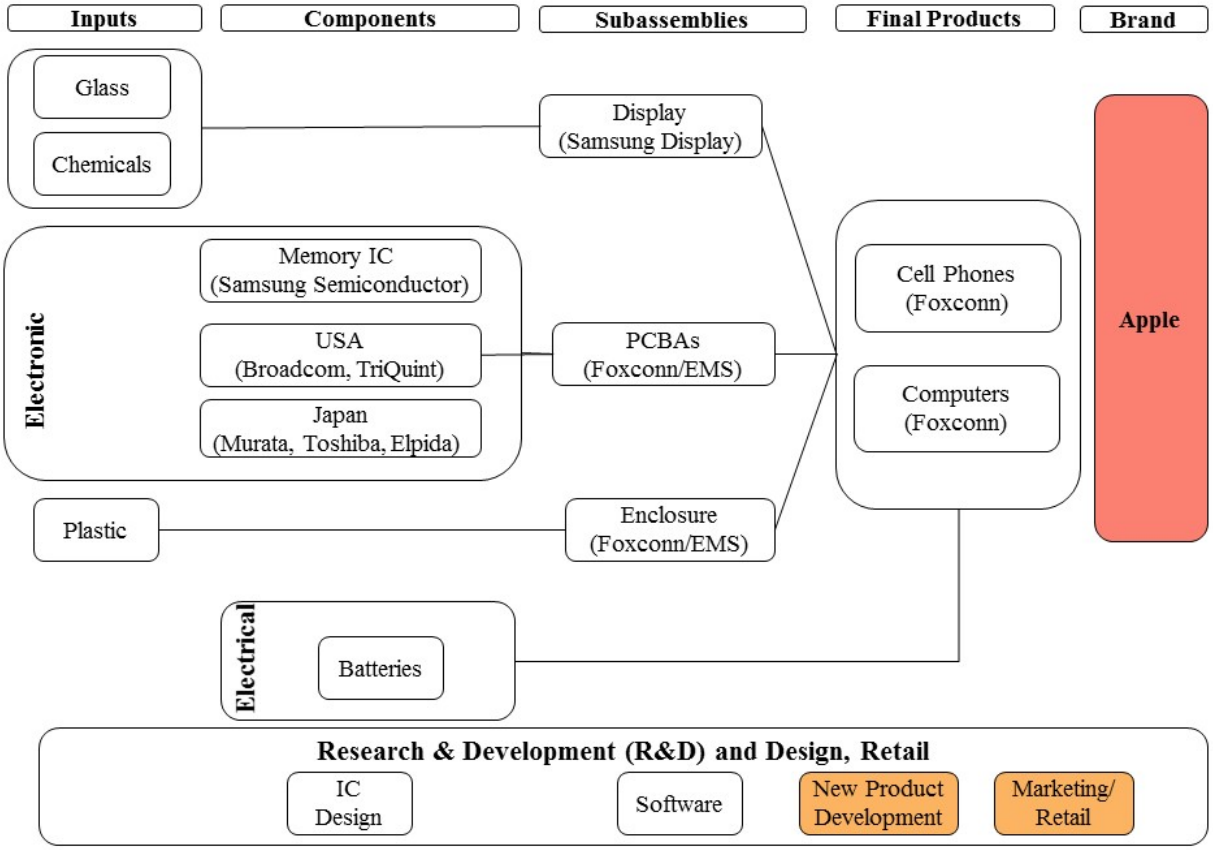
Figure 3-4. LG Electronics (top) and LG Display (bottom) Value Chains



Sources: Frederick, 2017; LG Display data based on LG Display 20F and website (gives unit values in 20F)

(2) Apple is the second largest smartphone company. Apple was a pioneer in using EMS contract manufacturers for smartphone production and now almost the entire production of Apple's products is conducted by third-party suppliers, mostly in China, who take care of sourcing, manufacturing and related logistics, while Apple focuses on upstream and downstream parts of its value chain, i.e., R&D, design, branding, sales and marketing. Therefore, while Apple is not based in East Asia, its supply chains are deeply embedded in the region, and the company significantly influences the Asian supply chains. Figure 3-6 illustrates the chain of the iPhone 4s and the distribution of value across chain actors. It shows the product heavily relies on high-tech MNEs from East Asia, Western Europe and North America, which capture a significant portion of the value added, as well as EMS provider, i.e., Foxconn, which takes advantage of its geographic proximity to major component suppliers and lower production costs in China. Apple also has a complex relationship with its East Asian suppliers. Notably, Samsung Semiconductor is one of Apple's major suppliers of microprocessors and memory chips, while two companies are in fierce competition in the smartphone market. Similarly, LG Electronics produces smartphones in competition with Samsung and Apple, but its related firm, LG Display, and its units based in China, is one of the major display suppliers to Apple (Figure 3-5).

Figure 3-5. Apple's iPhone4s Supply Chain



Sources: OECD (2011); Tear Reports

(3) Chinese domestic brands have vastly increased their competitive positions in the local Chinese market and increasingly abroad. Over the last several years, a host of new

domestic brands like Xiaomi, OPPO, Vivo, Meizu and Gionee expanded their market share considerably, while established foreign brands like Samsung, Nokia (now Microsoft), HTC, and LG, experienced a significant setback in their market position, and even some locals like ZTE feel the pressure. As of 2015, three Chinese brands, Huawei, Lenovo, and Xiaomi, ranked among the top five in terms of smartphone sales (Gartner, 2016). The rise of Chinese brands, however, was not simply the outcome of their own capability building and upgrading to higher value-added activities like branding and marketing. It is also attributed to their integration in regional and global value chains and taking advantage of the availability of modular platforms they can quickly utilize. For instance, the wide use of Google's Android mobile operation system (OS) has enabled them to compete with other brands with little advanced capability in OS development. Also, the availability of mobile system-on-chip (SOC) solutions, especially from Mediatek, has helped Chinese producers to quickly build their phones based on modular systems, without deep technological learning. The growth of Chinese OBMs has fueled the emergence of local mobile phone brands in other Asian emerging economies like India. For instance, Micromax is India's second largest mobile phone seller (after Samsung) as well as one of the country's burgeoning local mobile phone brands. The company imports most of its products from Chinese manufacturers, with only limited volumes manufactured locally, although they plan to produce more locally in the future.

A comparison can also be made between Korean and Japanese firms in the overall 3C market. Korean (i.e., Samsung and LG) and Japanese firms (i.e., Sony, Sharp, and Panasonic) took different routes and primarily focused on different segments. Korean firms kept manufacturing in-house and vertically integrated into key component technologies. They have leveraged lower cost locations to offshore manufacturing for final assembly. Sony, the top Japanese consumer electronics company, is not vertically-integrated into display panels, and has lost global market share to the Korean companies as technology has quickly advanced. Sony instead shifted emphasis to the video game and audio segments. Sharp was just purchased by Foxconn.

3.3. Korea and the Electronics Global Value Chain

The electronics industry spearheaded Korea's upgrading from light manufacturing, such as apparel, footwear, and toys, to technology- and capital-industries, such as electronics, steel, automobiles, shipbuilding and machinery. Electronics have been a mainstay of the Korean economy since the 1960s, with the first industry-specific policy put into place in 1969. During the 1970s Japanese investors came to Korea, mostly concentrating in the Masan FTZ as did US semiconductor companies and Nokia.

By 1988, electronics were Korea's largest export accounting for approximately 25% of exports. They have maintained this top position for nearly 30 years, with electronics share of production ranging between 25 and 30% of the country's exports. In early years, electronics were primarily final products, however more recently, Korean lead firms have moved final product manufacturing to offshore locations. Offshore assembly locations in China grew during the 1990s, while in the 2000s factories have shifted to Vietnam as well. Today, exports from Korea are primarily key intermediate inputs including semiconductors and displays to these offshore factories. In 2015, Korea's total electronics export value was $120 billion, and the country was

the 3rd most significant exporter of 3C subassemblies and 5th in electronic components. In other end markets, such as industrial electronics and medical electronics, Korea is not as important, ranking 10th and 7th respectively.

FDI and technology transfer played a role in Korea's early development in the 1970s, however there are few foreign firms playing significant roles in the country today. Most activity in the country is by a few top companies, Samsung, LG and SK Hynik. In terms of employment and exports, these three companies and their supporting suppliers are the mainstay of the electronics industry in the country. Korea's electronics industry has a very well-established supporting environment with strong support from the government in both funding and protecting new products and technologies.

Korean firms hold the largest share of the mobile phone market category, and the second position for consumer electronics and computers (based on volume data). Korean firms have also been technology leaders in certain product areas, particularly in memory ICs and display technologies (OLED and large LCD). Korean firms also hold the largest market share in displays, and the number two and five positions based on revenue for semiconductors (and the top two for memory semiconductors specifically).

3.3.1. Development of the Electronics Industry in Korea

The beginning of the electronics industry in Korea traces back to 1959, when the country produced a radio set for the first time (KEA, 1999). Korea soon began to export products; the first radio sets were exported in 1962. From the mid-1960s, FDI flowed into the electronics sector. In the face of rising costs at home, firms in the US and Japan moved their production to Korea and other developing countries in Asia using a combination of own affiliates, joint ventures with local firms, or offshore outsourcing. Fairchild, Motorola, IBM and Control Data were the major US firms that established Korean operations by 1970s (KEA, 1999, p. 50). Between 1963-1969, the number of electronics firms in Korea increased quickly from 27 to 145 in 1969 (PCSYKE, 2010a, pp. 50, 410-411).

