Joint Project between GVCC and KIET

Korea in Global Value Chains: Pathways for Industrial Transformation

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Introduction

The economic policies carried out by Korea over the past half century have transformed the country from a rural economy into an industrialized one. Gross Domestic Product (GDP) has quadrupled since the late 1990s alone, to US$1.4 trillion in 2016, making it the 11th largest economy in the world (WDI, 2017).[1] In the process, Korea has become one of the world's most important manufacturing hubs. Several of the country's firms have risen to prominence in key global sectors including automotive, electronics and shipbuilding; today, Samsung, LG, and Hyundai are household names around the globe. This success has been built through rapid government-led industrialization and its support for a small number of large, globally competitive firms.

Korea's rise as an industrial power has occurred during a period of major reorganization of global trade and industry around global value chains (GVC). Since the mid-1960s, global firms have been slicing up their supply chains in search of low-cost and capable suppliers offshore. This process of global outsourcing and offshoring initially focused on the simple assembly of parts supplied by US manufacturers, typified by the US production-sharing with Mexico, but the pace of offshore production soon accelerated dramatically (Dicken, 2011).[2] In the 1970s and 1980s, retailers and brand-name companies joined manufacturers in the search for offshore suppliers of most categories of consumer goods. The geography of these chains expanded from regional production-sharing arrangements to full-fledged global supply chains, with a growing emphasis on East Asia (Gereffi, 1996).[3] In the 1990s and 2000s, the industries and activities encompassed by global supply chains grew exponentially, covering not only finished goods but also components and subassemblies, and affecting a wide range of sectors, from automotive to electronics and household appliances to infrastructure and shipbuilding.

A central element of these changes has been the relocation of manufacturing sectors to a host of emerging countries, including China, Mexico and Vietnam. While this began with light manufacturing, it increasingly covers more high-tech sectors. This relocation continues to gather momentum with more and more developing economies entering GVCs. More recently, however, new disruptive technologies, such as automation, have emerged that could facilitate the return of many value chain activities to traditional centres in North America and Europe (Butollo, 2017).[4] Thus, having built its economy on a strong manufacturing base, Korea must now redefine its growth drivers for the future. Its strong commitment to process and product improvement have seen steady gains in productivity and output in the past. However, as the country looks to its future, this may not be sufficient to maintain its competitiveness versus both the lower cost locations which are steadily upgrading, and those advanced industrialized countries which are rapidly innovating, defining brand-new industries, and ramping up new production technologies.

While leading manufacturing bases in the US, Europe and Japan are likewise grappling with how to best confront the changing global stage, Korea's unique past development trajectory which shaped the way it engaged with GVCs now means it must chart a distinct course forward. Where

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[1] World Development Indicators Database. Washington, D.C.: World Bank.

[2] *Global Shift: Mapping the Changing Contours of the World Economy* (6th ed.). New York: Guildford.

[3] Commodity Chains and Regional Divisions of Labor in East Asia. *Journal of Asian Business, 12*(1), 75-112.

[4] *Digitalization and the Future of Globalized Production: Exploring the Issues*. Paper presented at the What's Next? Disruptive/Collaborative Economy or Business as Usual?, Lyon, France.

leading firms from the US, Europe and Japan used their knowledge and coordination leadership to leverage the capabilities of strong international networks to become global players, successful firms from Korea have followed a somewhat different path. Well-known global giants, such as Samsung and Hyundai, supported by the national government, have rather relied on high degrees of vertical integration and networks of smaller, local suppliers to be competitive. In doing so, these strong lead firms have maintained control over their manufacturing capabilities and driven their competitiveness through in-house productivity, product and technology improvements. This has been facilitated by investment in research and development (R&D) that outranks the rest of the world. However, in doing so, the country has focused its innovative energies on just a small set of industries. Policymakers now face the question of how to orient these tremendous resources to competitively position Korea as a global economic leader of tomorrow.

As part of efforts to identify the best course forward, the Korea Institute for Industrial Economics & Trade (KIET), commissioned a global value chain study to Duke University Global Value Chains Center (Duke GVCC). The goal of this study is to analyze the country's participation in specific global industries to identify broader lessons for Korea's future ambitions for industrial transformation. To do so, we examine Korea's participation in two major industrial sectors: electronics and shipbuilding. Together, these two industries comprise 30% of exports, account for over half a million semi- and skilled jobs and a substantial share of the country's R&D spending. They provide two distinct perspectives for Korea's participation in GVCs. On one hand, electronics products are targeted to the consumer market, technologies are rapidly changing and profits are derived from bulk production for mass consumer markets, and control over marketing and branding. Shipbuilding, on the other hand, is very capital-intensive, ships have long life cycles, and production is highly concentrated in three countries. In both industries Korea has established a global leadership position in a select number of final product categories and key component products by continually investing in process and product upgrading coupled with strong R&D investments.

Report Methodology and Organization

The current research project was undertaken between September 2016 and August 2017. It draws on multiple sources of information: an extensive review of the academic and business literature available for the two global value chains; in-country interviews with 17 representatives from the private sector firms, industry associations, research institutions, and regulatory bodies; national economic growth plans; aggregated international and national trade data available from United Nations Statistics Division database (UNComtrade).

This report is structured as follows: The first chapter introduces the concepts of global value chains, recent trends, and industrial restructuring, and implications for future development. The second chapter introduces the policy environment and industrial structure in Korea to provide an understanding of how economic policy has been carried out in the country until now. This chapter includes an overview of key institutional stakeholders, the role of large conglomerates (*chaebol*), the policy environment related to industrial development, R&D, trade and investment, and human capital, and lastly a comparison of Korea's economic plans in comparison to China.

The third and fourth chapters use the Duke GVC framework to provide a structural and theoretical lens for understanding the global dynamics in the electronics and shipbuilding sectors, how this impacts the actors in the chain, and what a country's status and prospects are in these industries. The fifth and final chapter provides crosscutting observations and potential future directions for Korea's industrial transformation.

Chapter 1. Global Value Chains and Economic Development[1]

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[1] Chapter prepared by Penny Bamber, Lukas Brun, Stacey Frederick and Gary Gereffi.