The Korean government, noticing the emerging opportunities to attract foreign investors and technology, initiated a series of supportive policy measures to promote electronics production, as part of its broader effort to move the economy towards export-oriented industrialization. In 1969, the Electronics Industry Support Act was enacted to provide a legal basis of supporting the burgeoning sector. Based on the Act, an eight-year plan for the promotion of the industry was formulated with a variety of supportive policy measures put in place (KEA, 1999).

Over the ensuing decades, Korea's electronics industry moved into new technological domains and more advanced products. By the early 1990s, the country had made inroads into the key sub-sectors that later would be the mainstay of its electronics exports: semiconductors (memory), displays and mobile phones. In 1992, Samsung Electronics developed the world's first 64M dynamic random-access memory (DRAM). Korea developed the first TFT-LCD (thin-film-transistor liquid-crystal display) products in 1992 also, laying the foundation for the country's rise in the display industry in the following decades.

Korea entered the telecommunications sector in the late 1980s by developing its first electronic switching system, TDX-1. In 1995, it established the first commercial CDMA (code division multiple access) cellular network system, which facilitated the rise of Korean-branded mobile phones in a highly competitive global market in the ensuing decades. Table 3-12 shows some of the important milestones in the history of Korea's electronics industry.

Table 3-12. Milestones in the Korean Electronics Industry, 1970s-2000s

Era	Year	Milestones
1950s	1958	LG Electronics established
1960s	1966	Goldstar (now LG) produced 19-inch black-and-white TVs for the first time in Korea in 1966 through a technology partnership with Japanese Hitachi
	1969	Samsung Electronics (first year started in electronics, but Samsung earlier)
1970s	1970s	Fairchild, Motorola, IBM, Control Data: big US firms to establish semiconductor operations
	1970	Masan Free Export Zone established (SF: entry of Japanese firms)
	1971	Gumi Electronics Industry Zone established
	1974	First color TVs manufactured through a partnership with Japanese TV makers
	1975	Radio cassettes, electronic watches manufactured
	1976	Korean Electronics Industry Promotion Association established
	1978	Electric and Electronic Industry Division established in Ministry of Commerce & Industry
1980s	1980	First color TV broadcasting started
	1981	Personal computer developed / Electronic Industry Promotion Act revised
	1984	64K DRAM developed
	1985	TDX-1 (electronic exchange) developed
	1987	Annual electronics exports surpassed $10 billion (Nokia was a key exporter)
	1988	Computer networks built for the Seoul Olympics
1990s	1992	TFT-LCD developed (Samsung)
	1993	HDTV receiver prototype developed
	1995	Information Society Promotion Act
	1995	CDMA cellular system commercialized
	1998	1G DRAM developed
2000s	2006	LG Display
	2012	Samsung Display (spin-off from Samsung Electronics)

Source: 1970s-1990s: KEA (1999, p. 474); (PCSYKE, 2010a, pp. 206-207)

Korea's electronics exports first surpassed $10 billion in 1987, and became the largest export sector in 1988, accounting for a quarter of the country's total exports. By the end of the 1980s, Korea emerged as the world's top producer of black-and-white TV sets, and second in video tape recorders and microwaves, and the third largest telephone producer (PCSYKE, 2010a, p. 208). Table 3-13 shows the rapid upgrading and the role played by electronics. In 2005, Korea's electronics exports exceeded $100 billion; a ten-fold increase in exports in less than two decades.

Table 3-13. Korea's Exports by Sector, 1970-1998

Year	1970		1980		1990		1998	
	$billion	%	$billion	%	$billion	%	$billion	%
Total	**0.84**	**100**	**17.4**	**100**	**65.0**	**100**	**132.3**	**100**
Primary	0.15	18	2.1	12	3.3	5	10.4	8
Light manufacturing	0.58	69	8.1	47	25.0	39	25.0	19
Heavy & chemical manufacturing	0.11	13	7.2	41	36.7	57	96.9	73
-- Electronics	0.06	7	2.0	11	17.2	26	38.7	29

Source: KEA (1999, p. 481)

While the 1980s and the 1990s represented a high growth era for the electronics industry, it also became clear that the sector and the Korean economy, in general, were increasingly confronting challenges from globalization. Noticing Korea's fast rising exports and expanding trade deficits, the US and European countries began to put pressure on the Korean government to open the domestic market, which was largely protected from direct competition with foreign firms that had advanced products and technology. A series of trade and investment liberalization over the decades, including the Uruguay Round, prompted Korean electronics firms to confront rising competitive pressure at home, but it also posed new opportunities abroad.

In response, Korean firms began to expand overseas investment. FDI by Korean electronics firms started in the early 1980s as an effort to move production closer to export markets to circumvent trade barriers. In 1981, Goldstar (later LG Electronics) first established an overseas production operation for color TVs and microwave ovens in the US, and Samsung Electronics opened its first foreign factory in 1982 to produce color TVs in Portugal (KEA, 1999, p. 189). A more aggressive investment move occurred in the early 1990s, as shown in Figure 3-6 below. At the same time, in the face of intense price competition with producers from newly developing Asian economies like China and rising production costs at home, many electronics firms began to relocate production to lower-cost countries, notably China. China accounted for 31% of overseas investments by Korean electronics firms by 1997, of which 433 out of 461 investments were for production (Table 3-14). This initial effort of internationalization has gradually evolved to the rise of a complex form of regional production networks cutting across multiple Asian countries in the ensuing decades, as discussed in detail below. Overall, the expansion of foreign operations in the face of globalization has deepened Korea's engagement in global and regional value chains in electronics.

Table 3-14. Korean Investment in Electronics in China, 1980s-1997

Type of Corporation	1980s	1990	1991	1992	1993	1994	1995	1996	1997	China Total	Worldwide Total
Production	2	4	13	30	43	85	81	80	95	433	1,475
Sales	-	-	-	-	-	7	4	6	1	18	971
R&D	-	-	-	-	-	1	-	-	-	1	334
Other	-	-	-	-	1	2	-	4	2	9	37
Total	**2**	**4**	**13**	**30**	**44**	**95**	**85**	**90**	**98**	**461**	

Source: Bank of Korea, cited from KEA (1999, p. 217); Note: This is based on the 'count' of investments. When a firm makes a new or repeated investment, they report the event to the Bank of Korea. Therefore, this may represent a new factory in a Greenfield location, adding a new one to an old one, or establishing a sales office or R&D center.

Over the last decade, Korea's electronics industry has continued to grow. As shown in Table 3-15, electronics production nearly doubled from 1.8 trillion won to 3.3 trillion won in 2004-2014. The most notable growth took place in parts and components, whose production more than doubled from 787 billion won to 1.9 trillion won over the decade, indicating a shift of the domestic production from finished products to intermediate goods that are supplied to other producers at home and abroad. The growth pattern is similar in exports. Korea's exports steadily increased despite the global economic crisis of the late 2000s, by far the most dynamic growth took place in parts and components, whose exports increased nearly threefold.

Table 3-15. ICT Equipment and Device Production in Korea (trillion KRW)

	2004	2006	2008	2010	2012	2014
Telecommunication	46.6	49.9	69.8	73.2	65.6	70.4
Broadcasting	16.1	15.3	12.9	15.5	14.7	15.3
Computer and peripherals	16.9	13.1	9.8	9.9	10.4	10.7
Parts and components	78.7	95.0	109.0	174.3	180.6	186.2
Home and office appliances and others	24.5	28.2	31.3	36.8	43.3	46.9
Total	**182.9**	**201.6**	**232.8**	**309.8**	**314.6**	**329.5**

Source: KAIT & KEA (2016); see ICT Industry Survey 1993-2014 Excel file (Reference-KOR folder). Based on the ICT statistical classification system. It started with the establishment of the "ICT industry unification classification system" in November 1994, and changed its name to "ICT sector goods and service classification system" in Oct. 1996. In December 2013, ICT statistics were reorganized into "ICT Statistical Classification System" p. 20.

3.3.2. Korea's Participation in the Electronics GVC/RVC

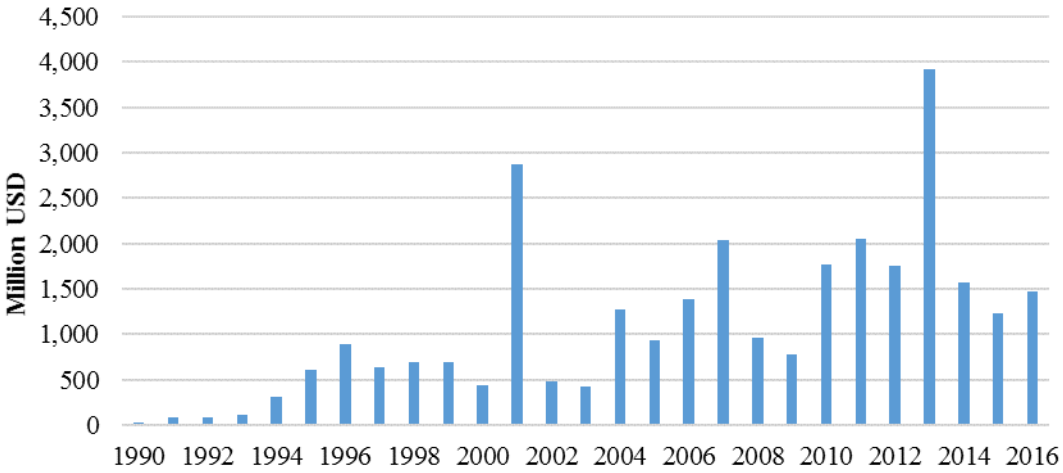
Korea's electronics industry has developed over the past few decades with a strong focus on developing global brands for consumer markets. Industrial upgrading has focused on deepening engagement along the chain into key intermediates.

While FDI has played a more limited role in Korea's overall economic development (see Chapter 2) compared to other Southeast Asian countries, it has not been completely absent. Between 1962 and 2008, the electronics sector attracted $19.9 billion, equivalent to 13.3% of the country's total FDI inflow during the period (PCSYKE, 2010b, p. 143). Efforts to attract foreign investment and technology were most notable in the early years of industrial development. Early entry into consumer electronics in the late 1960s and 1970s was aided by technology partnerships with Japanese firms, while the foundation for semiconductor production was laid by US firms in the 1970s seeking lower-cost production sites in Korea (PCSYKE, 2010a, pp. 206-207). The Masan FTZ in the south was a popular destination for foreign electronics investments in the 1970s and 1980s. The most notable investor in the Masan FTZ was Nokia's mobile phone factory (1984-2014), which led to several component suppliers setting up operations in the zone.

Over the next decades, the focus of Korean firms shifted gradually from learning how to perform specific tasks to importing fading technologies, then to acquiring mature technologies, and later to getting involved in developing core technologies. Accordingly, the mode of technology transfer and acquisition changed from technical aids to technology licensing and joint ventures, and later to cross-licensing, joint R&D, and foreign investment for technology acquisition (PCSYKE, 2010a, p. 281).

As noted above, Korean electronics firms began to establish new production sites in lower-cost countries as early as the 1980s, but they really started to grow in the mid-1990s (Figure 3-6). The initial take-off was moderated by the Asian financial crisis of the late 1990s and the burst of the IT bubble in the early 2000s, but a new wave of outflow emerged in the mid-2000s. Again, the trend was hit by the global economic crisis of 2007-2009, but it recovered in 2010. Semiconductor, display panel and audio equipment production led Korea's outward FDI in the electronics sector in 2001-2006. Asia accounted for most of the outflow of FDI from Korea. China was the leading recipient, representing 55% of Korea's total outward FDI, followed by Vietnam, Hong Kong and Japan.

Figure 3-6. Korea's Annual Outward FDI in Electronics, 1990-2016



Source: Ex-Im Bank of Korea (1990-2016); the spike in 2013 is likely due to Samsung's estimated $3 million investment in a mobile phone factory in Vietnam. Samsung is the largest foreign investor in Vietnam with $11.3 billion invested (CIEM, 2016).

At the same time, electronics production, especially finished goods, has been increasingly outsourced to offshore locations, particularly lower-cost economies, while Korea exports more intermediate goods to those economies. Meanwhile, Korea increasingly imports finished electronics products from developing countries. In 2014, over three quarters of Korea's imports of electronics for final consumption were imported from middle income countries, with only 16% from OECD countries.[12]

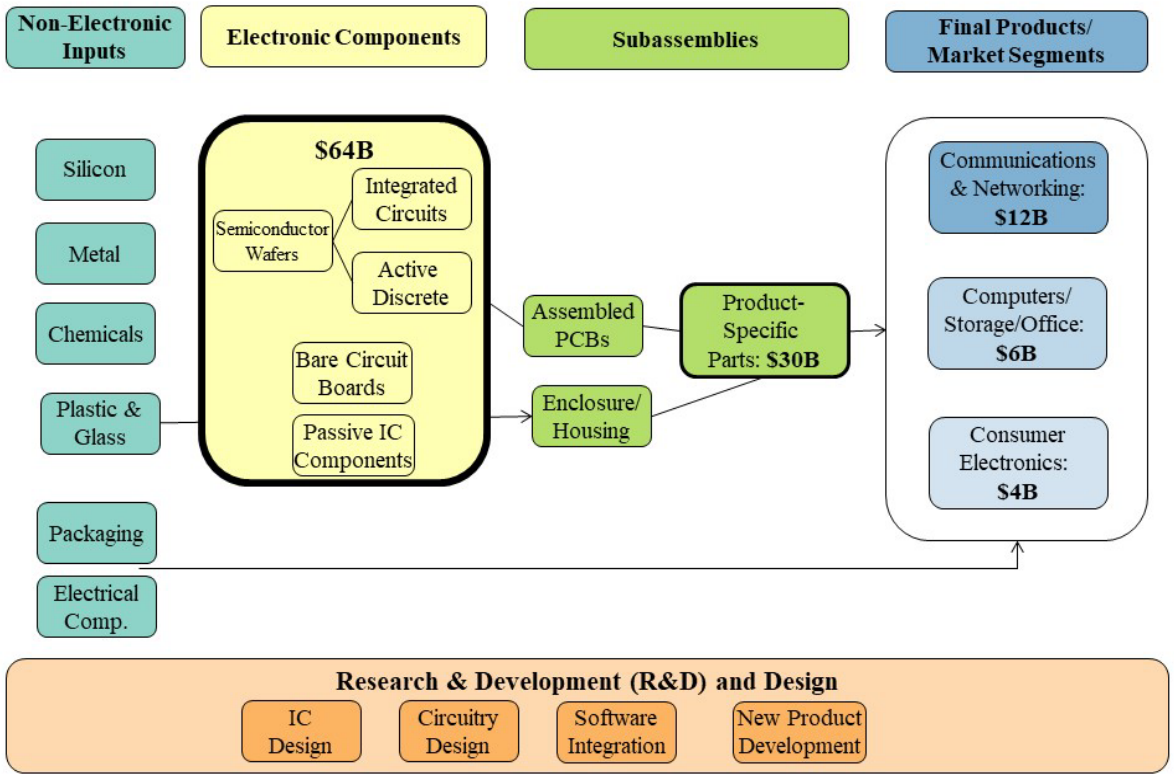
3.3.3. Product Profile and End Markets

Korea's primary strengths in the electronics value chain are in semiconductors/ICs (memory), led by Samsung and Hynix, displays (Samsung Display and LG Display), and mobile phones (Samsung, LG) in terms of products in which the brand owner is Korean and manufacturing is in the country. From a brand ownership perspective, Korea is also a top company in consumer electronics (namely TVs), computers, and cell phones.

Korean firms have increased market share in consumer electronics, however overall volume is going down for these products, and like cell phones, Chinese producers are quickly taking over. In computers, Samsung holds 10% of the world market by volume. Korea is not a player in the video game hardware market, and plays a small role in video game software. Also, while Korea has been a global leader in cell phones, they do not have a significant global presence in the other half of the communications market, which consists of telecommunications equipment (this is an industrial or institutional market related to infrastructure rather than consumer products).

[12] Source: UN Comtrade; based on SITC finished electronics codes: 751-752, 761-763.

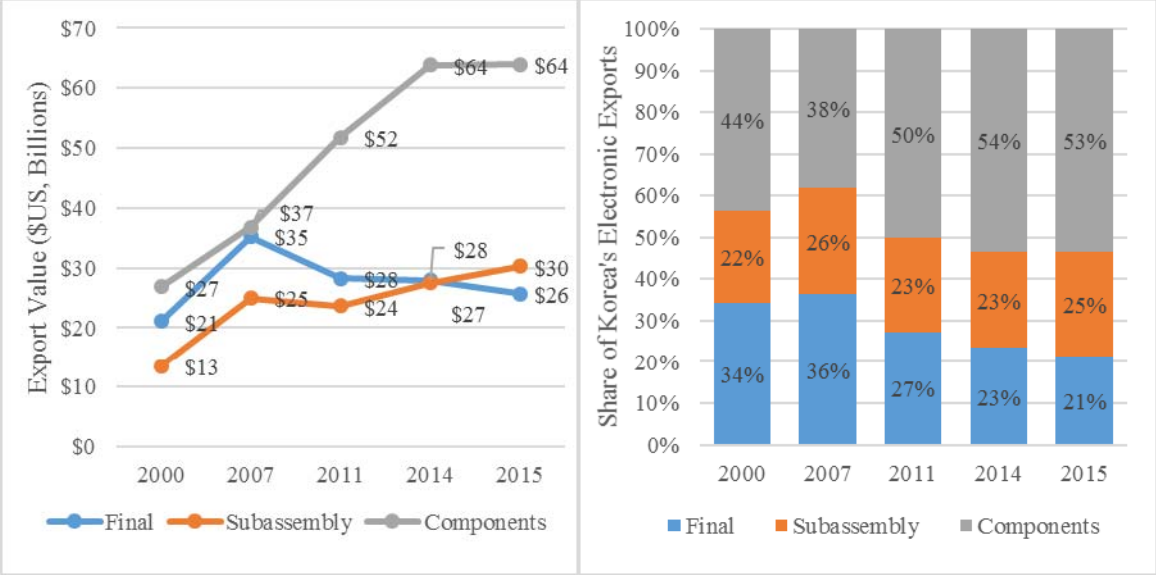
Figure 3-7. Korea's Participation in the Electronics Global Value Chain, 2015



Source: Authors; exports from UNComtrade; HS definitions

Korea is primarily an exporter of **electronic components and subassemblies.** Within final products, Korea is in communication equipment and computers/storage devices. Korea's total electronics export value in 2015 was $120 billion (Table 3-16).