1. Global Value Chains and Economic Development

1.1. Introduction

Since the early 1990s, profound changes in the structure of the world economy have reshaped global production and trade, altering the organization of industries and national economies (Gereffi & Sturgeon, 2013). These changes have been driven by heightened international competition from trade liberalization and improvements in transport and telecommunications technologies. The resulting reconfiguration of industries has led to the geographic fragmentation of production and an increase in vertical specialization in supply chain activities by different firms at the national, regional and global levels (Gereffi, 2014). These changes began in labor-intensive industries such as apparel and electronics (Bair & Gereffi, 2001; Gereffi, 1994, 1995), but were closely followed by more advanced manufacturing sectors like automotive (Sturgeon et al., 2007). Today, most major industries, including agriculture and services, are organized as GVCs (UNCTAD, 2013).

These changes have been documented in the extensive and rapidly growing global value chain (GVC) literature (Gereffi et al., 2001; Gereffi & Lee, 2012).[2] The GVC framework has been developed over the past two decades by a global network of researchers from diverse disciplines in order to understand the phenomenon of globalization (Barrientos et al., 2011; Gereffi, 1999, 2005; Gereffi et al., 2005; Humphrey & Schmitz, 2002; Kaplinsky, 2004, 2010). It allows one to understand how industries are organized by examining the structure and dynamics of the different actors involved. This framework originated as “global commodity chains” research in the 1990s, which primarily focused on understanding how companies were reconfiguring their supply chains to source from lower cost locations around the world (Gereffi, 2011). This gave way to the broader GVC framework as researchers sought to understand the distribution of value creation and value capture across all possible chain activities, firms and countries involved in the production of goods and services.[3]

Central to this framework is the ***value chain concept***. The value chain describes the full range of activities that firms and workers around the globe perform to bring a product from conception to production and end use (Gereffi & Fernandez-Stark, 2016; Kaplinsky, 2000). This includes both tangible and intangible value-adding activities, such as research and development (R&D), design, production, distribution, marketing and support to the final consumer. Global value chains thus consist of cross-border, inter-firm networks that bring a good or service to market. Value chain analysis examines the labor inputs, technologies, standards, regulations, products, processes, and markets in specific industries and international locations, thus providing a holistic view of industries both from the top down and the bottom up. The key concept for the top-down view is the governance of GVCs which focuses mainly on lead firms and the organization of global industries; while the main concept for the bottom-up perspective is upgrading, which

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[2] For a review of this literature, see the links and more than 800 publications listed at the Global Value Chains website, https://globalvaluechains.org/publications.

[3] A parallel body of work on global production networks (GPN) has evolved at the same time. While GPNs and GVCs are terms often used interchangeably, the GPN literature has focused more on the local institutional context in which these networks are embedded, while the GVC literature has maintained firm analysis as the central element. See Yeung and Coe (2015) for a discussion of the differences between these frameworks.

focuses on the strategies used by countries, regions and other economic stakeholders to maintain or improve their positions in the global economy (Gereffi & Fernandez-Stark, 2016).

Governance shows how corporate power can actively shape the distribution of profits and risks in an industry, and it identifies the actors who exercise such power. Powerful lead firms determine how resources and knowledge are generated and distributed through the chain (Gereffi, 1994; Humphrey & Schmitz, 2002). In the past, the large flow of information regarding production processes between these lead firms and suppliers helped to facilitate development of capabilities, and expertise of the latter were important drivers for upgrading in developing countries (Gereffi, 1999). These lead firms source their products from a global network of suppliers in cost-effective locations to make their goods. The most notable form of ‘supplier power’ comes via platform leadership (e.g., firms that exhibit marketing or technological dominance, which allows them to set standards and get higher returns for their products), although supplier power typically is not associated with the explicit coordination of buyers or other downstream value chain actors (Frederick & Gereffi, 2009; Sturgeon, 2009).

Economic upgrading involves increasing the value generated from a country’s engagement in the chain, using either the firm or the industry as the unit of analysis. As cheaper locations vie to join chains, those already participating must develop strategies to sustain their inclusion, such as increasing their total factor productivity, specializing in higher value operations or niche sectors that are more insulated from competition (Humphrey & Schmitz, 2002). Upgrading trajectories can be analyzed at both the firm and the country levels. In general, a country upgrades when a critical mass of firms located within its borders achieves upgrading. Upgrading depends considerably on how firm strategy leverages local competitive advantages such as qualified labor, presence of suppliers, geographic location and regulatory conditions. The GVC analytical framework thus provides a typology for identifying potential upgrading trajectories; the most commonly pursued strategies are highlighted in Table 1-1.

Table 1-1. Upgrading Trajectories

Type of Upgrading	**Description**
Process Upgrading	Improvements in productive efficiency leading to higher productivity, such as the use of more sophisticated technology, or the incorporation of lean manufacturing techniques
Product Upgrading	Shift into the production of a higher value product
Functional Upgrading	Movement to new higher value segments in the supply chain
Chain/Intersectoral Upgrading	Leveraging capabilities developed in one chain to move into an entirely new sector
End Market/Channel Upgrading	Incursion of firms into new end market segments, either industrial (e.g., from textiles to medical devices) or geographical (e.g., regional markets in Asia to Europe)
Upgrading into Production Technologies	Moving into the design/fabrication of production machinery and capital equipment. This requires in-depth knowledge of production process.

Source: Authors; adapted from Humphrey and Schmitz (2004).

1.2. The Development Implications of Global Value Chains

The use of the GVC analytical framework has broadened over time from a research agenda to an active policy tool as the emergence of GVCs has redefined how we conceptualize economic development. For most early industrializers (pre-1990), including the US, Germany and Japan, as well as later ones such as Korea, industrialization meant building relatively complete supply chains at home. The core idea was that no nation could become globally competitive without a broad and deep industrial base, and thus considerable effort was dedicated to bring together the capital, technology and labor needed to create new industries (Gereffi, 2014). In the past twenty-five years, however, the fragmentation of production associated with the rise of GVCs now allows firms in different countries to engage in international trade without developing the full range of vertical capabilities across the value chain.

As such, GVCs have thus ushered in a new paradigm of thinking regarding industrial development (Gereffi, 2014; Taglioni & Winkler, 2016). The development trajectory of the 'old' or traditional paradigm was to move from agriculture into manufacturing and finally into services. Upgrading in a GVC-oriented world today, essentially means moving into higher value segments of the industries in which countries have already established expertise. GVC-oriented industrial policy is therefore based on specialization in specific functions. This shift in development thinking has important implications for developed and developing countries alike.