Figure 3-8. Korea's Electronics Exports, by Value Chain Segment, 2000-2015



Source: UNComtrade (2017a)

In 2015 Korea was the 8th top exporter of 3C final products (2% global share), 3rd for 3C subassemblies (9%), 5th for electronic components (8%), 10th in industrial electronics (2%), and 7th in medical electronics (2%).

Electronic components are the main export stage and Korea has held a steady share of the world export market (6-8%) between 2000 and 2015, however Korea's export destinations have drastically changed. In 2000, only 22% of exports were to China/Hong Kong, Vietnam and Philippines, however this increased to 76% by 2015. Prior to 2007, exports were to the US and more developed Asian countries (Singapore, Taiwan and Japan) (Figure 3-9).

Most domestic value added (DVA) included in Korea's intermediate products was exported to China.[13] In 2011, Korea's intermediate goods exported to China contained 67% of Korea's DVA (only 10% in 2000). In contrast, the relative share of other countries like the US, Taiwan and Japan, declined over the period.

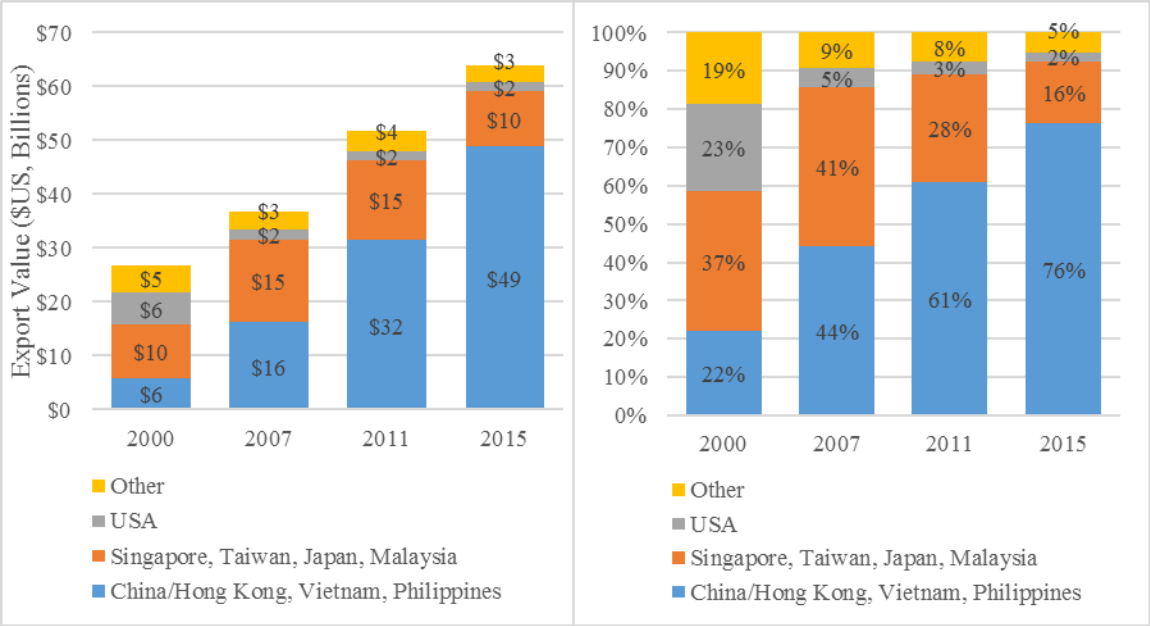
Table 3-16. Korea Electronics Exports: Final, Subassemblies and Components, 2000-2015

Category/Stage	Value ($, US, Billions)				Share (%)				Share of World (%)			
	2000	2007	2011	2015	2000	2007	2011	2015	2000	2007	2011	2015
World Total	**61**	**97**	**104**	**120**					**5%**	**5%**	**5%**	**5%**
Communication Equipment	6	20	17	12	10%	21%	16%	10%	5%	9%	6%	3%
Computers/Storage Devices/Office Equipment	10	10	6	6	16%	10%	5%	5%	4%	3%	2%	2%
Consumer Electronics	5	4	4	4	8%	4%	3%	3%	5%	2%	2%	2%
Industrial Final	0	1	2	2	1%	1%	1%	2%	1%	1%	1%	2%
Medical Final	0	1	1	1	0%	1%	1%	1%	1%	1%	2%	2%
3C Subassemblies	13	25	23	30	22%	25%	22%	25%	5%	8%	7%	9%
Industrial Subassemblies	0	0	1	1	0%	0%	1%	1%	0%	1%	2%	2%
Electronic Components	27	37	52	64	44%	38%	50%	53%	7%	6%	8%	8%
By VC Stage												
Final	21	35	28	26	34%	36%	27%	21%	4%	4%	3%	2%
Subassembly	13	25	24	30	22%	26%	23%	25%	5%	7%	7%	9%
Components	27	37	52	64	44%	38%	50%	53%	7%	6%	8%	8%
Final 3C Total	21	34	26	22	33%	35%	25%	19%	5%	5%	3%	2%

Source: UNComtrade (2017a); HS96; based on Korea's exports.

[13] EXGR_INTDVAPSH (DVA in exports of intermediate products, partner shares) in industry code C30T33X. However, China is the largest importer of Korea's intermediate exports, so it is logical to also account for the highest share of Korea's domestic content.

Figure 3-9. Korea's Electronic Component Export Destinations, 2000-2015



Source: UNComtrade (2017a); HS96; based on Korea's exports. China/Hong Kong, Vietnam and the Philippines are top destinations that had a positive growth rate between 2007 and 2015, whereas exports to Singapore, Taiwan, Japan and Malaysia had a negative change.

Korea is also a significant exporter of 3C subassemblies (Table 3-17). In the early 2000s these were for computers, but shifted in focus to communication devices (mobile phones) in 2007. Like components, export destinations fluctuate significantly over the last 15 years, changing as the end products changed. In 2015, exports primarily were to China, Hong Kong and Vietnam (mobile phones). Between 2007 and 2011, Brazil was also a top location (communication equipment and multiple), and in the early 2000s, the US and Taiwan were top destinations (computers).

These export patterns can be explained by the offshoring strategies of the lead firms: Samsung has mobile phone manufacturing operations in both China and Vietnam. Samsung's production started in Korea, then shifted to China and Vietnam (2012/13), and Indonesia (new plant here, 2015). Samsung's production for TVs is in Korea, China, Mexico, Brazil, and Hungary (Samsung Electronics, 2016). LG has/had mobile phone manufacturing in Brazil and India.

Table 3-17. Types of 3C Subassemblies Exported from Korea & Top Destinations, 2000-15

Final Product	Export Partners	Export Value ($, US, Billions)			Share (%)		
		2000	2007	2015	2000	2007	2015
Total		**13**	**25**	**30**			
Communication Equipment	China, Vietnam Hong Kong, Brazil	0	8	18	2%	34%	59%
Computers/Storage Devices/Office Equipment	US, Taiwan, China	10	9	6	75%	35%	19%
Consumer Electronics	Japan, China	1	1	1	9%	4%	2%
Multiple	Mexico, China	2	7	6	15%	27%	20%

Source: UNComtrade (2017a); HS96; based on Korea's exports.

Korea's 3C final exports are primarily destined for the US, which accounted for approximately 38% of exports in both 2000 and 2015. Japan has also maintained a stable share (5-12%), while the EU-15 has declined significantly and China/Hong Kong has increased in importance (21% in 2015). Consumer electronics share of final products has declined since 2000 as the top two companies (Samsung and LG) have offshored manufacturing to China, Vietnam and some regional manufacturing locations in Eastern Europe and South America. According to interviews with industry stakeholders, as of 2014, approximately 98% of final consumer electronic and electrical goods for Samsung and LG were manufactured outside Korea. An increasing share of Samsung's employment is overseas (69% in 2014), however, domestic employment has remained steady (Lee & Lim, 2016).

The strong tendency toward vertical integration has led to the relative underdevelopment of local contract manufacturing. Many local component suppliers are in dependent relationships with domestic buyers, which are much bigger, more globalized and in a dominant market position (Lee et al., 2016). As such, contract manufacturers have not developed in Korea. Control over supply chains has limited the opportunity for growth of local SMEs specializing in components and contract manufacturing.

Software and services: The Korean government and local firms adopted the CDMA digital cellular technology, developed by Qualcomm, a US company. A state-led consortium was formed by a major government research institute and a few large domestic electronic makers, notably Samsung and LG, to facilitate Korea's technological learning (Lee et al., 2016). By awarding CDMA-only mobile service licenses, the government protected local producers in the domestic market from competition with global brands, such as Nokia and Ericsson, which opted for the Global System for Mobile Communications (GSM) standard technology (Lee et al., 2016). This alliance explains why exports from Korea to the US were higher than to European countries. Aligning with the US on CDMA has mixed benefits. It has likely been a brief setback because GSM has ultimately been adopted by the rest of the world. However, given that Korea's mobile phone companies are also became key providers of critical components, this alignment with the US over Europe or Japan made them a likely supplier into Apple's supply chains.

Korea is not a significant player in the software and services segments of the electronics GVC. The 2017 World Investment Report (WIR) lists the top 100 digital MNEs by sales/operating revenue in 2015. It divides companies into four areas: internet platforms, digital solutions, digital content and e-commerce. There is only one Korean firm on the list, Naver, in the internet platforms category. The report also lists the top IT software and services companies, and there is only one Korean company on the list as well, Samsung SDS (#18 of 21) (UNCTAD, 2017). In video game software, Korean companies account for approximately 4% of the top 55 firms (note that 63% is listed as 'others' given how disperse the industry is). Korean firms on the list include SmileGate (#5), Nexon Mobile, Netmarble Games, Webzen, NCsoft, Eyedentity Games, and NHN (Euromonitor, 2016).

Backward linkages: Korea's imports of 3C subassemblies and electronic components were $51 billion in 2015 of which 79% were electronic components ($41 billion). The main electronic

component sources growing in importance are China and Taiwan; Japan and the US are still important, but imports have steadily declined since 2000 (UNComtrade, 2017b).

3.3.4. Institutional Context (sector-specific) and Supporting Stakeholders

The Korean government plays a major role in shaping the institutional context for the electronics industry. Active industrial policy in the high-growth era has given way to a more facilitative role played by the government to create a favorable environment for the private sector as the latter, with greater resources, takes leading part in upgrading and technological development.

Two ministries lead the government effort to provide support to the electronics industry: Ministry of Trade, Industry and Energy (MOTIE) and the Ministry of Science, ICT and Future Planning (MSIP). MOTIE has long been at the center of industrial policy in Korea, currently with two divisions in place to support the sector: the Electronic Parts and Materials Division is in charge of formulating and implementing policy regarding the electronics parts sector, including semiconductors and displays, and the Electronics and Electrical Division addresses policy issues regarding home appliances and other electronics products along with electrical equipment. MSIP is a relatively new ministry, established in 2013 as part of a government reorganization. It is dedicated to overseeing the government's overall ICT policy and specifically supporting the telecommunication and broadcasting sectors, as well as promoting science and technology (MSIP, 2016b).

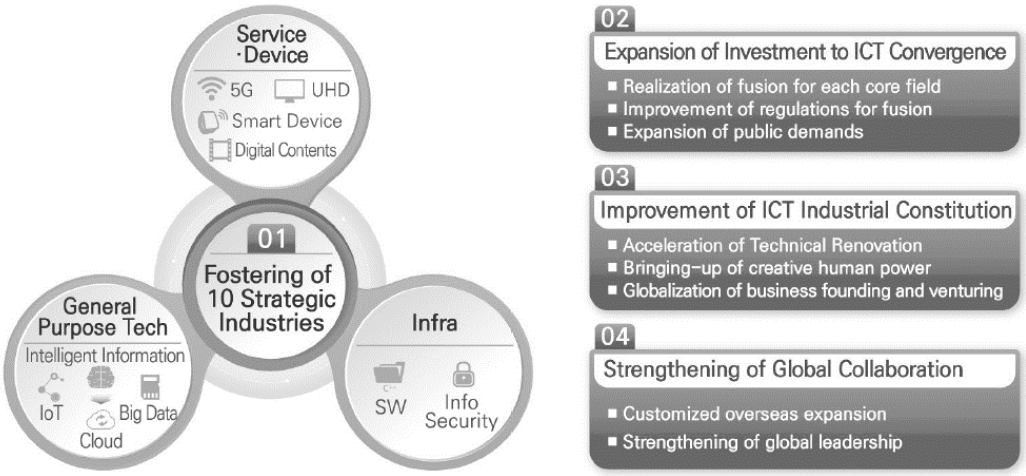
Table 3-18. Major Policy Measures Supporting the Korean Electronics Industry

Products	**Supportive Measures**
Semiconductors	- Spur the growth of high value-added System-On-Chip (SOC) sector - Facilitate the localization of front-end equipment for semiconductor production
Displays	- Expand the overall sectoral infrastructure - Promote standardization in wearable devices - Provide tax incentives to materials, parts and equipment for AMOLED - Workforce development for display parts and equipment production - Support developing advanced materials for display production - Facilitate international cooperation, overseas marketing and exports
Electric, electronics and other final products	- Nurture 3D printing sector - Support developing high-end, small- and medium-size, smart home appliances - Build sectoral infrastructure for secondary cell technology - Foster the development of medical device technology and products

Source: MOTIE (2015)

These policies focus on supporting the development of the overall infrastructure and workforce in key products and subsectors. From a supply chain perspective, Government support focuses on technology and inputs, including materials, components, and equipment, as shown in Table 3-18. Investment is also centered on the technological and product domains where Korea is weaker or economic potential is higher. For example, Korea is weaker in equipment and machinery for the front-end process of semiconductor production; in response, the government provided a roadmap for enhancing local producers' capabilities in developing advanced front-end equipment and facilitated joint R&D efforts by local firms (MOTIE, 2015).

Figure 3-10. K-ICT Strategy: Vision and Goals



Source: MSIP (2016a, p. 18); "Realizing a Creative Korea led by K-ICT"

In addition to this focused support to electronics, the government aims to develop the overall ICT industry, including electronics, as an innovative growth engine for the economy.

Figure 3-10 illustrates the vision and goals of the 'K-ICT' strategy. The strategy targets ten strategic industries as future growth areas: **5G mobile communication technology**, ultra-high-definition (UHD), digital content (including virtual reality), **smart devices such as wearables**, **the Internet of Things (IoT)**, cloud system, **big data**, artificial intelligence (AI), software, and information security. To achieve the goal of increasing added value of ICT production to 240 trillion won and ICT exports to $210 billion by 2020, the government plans to expand its investment in convergence technologies, implement regulatory reforms to facilitate convergence, improve the quality of innovation and workforce and strengthen global cooperation and collaboration (MSIP, 2016b, pp. 18-23). Four of the ten areas listed above (in bold) are also on the list of 19 future growth engines indicating there may be a lack of coordination to strategy development. One of the areas in the future growth strategies report that is not included in the K-ICT strategy is intelligent semiconductors. The localization rate of intelligent semiconductors in key industries (automobile, mobile, smart appliance, energy) is very low, on average 10% or less. Given Korea's strength in manufacturing, increasing capabilities in these other types of semiconductors that are critical to digitalization trends would be beneficial for Korea.

Korea has a highly elaborated institutional environment supported not only by government ministries but also by various public R&D institutes, including the Electronics and Telecommunications Research Institute (ETRI), established in 1976, and the Korea Electronics Technology Institute (KETI), established in 1991. The government also operates promotional agencies for the ICT sector that play a role in formulating and implementing policy measures and building a bridge between the public and private sector, such as the Korea Electronics Association (KEA) and the Korea Association for ICT Promotion (KAIT). Other stakeholders

include industry associations, including the Korea Semiconductor Industry Association (KSIA), the Korea Display Industry Association (KDIA), and the Korea Printed Circuit Association (KPCA), and various academic associations for different technology and product areas. A list of key institutional stakeholders in the electronics sector is provided in Table A-3-2. Korea Electronics: Establishments, Employment, Output, 2012

ISIC Rev 4	**Establishments**	**Employment**	**Output ($US, Billion)**
Components	**2,195**	**278,314**	**$148.8**
2610 Electronic components and boards	2,186	278,115	$148.8
2680 Magnetic and optical media	9	199	$0.0
Final 3C	**1,901**	**117,911**	**$77.1**
2620 Computers and peripheral equipment	284	9,345	$3.3
2630 Communication equipment	1,258	77,090	$67.8
2640 Consumer electronics	359	31,476	$6.0

Source: INDSTAT4

Table A-3-3. Supporting Electronics-Specific Stakeholders by Focus Area.

While the government invests quite a bit in R&D, it also places emphasis on protecting the technologies it has invested in. In 2016, at least half of the country's national core technology areas were related to electronics (including all listed in the electronics and telecommunications categories plus several from machine/robots and space). Those listed as electronics pertain to integrated circuits, display panels, and some application-specific electronic components (mostly pertaining to communications).