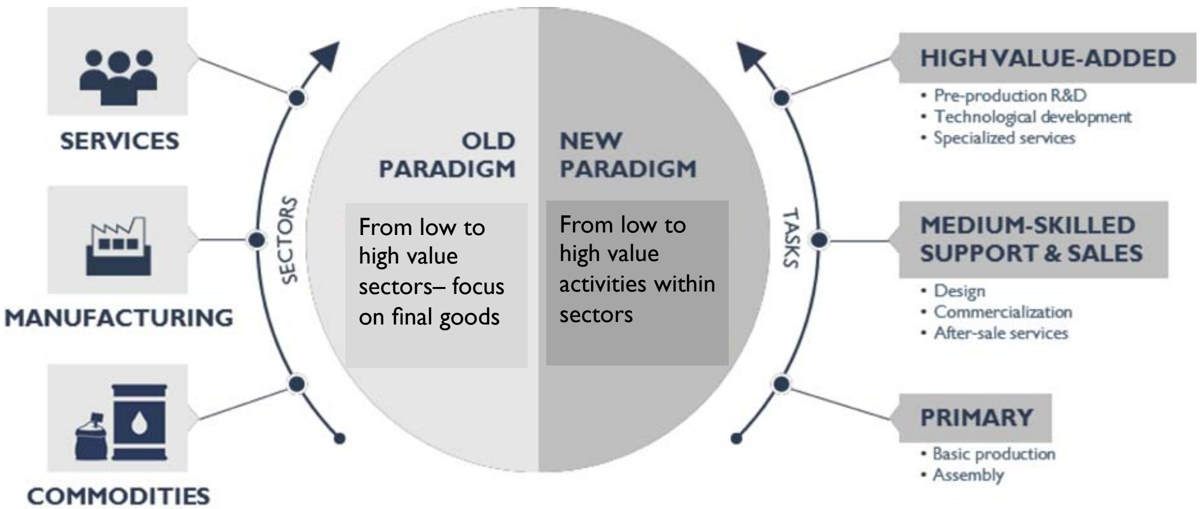
First, countries develop competencies along the supply chain of a given GVC, breaking the preconceived notion of how 'industries' understood in industrial classification systems. This is particularly relevant for the top producing and exporting countries that manufacture in large volumes. For example, in the apparel industry countries often start by assembly of final products, however as they have enough demand, they move backwards into fabric production (first knit and then woven), yarn production, man-made fibers, and finally into the actual production equipment needed to produce these products. At each stage of the chain, countries improve their productivity and the quality of their output to remain competitive.

Second, countries tend to move from production activities into service activities for any given industry. Countries often enter in production operations and over time move into distribution and sourcing, design, marketing, branding, retail and/or after-sales services. This is called 'functional upgrading' in GVCs; this is considered the pathway to GVC leadership. In many GVCs and countries, as capabilities in these higher-value segments improve, the country may move out of production and solely focus on the services segment as a result of a changes in its relative competitiveness, such as labor and/or technology costs.

Third, while countries have a tendency to upgrade within a given GVC, given the focus on specialization of functions, skills developed for one industry are often transferable to other industries. Traditional manufacturing centers including the US and the United Kingdom (UK) have been able to keep their industrial sectors alive by constantly shifting into an ever-evolving array of new, higher technology and more sophisticated sectors. Today, the sectors at the forefront include bio- and nanotechnology and artificial intelligence. In GVC chains, this is referred to as chain or intersectoral upgrading.

Finally, the more advanced a country or firm's participation along these value chains, the closer they are to the global knowledge and technology frontier. These firms define the technologies, standards, and pathways for development of these new sectors.

Figure 1-1. Rise of GVCs: Old versus New Paradigm for Development



Source: Taglioni and Winkler (2016, p. 23)

For *developing regions of the world,* this has essentially "compressed" the development experience and made non-linear catch up possible (Sturgeon & Memedovic, 2010). In the process, GVCs have allowed countries from all over the world to participate in a range of low to very high-tech sectors. For example, this has allowed Vietnam to enter the semiconductor sector, the Philippines into aerospace, and even small countries such as Costa Rica into medical devices (Bamber, Frederick, et al., 2016a; Bamber & Gereffi, 2013). This has provided emerging economies the opportunity to support their development goals by driving employment creation, adding value to their local industries and diversifying their economies. Policymakers in these countries thus have been focused on providing overall conditions for participation and upgrading, such as increasing liberalized trade, flexible labor regimes and improved infrastructure (Bamber et al., 2013).[4]

For *developed regions*, the rise of GVCs and the entry of developing countries into these sectors have provided significant opportunities, but also pose important challenges for policymakers. On one hand, firms from these regions have successfully used lower cost locations to increase their competitiveness, offshoring and outsourcing routinized codifiable tasks such as those in labor-

[4] Due to the complexity faced by many developing countries in achieving progress along these multiple policy dimensions, special economic zones, or Economic Processing Zones (EPZs) have been developed as a key instrument in facilitating entry and upgrading in GSCs. These zones, which often operate as separate jurisdictions, buffer companies involved in GSCs from poor infrastructure, bureaucratic procedures, and other challenges of operating in developing countries (Farole, 2011). In some cases, these EPZs may also operate under different labour codes than the host economy (Cairola, 2015).

intensive assembly operations while maintaining “core competencies” and high value adding activities such as branding and R&D at home. This combination of offshoring and outsourcing has allowed them to reduce their costs, enter new markets and, more recently, also access new technologies.

On the other hand, these changes have altered the demands on policymakers in more industrialized countries. In particular, as they see their competitive advantages in production erode, developed countries have been forced to re-focus their growth models, emphasizing sectors and activities that leverage their comparative advantages in knowledge and innovation. The past emphasis on production efficiencies has been supplanted by the need to foster an environment where innovation can thrive, supported by highly skilled labor and intellectual property protection, while gaining access to new manufacturing hubs through the reduction of tariff and non-tariff barriers on intermediates (OECD, 2014). In doing so it has raised the question of how to remain innovative without a manufacturing base (Gereffi, 2014). Combined, globalization and the logic of value-added production mean that industries are “hollowed out” (Goos & Manning, 2007; Goos et al., 2009, 2014). This has had important implications on labor. The concentration on higher value activities has meant fewer, albeit highly skilled, jobs while this has had positive outcomes for many, unskilled and semi-skilled labor in these countries has suffered (Bacchetta & Jansen, 2011). In numerous communities this has led to pressure for more protectionist policies against this offshoring of jobs.

1.3. Current Trends in Global Value Chains

While GVCs have fundamentally reshaped international trade since the 1990s, the chains themselves are dynamic and constantly evolving in response to shifts in demand, changes in national and international trade and investment policy, and technological advances. Most recently, in the aftermath of the 2008-2009 global financial crisis, four broad changes have begun to change alter existing GVC dynamics: (1) rationalization, (2) reorientation towards Asia, (3) automation/additive manufacturing, and (4) servicification. The latter two are based on changes being ushered in by “Industry 4.0”; automation/additive manufacturing affects tangible production operations, while servicification covers a new series of intangible operations in chains. Each of these trends is addressed below.

First, global lead firms are more actively consolidating their supply chains to include fewer, but more technologically capable and strategically located suppliers (Gereffi, 2014, p. 15). This organizational rationalization of the supply base has been driven by the need to reduce transaction costs. A handful of suppliers were increasingly delivering the majority of value; and lead firms found that supply chain management could be done more efficiently and frequently if a fewer number of highly capable suppliers were engaged. Although consolidation was growing at both the country and supply chain levels in a number of hallmark global industries pre-crisis, such as apparel (Gereffi & Frederick, 2010), automobiles (Sturgeon & Van Biesebroeck, 2011; Sturgeon et al., 2008) and electronics (Brandt & Thun, 2011; Sturgeon & Kawakami, 2011), it has subsequently gained pace. Two noteworthy consequences of this consolidation is the growth of very large GVC suppliers and intermediaries (Gereffi, 2014), and the subsequent crowding out of smaller firms from participating in these global industries (Bamber et al., 2013; Bamber, Frederick, et al., 2016a). These changes have been particularly prevalent in bulk/volume segments, or where large scale is required; niches based on high levels of customization, and smaller volumes provide opportunities for smaller firms to participate.

A second trend in GVCs is a notable reorientation of chains towards Asia, as a result of shifting patterns of both demand and supply. The region's low cost labor and growing industrial base combined with its rapidly growing local demand is increasingly concentrating trade into regional value chains in a number of industries, including apparel, chemicals, electronics and shipbuilding (Bamber, Frederick, et al., 2016b). This shift towards markets in Asia is also evident by the growth in trade between emerging regions. While the general pattern of trade throughout the 20th and 21st centuries has been between countries in the northern hemisphere and between countries in the northern and southern hemispheres, today, the fastest growing corridors of trade are between Asia and Middle East North Africa, Asia and Sub-Sahara Africa, and Asia and Latin America (WTO, 2013). The Asian Development Bank projects these trade patterns could increase from 33% in 2004 to 55% in 2030, and that the South's share of global trade could overtake that of traditional trade leaders in the northern hemisphere by 2030 (Anderson & Strutt, 2011). Regionalization, of course, is not new to global value chains or international trade (Gereffi, 2014). In the past, this has often been the outcome of trade agreements such as the European Union and NAFTA. This reorientation to Asia is perhaps more striking as it is being driven by a significant shift in demand and supply.

The third trend is the rise of new disruptive technologies in the manufacturing process. Heralded as part of Industry 4.0 (Schwab, 2017),[5] this includes automation, human to machine interface, and additive manufacturing (see Box 1.1) (Baur & Wee, 2015; Manyika et al., 2015; Rüßmann et al., 2015).[6] This collection of technologies is expected to change the way things are manufactured. The overall vision of these systems is to automate and integrate production lines, design and produce collaboratively and virtually, and improve the efficiency with which these are delivered to the client/consumer. Automation is already being increasingly incorporated into scale operations, while 3D printing has begun to be used in niche, high value manufacturing operations. The cost of these technologies is decreasing rapidly, with reductions up to 90% over the past four years.[7] As costs have declined, technology adoption has increased; estimates of additive manufacturing adoption are that it has increased four times what it was ten years ago (Manyika et al., 2013). 3D printing is already expanding from consumer use to direct product manufacturing, and tool and die manufacturing. Physical components can be produced near the assembly site in the country of consumption, further reducing the number of suppliers and inventory required. General Electric's new LEAP engine, for example, is equipped with 3D-printed fuel nozzles in alloyed metal – extending the product lifetime by a factor of five, decreasing weight by 25%, and reducing its assembly from 18 parts to one (Rehnberg & Ponte, 2016). Although the current range of products able to be produced by the various techniques of additive manufacturing is limited to complex, low-volume, highly customizable parts like

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[5] See Table 1-A1 in the Appendix for an overview of the different definitions.
[6] Manyika et al. (2013) identify twelve technologies that are part of Industry 4.0. In general, they overlap later efforts at defining Industry 4.0, such as those by Rüßmann et al. (2015) and Baur and Wee (2015), although they also include genomics and energy related technologies (storage, enhanced oil/gas exploration & recovery, and renewable technologies), which are now not considered as part of Industry 4.0 technologies.
[7] Adopting productivity enhancing technologies will require a 35% capital investment increase over the next five to ten years, but is expected to yield 30% reductions in labor, operating, and overhead costs, and 50% reductions in logistics costs (Rüßmann et al., 2015).

aircraft fuel nozzles, the electronic proliferation of tool and die specifications needed to make components through traditional manufacturing techniques could significantly affect the location of manufacturing activity (Manyika et al., 2013; Rehnberg & Ponte, 2016).

Box 1-1. Supply Chain Digitalization: Industry 4.0

Supply chain digitalization is defined as the use of advanced data analytical tools and physical technologies to improve the digital connectivity and technological capabilities of supply chains (Mussomeli et al., 2016). Advanced data analytical tools include visualization, scenario analysis, and predictive learning algorithms, typically called information technology (IT). Advanced physical technologies include robotics, drones, additive manufacturing (3D printing), and autonomous vehicles, typically called operations technology (OT). The combination of IT and OT, made possible by improved processing capabilities, increased computing power, and reduced costs of computing, storage, and bandwidth over the past 15 years has allowed for real-time access to data, analysis, and optimization in the production system. These key areas include:

- Big Data and Analytics are used to collect and evaluate data from production equipment and systems, enterprise and customer-management systems to support decision-making.
- Autonomous robots are developing to become flexible and cooperative with one another and able to learn and work with humans; robots will cost less and have a greater range of capabilities than those that currently exist in manufacturing sites.
- Simulations: real-time virtual model of machines, products, and humans mirroring the physical world. These virtual models allow operators to test and optimize machine settings for the next product in line before a physical changeover, reducing machine set-up times and improving quality.
- The industrial Internet of Things will increase the connectivity of machines and products through distributed systems, allowing real-time response.
- Cybersecurity will become more important as increased connectivity and use of standard communications protocols by industrial and manufacturing systems will require secure, reliable communications, identity, and access management systems.
- The Cloud will increase connectivity and data sharing across sites and company boundaries as part of the Internet of Things. It will improve to also hold monitoring and control processes.
- Additive Manufacturing will go beyond prototypes and individual components to small batches of customized products that can be produced onsite reducing transportation distances and inventory.
- Augmented Reality support parts selection in warehouses and sending repair instructions. Although currently in its infancy, augmented reality may allow workers to receive repair instructions in real-time while looking at the system needing repair. Virtual training through augmented reality may also be used increasingly.