Table 3-19. Electronics National Core Technology Areas

Product Area	**Technology**	**2007**	**2010**	**2012**	**2016**
NAND Flash	Design, process, device	≤70nm	≤50nm	≤50nm	≤30nm
	3D lamination forming	--		≤50nm	≤30nm
	Assembly and inspection	≤70nm	≤30nm	≤30nm	≤30nm
DRAM	Design, process, device	≤80nm	≤60nm	≤60nm	≤30nm
	3D lamination forming	--		≤60nm	≤30nm
	Assembly and inspection	≤80nm	≤40nm	≤40nm	≤30nm
Foundry	Process and device	--	--	≤30nm	≤30nm
	3D lamination forming	--	--		≤30nm
TFT-LCD Panel	Design, process, manufacturing	Unspecified	7th Gen. +	7th Gen+	8th Gen.+
PDP Panel	Cell Structure Technology	2007	--	--	--
AMOLED Panel	Design, process, manufacturing	--	--	2012	2016
Li Secondary Battery	Technology; For EV	--	--	2012	2016
LTE/ LTE_adv	Baseband Modem Design Technology	--	--	--	2016
WiBro Terminal		--	--	--	2016
Mobile Application Processor SoC	Design/Process Technology	--	--	--	2016
Electronics Total		4	5	8	11

Source: KLRI (2016); (--) indicates it is not listed in the given year.

3.3.5. Electronics Recommendations

Korea is the only country with lead firms still competing in the 3C market segments with minimal international ties or outsourcing-centric business model. Samsung and LG are the world's two largest consumer electronics brands *and* manufacturers. Unlike computers and to a lesser extent cell phone brands, these lead firms own final assembly operations. They have offshore production, but they have not engaged in outsourcing. They are also integrated into key component segments. While the parent company does not own each division entirely, the various companies all hold sizeable shares in the other divisions. Both own display manufacturing (the most expensive component), and other key input technologies (LG owns key chemical and other electronic components via LG Chemical and LG Innotek) and Samsung owns semiconductors, semiconductor manufacturing equipment, chemicals, and EMS manufacturing.

Whereas this hierarchical/captive governance structure is not a disadvantage in and of itself, it may present challenges in terms of collaborative innovation in the future. First, it places dependence on a small number of firms and a relatively small number of products. Second, it assumes the two top firms can continue to be experts in all value-adding activities, which may

prove to be increasingly difficult as the pace of new product development shortens. And third, it isolates Korean firms in the eyes of potential firms and organizations outside Korea.

However, it also enables key firms to develop and control new technologies and has been an advantage for Korea because it has resulted in top global brands. It has also lead to a strong position in intermediates (displays and semiconductors), which are key to entering new end markets for final electronic products. Korea has a unique opportunity to use this to the country's advantage, given that most lead firms no longer have direct control over production.

Collaboration among key conglomerates for end market upgrading: While Korea is strong in the 3C markets, it is not a significant player in the other end markets that tend to be less price sensitive (industrial, transportation-related and medical). Korea is home to some of the world's top companies in industries that could greatly benefit from collaborating with each other. Collaboration among companies or industries, a common benefit cited in cluster-based development, leads to opportunities for chain or intersectoral upgrading. Electronic components are key platform technologies that are embedded in an increasing number of final products that are also produced in Korea such as cars and ships. This type of collaboration is not just limited to manufacturing companies. As the market continues to grow in Asia, Korean electronics firms can explore opportunities to expand into new geographic markets by partnering with Korean hospitality and retail companies. For example, by developing new, potentially lower-priced store brands to sell in retail chains to expand market share in emerging Asian markets.

Reorientation to Asia: diversifying into new regional markets within Asia offers better prospects for Korean SMEs to enter GVCs. These markets are not already saturated by existing global brands, and consumers in Asia have different product preferences than US and European customers. Korean firms have several opportunities to take advantage of these emerging markets: (1) via new firms and brands specifically targeted to Asian countries, (2) as new brands or divisions of existing MNEs that mask the association with the parent firm. A common strategy of Korean firms has been to use a uni-brand strategy rather than create multiple lifestyle brands that target a specific demographic (i.e., age, gender, income level). China has shown early success using this model by having brands that target both the low and high-end markets both regionally and abroad. Given that Korean firms still control their production networks, they could pursue a similar strategy by developing new, lower-priced versions of their 3C products in less developed regions.

Automation and Servicification: Three technologies are predicted to have the most impact on the electronics industry: robotic automation, 3D printing (or additive manufacturing) and IoT (Rynhart et al., 2016).[14] The first two align with our trend of automation whereas IoT is part of servicificiation.

Automation: Given that Korea is already a global lead firm, it is in a position to instigate the shift to automation by developing the new technologies and introducing them into the supply chain. Automation will impact the labor-intensive activities that have been offshored from Korea to China and Vietnam. Korean firms' now have the opportunity to develop these new technologies

[14] While 3D printing is mentioned, it also suggests that this will be difficult to implement in electronics given the variety of materials used on PCBs.

and equipment. Korea is a global leader in three of the following four industry groups that will account for 75% of global robot installations in 2025: (1) computers and electronic products; (2) electrical equipment, appliances and components; (3) transport equipment; and (4) machinery (Rynhart et al., 2016).

While Korea does not have the firms or capabilities right now in these areas, they have the types of globally recognized firms that these companies want to partner with to develop future technologies. Forming early partnerships and alliances with firms in other countries that hold key assets is critical. While Korean firms can attempt to do this on their own, the ability to be the best and to do it at the pace of current development will be challenging.

Moving into production equipment and key components has been a strength of Japanese firms. They have exceled in production and equipment technologies, imaging devices, and electrical components (i.e., capacitors, resistors, batteries). While these companies are unknown to the common consumer, they are pivotal in the operation of modern electronic and electrical devices and formed the foundation of early appliances. For example, Japanese companies dominate the camera and imaging market, which led to developing front-end semiconductor lithography equipment, which has led to technology licensing and IP revenue. Canon and Nikon developed early semiconductor manufacturing equipment, and still hold shares in key imaging areas.

China, for example, has already stated intent to increase the market share of local players in robotics to 50% by 2020, however most are now from four European and Japanese robotic producers – ABB, Fanuc (est. 1972), Yaskawa (1915) and Kuka (1898); these four accounted for 65% of China's robotic purchases in 2013 (Research in China, 2014). A key element to competing in this market is access (or control) to key component technologies: controllers, server drives and precision gearboxes. These component technologies are vital to the usability and complexity of robotics. The "Made in China 2025" initiative highlights this as a vital and requisite area of development and reports increasingly show that China is emerging as an R&D hub (Rynhart et al., 2016). In 2016, China made a significant move into this area when Midea, a Chinese electrical appliance manufacturer, acquired the German automation company Kuka.

Upgrading into production equipment product development: Korean firms can draw on their expertise in 3C segments to develop the key automation manufacturing technologies that will drive industry 4.0 trends. Korean firms are at an advantage in this regard given they still produce final products in-house whereas most firms have outsourced this production. These are also the most labor-intensive sectors that will be the first targeted for automation. Owning the IP behind technology or production equipment also provides future revenue streams via licensing and offers opportunities in servicing systems in the future. Furthermore, as technology changes, it will become more difficult for Japanese and European equipment manufacturers to stay on top of new developments because these countries now have a limited manufacturing base for the products the equipment produces. As such, the workforce base dwindles.

*Servicification***:** the IoT phenomenon comes down to three things – access to the Internet (IT service companies), electronic sensors (i.e., semiconductor industry) and tangible 'things' (cars, appliances, security systems, etc.). Another way of thinking about IoT is that increasingly all products can become what have historically been considered 'electronics' and these 'electronics'

can now be connected to one another. Korea has an advantage in this area given they have three large electronics MNEs in the country and a leading footprint in several of the early 'things' to adopt this trend (e.g., cars, consumer electrical appliances). Where Korea lags is the service side, (with Navar being the only Korean-based digital company). In other countries, key IoT developments have had strong ties to **IT service-related companies**. For example, Ford teamed up with Amazon to connect its cars to sensor-laden smart homes. BMW, Daimler and Volkswagen's Audi division jointly purchased "Here", a mapping service to make sure that carmakers have an independent provider and do not depend on Google Maps. GM announced a US$500 million investment in Lyft, a ride-sharing service (Rynhart et al., 2016).

Intersectoral upgrading into IT services: Korea is strong in manufacturing, but relatively weak on the services side. Korea's experience in animation provides an example of how an export-oriented production industry has transitioned into service sectors that can be viewed as a potential model to further facilitate Korea's entry into other IT-related service areas. The case also highlights the importance of **network-building** between global and domestic firms to upgrade into new technology and service-oriented activities.

Box 3-1. Learning from Korea's Experience in the Animation GVC

Korea first engaged in the animation GVC as an offshore supplier for Japanese and later US and European buyers starting in the late 1960s through the 1990s (Taiwanese and later the Philippines were also destinations for this outsourced work). Unlike other industries at the time, the animation sector in this period was driven by SMEs working for foreign buyers as OEM suppliers. The government did not play a role in promoting this industry in Korea from the 1970s through the 1990s and upgrading was driven by learning via foreign buyers, however this was limited to the labor-intensive production stage of the chain (i.e., process and product upgrading).

By the 2000s, Korea's exports declined due to several factors; lower-cost production sites were increasingly available (China, India, Vietnam), technology was shifting to digital 3D computer animation, and the growing popularity of new entertainment media, such as video gaming and the Internet. To remain competitive, Korean firms shifted to 3D computer animation as well as their own original animation production focusing on pre- and post-production activities, and by 2007 more than half of industry revenue was from original rather than contract production for foreign buyers. This upgrading to original production was largely driven by new SMEs that did not have prior experience in the outsourcing years. Rather than learn through connections to foreign buyers. Instead, they began to build a linkage with different types of foreign firms through different channels, and international coproduction emerged as the major outlet for their animation

The government strategically selected animation as one of the post-industrial sectors for its policy push in the 1990s, focusing on removing key bottlenecks for functional upgrading, such as creative development, financing, and distribution. It was part of a broader government initiative to nurture globally competitive cultural and creative industries. The support exclusively focused on creating and bringing original animation to global markets. The government helped Korean animation studios increase their exposure to global markets and build relationships such as international coproduction with foreign firms. It invested in public-private joint funds to fund a promising start-up project in animation, a TV animation quota system was installed in 2005, which mandated TV networks to show newly produced local animation for a certain amount of their airtime to expand a distribution channel for local studios, and the government signed international coproduction treaties with Canada (1995), France (2006), and New Zealand (2008). Finally, the Korea Creative Content Agency (KOCCA) was established in 2001 as a government agency dedicated to cultural industries to support local firms' creative, sales and marketing efforts at home and abroad.

Functional upgrading requires a different form of firm capabilities from what is needed for process or product upgrading. For example, upgrading to pre- and post-production in animation required Korean studios to hire and nurture workers with **different skills** (e.g., computer animation), build **new business contacts** (e.g., foreign distributors), and implement a distinctive managerial approach (e.g., **greater risk-taking**). **That is also the case for**

government support. Network-building has become a new centerpiece of the government policies to support local firms' upgrading to original animation by facilitating international coproduction and overseas marketing.

Furthermore, even though the firms that emerged as original production producers were distinct from those that engaged in outsourced contracts for foreign firms, this put Korea on the map in terms of countries global producers would consider in terms of looking for partners. Korea is a newcomer to the global IT software and services industry, but it has a long history and reputation in the electronics/IT hardware value chain, animation, and gaming that can be leveraged as it seeks to strategically enter these sectors through international collaborations.

Sources: Lee (2011); J. Lee (2015)

References

Buetow, Mike (2015). Circuits Assembly Top 50 EMS Companies. Retrieved January 3, 2016, from http://circuitsassembly.com/ca/magazine/24900-ems-top-50-1505.html

CIEM. (2016). Scientific Research Level in 2015: Adjusting Industrial Policies of Vietnam in the Context of International Economic Integration. Hanoi: Ministry of Planning & Investment, Centeral Research Institute of Economic Management (CIEM). pp. 143.

Euromonitor. (2016). Consumer Electronics Statistics: World. Retrieved October 10, 2016, from Euromonitor Internationalfrom

European Commisson. (2015, 11/11/2015). Recast of the RoHS Directive. Retrieved March 20, 2016, from http://ec.europa.eu/environment/waste/rohs_eee/index_en.htm.

Ex-Im Bank of Korea. (1990-2016). Ex-Im Bank of Korea Foreign Investment Statistics.

Frederick, Stacey and Gary Gereffi. (2013). Costa Rica in the Electronics Global Value Chain: Opportunities for Upgrading. Durham, NC: Center on Globalization, Governance & Competitiveness (CGGC). pp. 67. http://www.cggc.duke.edu/pdfs/2013-08-20_Ch3_Electronics.pdf.

---. (2016). The Philippines in the Electronics & Electrical Global Value Chain. Durham, NC: Duke University, Center on Globalization, Governance & Competitiveness (Duke CGGC). pp. 78. http://www.cggc.duke.edu/pdfs/2016_Philippines_Electronics_Electrical_Global_Value_Chain.pdf.

Freedonia. (2012). Electronic Components: United States, pp. 24 pages.

Gartner. (2016). Gartner Says Worldwide Smartphone Sales Grew 9.7 Percent in Fourth Quarter of 2015. from http://www.gartner.com/newsroom/id/3215217.

---. (2017, February 15). Gartner Says Worldwide Sales of Smartphones Grew 7 Percent in the Fourth Quarter of 2016. from http://www.gartner.com/newsroom/id/3609817.

IBISWorld. (2012). Global Semiconductor & Electronic Parts: IBISWorld. pp. 50.

---. (2015a). Global Computer Hardware Manufacturing: IBISWorld.

---. (2015b). Global Semiconductor & Electronic Parts: IBISWorld. pp. 39.

---. (2015 (October)). Global Consumer Electronics Manufacturing: IBISWorld,. pp. 35.

IDC. (2015). Worldwide Electronics Manufacturing Services Forecaster. Framingham, MA, USA: IDC.

JETRO. (2014). Survey of Japanese-Affiliated Firms in Asia and Oceania (FY2014 Survey). Tokyo: Japan External Trade Organization (JETRO). pp. 71. https://www.jetro.go.jp/ext_images/en/reports/survey/pdf/2015_01_biz.pdf.

KAIT & KEA. (2016). 2015 Information & Communication Technology Survey [2015 년 ICT 실태조사]. Seoul: Korea Association for ICT Promotion; Korea Electronics Association.

KEA. (1999). *전자산업 40 년사: 1959-1999 [Forty Years of the Electronics Industry, 1959-1999]*. Seoul: Korea Electronics Association (KEA).

National Core Technology List, (2016).

Kraemer, Kenneth L., Greg Linden and Jason Dedrick. (2011). Capturing value in global networks: Apple's iPad and iPhone: Personal Computing Industry Center, University of California, Irvine. http://pcic.merage.uci.edu/papers/2011/Value_iPad_iPhone.pdf.

Lee, Hyun-Ho. (2015). 5 out of 10 SEC's mobile phones 'Made in Vietnam'. *Seoul Economy*. January 27 from http://www.sentv.co.kr/news/view/467518.

Lee, Joonkoo. (2011). *Animating Globalization and Development: The South Korean Animation Industry in Historical-Comparative Perspective.* Duke University, Durham, NC.

---. (2015). Globalization, Upgrading and Regional Engagement: International Coproduction and the Korean Animation Industry in Asia. In A. D'Costa (Ed.), *After-Development Dynamics: South Korea's Contemporary Engagement with Asia* (pp. 65-84). Oxford: Oxford University Press.
Lee, Joonkoo, Jong-Cheol Kim and Jinho Lim. (2016). "Globalization and Divergent Paths of Industrial Development: Mobile Phone Manufacturing in China, Japan, South Korea and Taiwan." *Journal of Contemporary Asia, 46*(2): 222-246.
Lee, Joonkoo and Hyun-Chin Lim. (2016). Mobile Asia: Capitalisms, Value Chains and Mobile Telecommunication in Asia. Seoul: Final Report submitted to Seoul National University, Asia Center. pp. 220. August.
Metha, Aashish and Stacey Frederick. (2015). Skill Requirements of the Technology Workforce in California. Center for Nanotechnology in Society (CNS).
MOTIE. (2015). *2013-2014 산업통상자원백서 [Industry, Trade and Energy White Paper, 2013-2014]*. Sejong: Ministry of Trade, Industry and Energy.
MSIP. (2016a). *2016 Annual Report on the Promotion of the Korean ICT Industry (Summary)*. Sejong: Ministry of Science, ICT and Future Planning.
---. (2016b). *2016 정보통신산업에 관한 연차보고서 [2016 Annual Report on the Promotion of the Korean ICT Industry]*. Sejong: Ministry of Science, ICT and Future Planning.
NVR. (2015). Worldwide Electronics Manufacturing Services (EMS) Market - 2015 Edition. Nevada City, CA, USA: New Venture Research (NVR). www.newventureresearch.com/wp-content/uploads/2015/05/ems2015bro-RS.pdf.
OECD. (2011). Global Value Chains: Preliminary Evidence and Policy Issues. Paris: Organisation for Economic Co-operation and Development, DSTI/IND(2011)3. http://www.oecd.org/dataoecd/18/43/47945400.pdf.
---. (2013). Interconnected Economies: Benefiting from Global Value Chains. Paris: OECD Publishing. http://dx.doi.org/10.1787/9789264189560-en.
PCSYKE. (2010a). *한국경제 60 년사 II: 산업 [Sixty Years of the Korean Economy II: Industry]*. Seoul: Publication Committee of Sixty Years of the Korean Economy (PCSYKE).
---. (2010b). *한국경제 60 년사 III: 대외경제 [Sixty Years of the Korean Economy III: International Economy]*. Seoul: Publication Committee of Sixty Years of the Korean Economy (PCSYKE).
Pegatron. (2015). 2014 Annual Report. Taiwan, pp. 316.
Rammohan, Lavanya. (2011). CEO 360 Degree on EMS and ODM Industry: Frost & Sullivan. http://cds.frost.com.prox.lib.ncsu.edu/p/58859/#!/nts/c?id=N9DC-01-00-00-00.
Rynhart, Gary, Jae-Hee Chang and Phu Huynh. (2016). ASEAN in Transformation: Electrical and Electronics: On and Off the Grid. Geneva: International Labor Organization (ILO), Bureau for Employers' Activities (ACT/EMP). pp. 52. July. http://www.ilo.org/public/english/dialogue/actemp/downloads/publications/2016/asean_in_transf_2016_r5_electr.pdf.
Samsung Electronics. (2016). 2015 Business Report (FYE Dec. 31). Korea, pp. 226.
Sturgeon, Tim and Momoko Kawakami. (2010). Global Value Chains in the Electronics Industry: Was the Crisis a Window of Opportunity for Developing Countries? Washington, DC: World Bank. pp. 53. http://elibrary.worldbank.org/doi/book/10.1596/1813-9450-5417.