Importantly, the incorporation of these technologies has huge potential pay offs. Manufacturing processes are becoming more automated and flexible to allow for smaller lot sizes and to allow for learning, self-optimization, and adjustment, and automated logistics will use autonomous vehicles and robots to adjust automatically to production needs (Rüßmann et al., 2015). By optimizing functions across the value chain, Industry 4.0 tech can result in increased productivity, reduction of waste and energy consumption and a further decrease in transaction costs. Supply chain partners are connected when and where necessary, reducing capital requirements necessary for efficient production, resulting in on-demand supply, which may permit smaller firms to compete on a more equal footing with larger firms. In manufacturing, companies can gather more information and make better use of it, particularly on technologies focused on process and resource efficiencies that can be enhanced through better technology.

Sources: Baur and Wee (2015); GTAI (2017); Manyika et al. (2015) and Mussomeli et al. (2016).

Finally, ***servicification*** or the increasing role of services in the GVCs; this has been particularly evident in manufacturing sectors (Low & Pasadilla, 2016). First, due to the rapidly changing technology, **pay-by-use and subscription services** are becoming more common. This has already begun in sectors characterized by high capital expenditure, at both the individual consumer and firm level. Rather than focus on selling a product to a customer, the focus is on selling a capability to a customer on a subscription or per-use basis. In transportation services, for example, car manufacturers are investing in ride sharing operations such as Lyft and ZipCar (Gauger et al., 2017; Porter & Heppelmann, 2014). The benefit for the customer is that they no longer own and maintain a car that is idle 90 percent of the time (Morris, 2016) and which uses 25 percent of disposable income (Hodges-Copple, 2017), while getting on-demand transportation services. The benefit for the manufacturer is the ability to deploy a single system for multiple customers who are all paying fees for the privilege of the service. Likewise, this is occurring where capital equipment is even more costly – including aerospace and extractive industries; essentially turning capital expenditures into operational expenditures (Baur & Wee, 2015; Mussomeli et al., 2016; Porter & Heppelmann, 2014). The model means that some manufacturers no longer own their production equipment but rather pay either a fixed subscription cost or variable "per-use" fee to equipment manufacturers to use and maintain the equipment; these manufacturers now redefine themselves as capability and service providers.

These changes are occurring across a wide range of sectors, facilitated by the rise of the Industry 4.0 technologies, generally referred to as the **"Internet of Things" and "Big Data**". As sensors and communication capabilities are embedded in products, they are being used to create system platforms of similar products, optimize their individual or combined use, or sold to develop new information products to new customers (Porter & Heppelmann, 2014). By opening the door for new analytical services, these tools allow traditional manufacturers to enter high value knowledge economy activities.[8] For example, data about the fuel efficiency of a vehicle under different operating conditions and the current driving conditions on roads could be valuable to a number of potential customers, including other drivers, transportation and logistics companies, and insurance companies. Data about how, when, and where the product is used could be valuable to product manufacturers to segment customers, customize features and provide specialized service plans or discounts for additional products to highly specific niche customers (Porter & Heppelmann, 2015). Manufacturers are beginning to develop new businesses that monetize their production expertise and data (Baur & Wee, 2015; Porter et al., 2014).

1.4. Potential Impacts of Changes on GVC Participation

Over the past two decades, developed and developing countries alike have competed to participate in different industries, shaping a series of policies based on the existing understanding of the distribution of value within the chain and the particular requirement of each of those stages. The development path used by many developing countries has been to attract segments of

[8] This is already happening in both the mining equipment and aerospace industries, where manufacturers are now netting over half of their revenue from life-cycle services (Bamber, Fernandez-Stark, et al., 2016; Bamber, Frederick, et al., 2016a). In mining, equipment manufacturers such as Komatsu (Joy Global) are increasingly signing performance based contracts with miners, with profits dependent on the productivity and availability of their machines (Bamber, Fernandez-Stark, et al., 2016). In aerospace, GE changed its business model from being a product and component supplier to being a power and propulsion provider in which it leased equipment on a "power by the hour" basis (Chesbrough, 2012).

GVCs utilizing comparative advantages in labor to conduct routine manual and service work in global industries at lower cost. As such, permissive labor policies, efficient and reliable infrastructure (transportation and energy), and low import tariffs, have been prioritized to enter into chains via low value assembly and production stages (Bamber et al., 2013). Developed countries have focused on research, design and technology development, in addition to branding and marketing skills, as well as negotiating trade and investment policies to leverage the benefits of low cost locations. The current trends are altering the dynamics of GVCs, affecting their value distribution, governance structure and geographic composition. As a result, the calculus for outsourcing and offshoring value chain activities by firms may change, affecting the development prospects of countries.

First, the new technologies and the rise of services **alter the value distribution within GVCs**. Automation and 3D printing could result in the re-integration of production processes, and reducing reliance on labor-intensive assembly operations, although the uptake will likely vary by industry and operation type for quite some time to come (Rehnberg & Ponte, 2016). Manufacturing related services, particularly those previously considered "after-sales" ones are becoming as important sources of revenue, if not more so, than manufacturing operations themselves (Low & Pasadilla, 2016). In some capital equipment sectors, these already account for more than 50% of manufacturing company revenues (Bamber, Fernandez-Stark, et al., 2016).

Second, they **shift the balance of power** within these chains; the shift is subtle, yet powerful and affects which firms can gain access to these chains. Traditional lead firms are being challenged by powerful suppliers with new technologies and capabilities (Gereffi, 2014); these include both large suppliers from the developing world, such as Foxconn and Li & Fung, which have gained dominant positions through rationalization and upgrading (Rehnberg & Ponte, 2016), as well as emerging, well-financed actors such as Amazon, Google, Uber and Akamai, which have successfully leveraged new services platform technologies to take on major coordination roles between buyers and suppliers.

Finally, these trends also change the **potential geographic distribution of chain activities,** with implications for which countries can participate. While automation and regionalization may foster the relocation of manufacturing activities closer to their markets, increased digitalization allows for globalization of services. Routine manufacturing tasks, such as component production and assembly, were the first portions of the value chain to be offshored due to lower relative wage rates (controlled for logistics costs). However, as a result of increased automation and digitalization capabilities, capital substitution of labor in routine manufacturing tasks is high and expected to be even greater as a result of expanded capabilities provided by Industry 4.0 technologies. As a result, the value of continued offshore production may be reduced in some manufacturing GVCs as new capital investments replace labor. **Access to large scale manufacturing GVCs will become more dependent on proximity to market, combined with expertise in automation technologies.** Countries benefiting the most from automation technologies are likely to be in the advanced industrialized world due to the need to improve productivity in the face of population declines (Bughin et al., 2017). Technology advances are likely to be slower in developing countries which have relied on their competitive labor advantage and failed to upgrade capabilities. Thus, a significant threat exists for countries and regions of the world historically using low relative costs of labor as their source of comparative advantage (Butollo, 2017).

Yet, countries may no longer have to be manufacturing hubs to participate in manufacturing GVCs; services such as data analysis for life-cycle management can be carried out anywhere in the world with the right mix of human capital availability and infrastructure. Currently, many of these activities are being carried out in the advanced industrial countries, however, the efficiency seeking ambitions that led to the first wave of unbundling in GVCs remains, and non-automated services too are being offshored to lower cost locations (Fernandez-Stark et al., 2011).

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Appendix

Table A-1-1. Definitions of Current Technology Trends

Term	Definition
Industry 4.0	A term extensively used by McKinsey and Company to describe "the fourth major upheaval in modern manufacturing, following the lean revolution of the 1970s, the outsourcing phenomenon of the 1990s, and the automation that took off in the 2000s…We define Industry 4.0 as the next phase in the digitalization of the manufacturing sector, driven by four disruptions: the astonishing rise in data volumes, computational power, and connectivity, especially new low-power wide-area networks; the emergence of analytics and business-intelligence capabilities; new forms of human-machine interaction such as touch interfaces and augmented-reality systems; and improvements in transferring digital instructions to the physical world, such as advanced robotics and 3-D printing (Baur & Wee, 2015)."
Industrie 4.0	A German strategic initiative, described in the German Trade and Investment Ministry's 2010 "High-Tech Strategy 2020" plan, seeking a "fusion of the online world and the world of industrial production" (Merckel, 2015) as a "means to establish Germany as a lead market and provider of advanced manufacturing solutions… Cyber-physical production systems (CPPS) made up of smart machines, logistics systems and production facilities allow peerless ICT-based integration for vertically integrated and networked manufacturing" (GTAI, 2017).
4th Industrial Revolution (4IR)	Championed by the World Economic Forum and its founder Klaus Schwab, the term Fourth Industrial Revolution ("4IR") describes the range of new technologies fusing the physical, digital and biological worlds into "cyber-physical systems." The emerging technology breakthroughs in artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3D printing and nanotechnology are a part of the 4IR. 4IR is distinguished from the first, second, and third industrial revolutions in which mechanization, electricity, and information technology, respectively, powered industrial change (Davis, 2016; Schwab, 2017).
Internet of Things ("IoT")	Embedding objects with technology that can communicate with IT systems and be detected by sensors. "The advent of the IPv6 internet protocol (which makes 600 quadrillion addresses per square millimeter of the earth's surface possible) means that all physical objects, in theory, can have their own IP address, creating a world of intelligent objects in an Internet of Things. The brave new world of the Internet of Things goes beyond simple machine-to-machine (M2M) communication; extending to machine-to-infrastructure and even machine-to-environment communication. Ordinary objects and devices in the physical world communicate independently and exchange information online thanks to increased programmability, memory storage capacity, and sensor-based capabilities (GTAI, 2017).
Digital supply network	Deloitte Consulting's term for combining information technology's (IT) advanced data analytical tools with operational technology's (OT) advanced physical technologies to improve the digital connectivity and technological capabilities of supply chains (Mussomeli et al., 2016).

Table A-1-2. Supply Chain Digitalization and Optimization Examples

Supply Chain Stage	Examples
Design process optimization	• Sensor/data-driven design enhancements
	• Open innovation/crowdsourcing
	• Rapid prototyping
	• Virtual design simulation
Product optimization	• Data as a product or service
	• Make-to-use with 3D printing
	• Ultra-delayed differentiation
Planning & inventory efficiency	• Analytics-driven demand sensing
	• Dynamic inventory fulfillment
	• POS-driven auto-replenishment
	• Real-time inventory optimization
	• Sensor-driven forecasting
Risk prevention & mitigation	• Proactive quality sensing
	• Track-and-trace solutions
	• Proactive risk sensing
Supplier collaboration	• Analytics-driven sourcing
	• Asset sharing
	• Blockchain-enabled transparency
	• Cloud/control tower optimization
	• Supplier ecosystem
Operations efficiency	• Augmented reality-enhanced operations
	• Automated production
	• Predictive maintenance
	• Sensor-enabled labor monitoring
Logistics optimization	• Augmented reality-enhanced logistics
	• Automated logistics
	• Direct-to-user delivery
	• Driverless trucks
	• Dynamic/predictive routing
Sales optimization	• Inventory-driven dynamic pricing
	• Sensor-driven replenishment pushes
	• Targeted marketing
Aftermarket sales & services	• Augmented reality-enabled customer support
	• End-to-end transparency to customers
	• Make-to-use with 3D printing
	• Predictive aftermarket maintenance

Source: Mussomeli et al. (2016)

Chapter 2. An Introduction to Korea's Economy[1]

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[1] Chapter prepared by Stacey Frederick and Joonkoo Lee, with research assistance by Minjung Lee.