---. (2011). "Global value chains in the electronics industry: characteristics, crisis, and upgrading opportunities for firms from developing countries." *International Journal of Technological Learning, Innovation and Development, 4*(1/2/3): 120–147.
Sun, Yutao and Seamus Grimes. (2016). "China's increasing participation in ICT's global value chain: A firm level analysis." *Telecommunications Policy, 40*(2): 210-224.
Ulama, Darryle. (2015). Circuit Board & Electronic Component Manufacturing in the US (33441b): IBISWorld,. pp. 34.
UNComtrade. (2017a). World Electronics Exports: Final, Subassemblies and Components, HS96, 2000-2015, *Retrieved March 2017 from UNComtrade*. New York: United Nations Statistics Division (UNSD).
---. (2017b). World Electronics Imports: Final, Subassemblies and Components, HS96, 2000-2015, *Retrieved March 2017 from UNComtrade*. New York: United Nations Statistics Division (UNSD).
UNCTAD. (2013). Global value chains and development: investment and value added trade in the global economy. Geneva: United Nations Conference on Trade and Development. http://unctad.org/en/publicationslibrary/diae2013d1_en.pdf.
---. (2017). World Investment Report 2017: Investment and the Digital Economy. Geneva, Switzerland: United Nations. pp. 252. www.unctad.org/wir.
van Liemt, Gijsbert. (2016). Hon Hai/Foxconn: which way forward? In J. Drahokoupil, R. Andrijasevic & D. Sacchetto (Eds.), *Flexible workforces and low profit margins: electronics assembly between Europe and China* (pp. 45-66). Brussels, Belgium: European Trade Union Institute (ETUI).
WTO. (2016a). Information Technology Agreement. Retrieved March 19, 2016 from https://www.wto.org/english/tratop_e/inftec_e/inftec_e.htm.
---. (2016b). WTO ITA Workshop on Non-Tariff Barriers (NTBs) Affecting Trade in IT Products. Retrieved March 19, 2016 from https://www.wto.org/english/tratop_e/inftec_e/workshopmay15_e/workshopmay15_e.htm.
Xing, Yuqing and Neal Dert. (2010). How the iPhone widens the United States Trade Deficit with the People's Republic of China: Asian Development Bank Institute.
Zino, Angelo. (2011). Semiconductors. New York: S&P Capital IQ. pp. 48. November.
---. (2015). Semiconductors & Semiconductor Equipment. New York: S&P Capital IQ. pp. 85. October.

Appendix

Table A-3-1. Electronics Product Categories, Based on Trade Data Classifications

Segment	Product Examples	HS Codes
3C Final Products	Consumer Electronics, Phones, Computers	8469, 8470, 8471, 8472, 8519, 8520, 8521, 8525, 8527, 8528 85181, 85182, 85183, 85184, 85185 85171, 85172, 85173, 85174, 85175, 85176, 85178 90061, 90062, 90063, 90064, 90065 90091, 90092, 90093 844312, 844351, 84433 950410, 950450
Medical Final Products	Capital Equipment	901811, 901812, 901813, 901814, 901819, 901820, 9022, 902140, 902150
Industrial Final Products	Analytical Instruments	8526, 901210, 901410, 901420, 901480, 901600, 902410, 902480, 90271-5, 902780, 90281-3, 90291-2, 90301-4, 90308, 90321-2, 90328
Industrial Subassemblies	Parts of above	901290, 901490, 902490, 902790, 902890, 902990, 903090, 903290
3C Subassemblies	Parts of above	8473, 8522, 8529, 851770, 851790, 85189, 90069, 90099, 844399
Components	ICs	8532, 8533, 8534, 8540, 8541, 8542, 8523, 8524

Source: Frederick (2017); based on UNComtrade HS classifications.

Table A-3-2. Korea Electronics: Establishments, Employment, Output, 2012

ISIC Rev 4	Establishments	Employment	Output ($US, Billion)
Components	**2,195**	**278,314**	**$148.8**
2610 Electronic components and boards	2,186	278,115	$148.8
2680 Magnetic and optical media	9	199	$0.0
Final 3C	**1,901**	**117,911**	**$77.1**
2620 Computers and peripheral equipment	284	9,345	$3.3
2630 Communication equipment	1,258	77,090	$67.8
2640 Consumer electronics	359	31,476	$6.0

Source: INDSTAT4

Table A-3-3. Supporting Electronics-Specific Stakeholders by Focus Area

Name/Abbreviation		Est.	Type	Focus	Budget ($US, Millions)	Emp./ Members	Description
Ministry of Trade, Industry and Energy (originally the Ministry of Commerce and Industry)	MOTIE	2013/ 1948	Government Agency	Policy			Two divisions to support electronics: Electronic Parts and Materials Division in charge of formulating and implementing policy regarding the electronics parts sector, including semiconductors and video display, and the Electronics and Electrical Division that addresses policy issues regarding home appliances and other electronics application products along with electric equipment.
Ministry of Science, ICT and Future Planning	MSIP	2013	Government Agency	Policy			Dedicated to overseeing the government's overall ICT policy and supporting the telecommunication and broadcasting sectors, as well as promoting science and technology.
Korea Communications Commission	KCC	2008	Government Agency	Policy; Regulations			Major functions: policymaking regarding terrestrial broadcasting, general programming and news channels; investigating and imposing sanctions against broadcasters in violation of relevant laws; formulating and implementing policies to protect consumers and their privacy; and preventing circulation of illegal and harmful information on the internet.
Korean Intellectual Property Office	KIPO	1977	Government Agency	Policy; IP			Responsible for handling IP-related issues.
Korea Information Society Development Institute	KISDI	1985	Government-Funded Center	Policy Research	$22	145	Overseen by National Research Council for Economics, Humanities, and Social Science (NRCS). Government-funded policy research center on ICT sectors.
Electronics and Telecommunications Research Institute	ETRI	1976	Government-Funded Center	Public R&D	$498	2,041	Overseen by MSIP. Contribute to the nation's economic and social development through R&D and distribution of industrial core technologies in the field of information, communications, electronics, broadcasting and convergence technologies.
Korea Electronics Technology Institute	KETI	1991	Government-Funded Center	Public R&D	$138	389	Overseen by MOTIE. Focuses on R&D capabilities to develop market-oriented and practical technologies to industrialize technologies in the theoretical and academic realm. It also shares accumulated core technologies with SMEs through a collaboration platform.
National IT Industry Promotion Agency	NIPA	2009	Government-Funded Center	ICT Industry Promotion	$233	333	Overseen by MSIP. Devoted to reinforcing the competitiveness of the ICT industry and contribute to economic growth through efficient support and laying the groundwork for industrial technology promotion.
Korea Internet & Security Agency	KISA	2009	Government-Funded Center	Internet industry	$176	638	Overseen by MSIP. Takes the lead in future Internet issues by looking at potential changes a step ahead of others, and creating

Name/Abbreviation		Est.	Type	Focus	Budget ($US, Millions)	Emp./ Members	Description
				promotion			a virtuous cycle of the Internet industrial ecosystem as well as laying the foundation for safer information security.
Korea Association for ICT Promotion	KAIT	1987		Industry promotion		40	Keeps up with new issues arising in the rapidly changing ICT convergence sector and identify future ICT convergence services. KAIT supports the Korean government in building a network for creative economy and lead ICT industry development; contributes to creating an ecosystem under which 'Contents, Platform, Network and Device' are interlinked.
Korea Electronics Association	KEA	1976		Industry promotion		473	Provides aid and assistance to enterprise operation fundamentals, how to follow environmental restrictions, infield training, energy-related maintenance, consulting, among others, while also mediating conflicts such as copyright infringements.
Korea Printed Circuit Association	KPCA	2003	Industry Association	PCBs		182	Constructs cooperation of its members and offers information on PCB market and products. It also manages KPCA-show as the World Electronic Circuits Council (WECC) and exerts all possible efforts to make the global PCB industry developed, in cooperation with the overseas associations.
Korea Display Industry Association	KDIA	2007	Industry Association	Displays		152	Promotes the common interest and bonds in the display industry to facilitate the development of display-related businesses. It also contributes to the mutual problem-solving of industry-wide technological challenges to advance innovation.
Korea Semiconductor Industry Association	KSIA	1991	Industry Association	Semiconductors		274	Promote new business and start-up efforts in the semiconductor industry; it is also involved in building a systematic industry-university research collaboration. It also makes efforts to attract new talent and ideas to semiconductor-related businesses.
Korea Information Display Society	KIDS	1999	Academic Association	Displays		4,000 industrial, academic, and research experts	Implement various business projects, such as providing support for research and academic activities for industrial development through the academic promotion and technical enhancement of the information display field, and by strengthening the international cooperation. Society members devote themselves to the technical development of display studies and the promotion of the industry's competitiveness.

Sources: compiled by authors from organization websites. See Institutional Context (sector-specific) and Supporting Stakeholders section for details