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Acronyms

ASEAN	Association of Southeast Asian Nations
CCEI	Centers for Creative Economy and Innovation
FDI	Foreign Direct Investment
FTA	Free Trade Agreement
FYEDP	Five-Year Economic Development Plan
HCI	Heavy and Chemical Industries
KIET	Korea Institute for Industrial Economics & Trade
KITA	Korea International Trade Association
KLIPS	Korean Labor & Income Panel Study
KOSIS	Korea Statistical Information Service
KOSTAT	Ministry of Strategy and Finance: Statistics Korea
KRW	Korean Won
KSCO	Korean Standard Classification of Occupations
KSIC	Korean Standard Industrial Classification
MOE	Ministry of Education
MOEL	Ministry of Employment and Labor
MOLIT	Ministry of Land, Infrastructure and Transport
MOSF	Ministry of Strategy and Finance
MOTIE	Ministry of Trade, Industry and Energy
MSIP	Ministry of Science, ICT & Future Planning
R&D	Research and Development
RCEP	Regional Comprehensive Economic Partnership
SMBA	Small and Medium Business Administration
SME	Small- and Medium-Sized Enterprise
STEM	Science, Technology, Engineering and Math
WEF	World Economic Forum

2. An Introduction to Korea's Economy

The past half century has seen Korea rapidly industrialize, transforming itself from a struggling agricultural economy to become one of the world's most important manufacturing hubs. Today, the country is the fourth largest economy in Asia and is home to some of the most successful global manufacturing conglomerates. This economic transformation has placed Korea amongst the ranks of the world's advanced industrialized nations.[2] Growth has been based on an unwavering commitment by policymakers to the country's manufacturing prowess. Since 2011, the contribution of manufacturing to GDP has been higher for Korea than all other Asian countries and among the top three countries globally with available data (WDI, 2017).[3]

Excellence in manufacturing was initially driven by state-led industrial policy, with five-year plans rolled out continuously through the second half of the 20th century. These plans laid the foundation for the emergence of a handful of globally competitive Korean lead firms, supported by heavy investments in human capital and research and development (R&D). The quality of the labor force is considered one of the most important factors in Korea's economic and industrial success, while the country leads globally in terms of R&D expenditure.

This chapter reviews the policies that impact industrial development in Korea across all industries, and examines how the country's approach to economic development has evolved over the past few decades. The review included identifying key stakeholders, trade, industrial and labor-related policies and programs. Detailed information on key stakeholders is included in the appendix of this report (Table A-2-1. Key Institutional Actors, Korea).

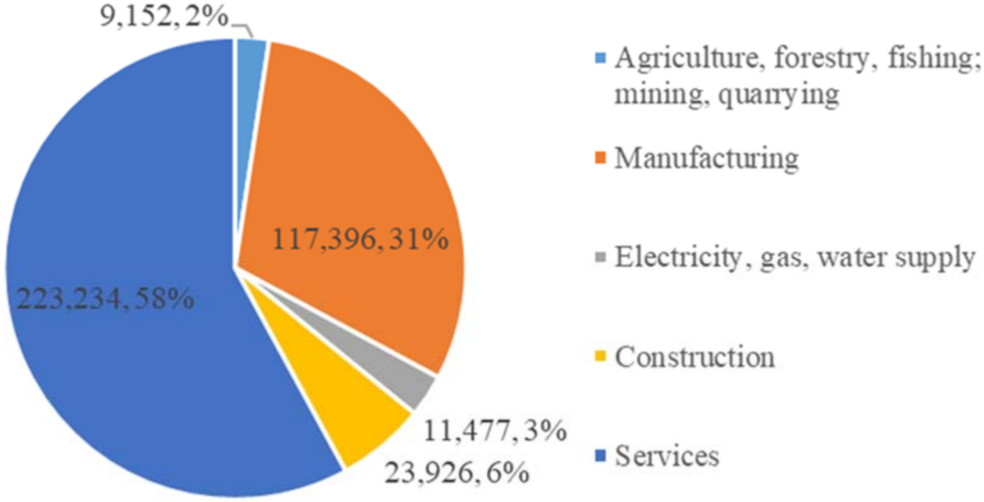
2.1. Korea's Economic Profile

Korea's economic portfolio reflects the activities of the large MNEs operating in the country since the early focus on heavy industries in the 1970s. As shown in

Figure 2-1, Korea's distribution of economic activity based on share of gross value added has remained consistent between 2001 and 2017 with services accounting for 58% followed by manufacturing at 30.5% for the first quarter of 2017 (compared to 59% and 28% respectively in 2001). Notably within services, business activities (including professional, scientific, and technical services and business support services) have increased at a faster rate than the overall average and other service activities.

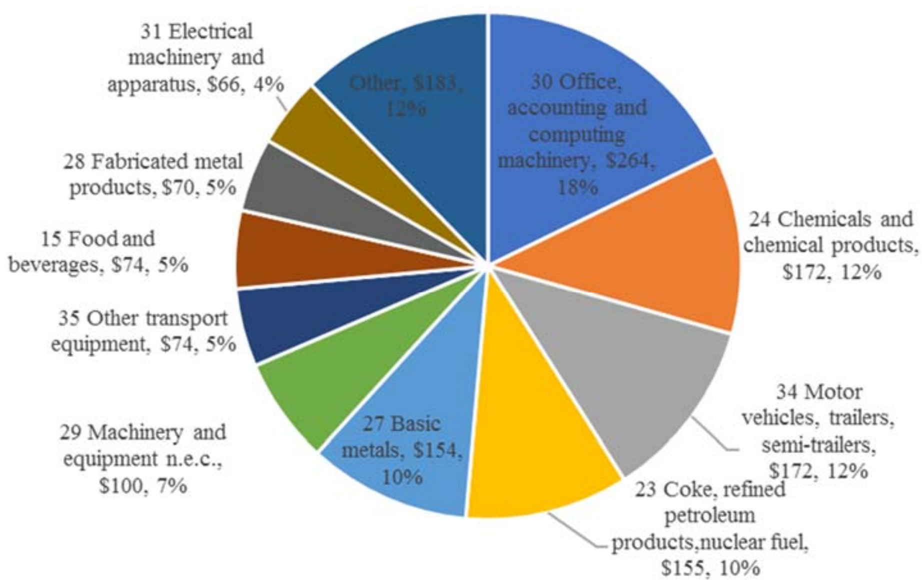
[2] Korea has consistently been considered a high-income country since 2001. Based on World Bank Income Classifications, GNI per capita in US$ (Atlas methodology).
[3] Korea narrowly surpassed China in 2011 (31.4% compared to 31.3%), however Korea's manufacturing contribution has remained steady or increased whereas China's has declined as services increase.

Figure 2-1. Korea's Gross Value Added by Economic Activity, 2017 (1st quarter)



Source: BOK (2001-2017); Value-added in basic prices, billion won

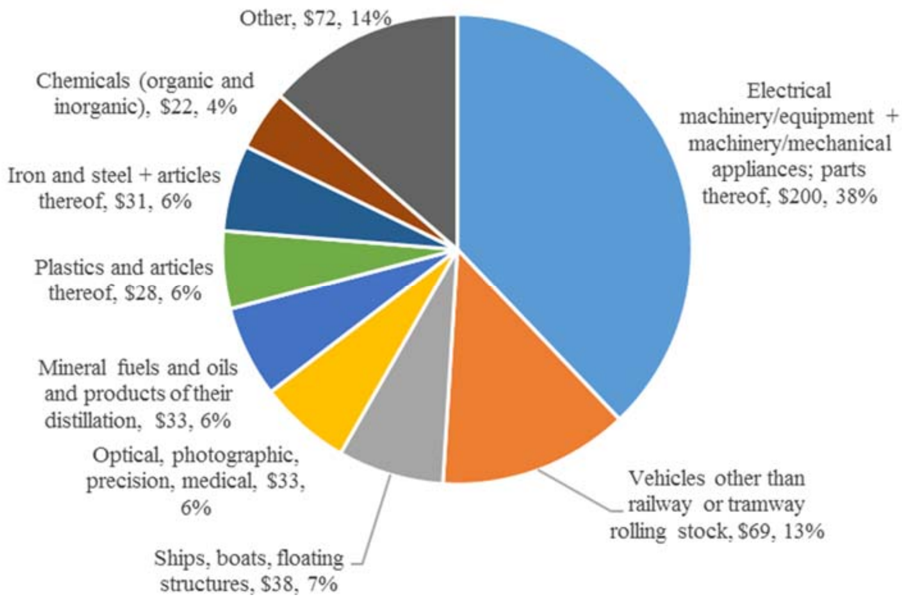
Figure 2-2. Korea's Manufacturing Output ($US, billions) by Industry, 2014



Source: UNIDO (1963-2014); based on INDSTAT2, Rev3.

Korea's manufacturing output in 2014 is driven by electronic components and final products (18%), chemicals (12%), and automotive components and final products (12%) (Figure 2-2). When compared with exports, the main difference is that chemicals are not a top category, indicating that output is largely for domestic consumption or as intermediate inputs into other exports (Figure 2-3).

Figure 2-3. Korea's Top Exports, 2015



Source: UNSD (2002-2015); Note: values in $US billions and shares represent share of Korea's total exports in 2015; descriptions represent HS02, two-digit codes and pairs of codes.

2.2. Industrial Policy in Korea

Korea has long been known for a state-led industrial development model during its post-war high-growth era. A close and effective relationship between the state bureaucracy and private business, albeit with occasional public revelations of corruption, was a hallmark of Korea's industrial policy for much of the period until the early 1990s (Amsden, 1989; Evans, 1995). Since democratization, the country's approach to industrial policy has shifted from a strong state-led model to one where the private sector plays a more proactive role (Devlin & Moguillansky, 2011; Yeung, 2014). This has been facilitated by the significant growth of private sector capabilities and resources over the past few decades. Yet, the Korean government still plays a key role in facilitating industrial growth, global integration, and post-industrial transformation, with emphasis on a knowledge-driven creative economy, small- and medium-sized enterprise (SME) growth, and advanced and innovative research and development (R&D), although policy instability and inefficient government regulations are often cited as major constraints on the country's global competitiveness (WEF, 2016). This section provides a brief background to the evolution of industrial policy in the country in order to set the stage for later discussions regarding the country's industrial transformation (see Chapter 5).

Korea's early industrial policy approach, which began in 1962 with the roll out of its first five-year economic development plan (FYEDP) and lasted until 1993, had a tremendous impact on the country's rapid industrialization. Since the turn of the century, industrial policy has been driven primarily at the ministerial level as national plans were dropped. Mostly these policies have focused on fostering future industries. The impact of these plans on the economy has been more muted than their predecessors. Reasons cited for this include: (1) economic structure was not yet suited for knowledge-based development, and it is difficult to measure progress; (2) there was a lack of coherence and continuity, with focus areas being switched too often (every five years); and (3) areas selected by the planning process were not strategic for the country and had considerable overlap with China, placing the country in direct competition with their considerably larger neighbor (KIET, 2015). Private domestic businesses (instead of FDI or SOEs) were chosen to drive the development of Korea's economy (Yeung, 2014). These have become known as "chaebols" and they are central to the country's economy (see Box 2-1).

Box 2-1. Korea's Unique Industrial Organization: Chaebols & the Economy

Korea's early industrial policy gave rise to the emergence of a group of very strong firms, known locally as *chaebols*. Largely protected in the domestic market until the Asian Crisis in 1997, these companies, today, are typically large, highly diversified conglomerates, with strong family oriented operations (Kim, 2015), and many of them are lead firms in their respective GVCs. These conglomerates are an essential part of Korea's economy, and helped transform the nation.

Table 2-1. Leading Chaebols

Firm	Primary Industry Interests	2016 Annual Revenue, US$ Billion
Samsung	Semiconductors, Electronics (phones, TVs), Electrical Appliances, Hotels, Pharmaceuticals, Shipbuilding	173.4
Hyundai Motor	Automotive	83
SK	Semiconductors; Oil and Gas; Telecomm, Finance	72
LG	Electronics (smartphones, TVs), Electrical Appliances, Cosmetics, Chemicals, Fertilizer	47.9
	Subtotal	376.3

Sources: KSE (2017), Reuters (2017), Forbes (2017)

Nonetheless, along the way, they have come to dominate most sectors (Vaswani, 2017). While this has proven to be a successful strategy for Korea, it has also "put a lot of eggs in one basket." These firms collectively held a nearly two-thirds market share in manufacturing by the end of the 1990s and it is estimated that Samsung accounts for one-fifth of Korea's exports (Tejada, 2017). Another estimate states that sales revenue from the top five chaebols is worth more than half of Korea's entire economy (Vaswani, 2017). Another states that Korea's four biggest chaebol groups – Samsung (SSNLF), Hyundai Motor (HYMTF), SK (SKMTF) and LG (KRX) – account for half the country's stock market value (Reuters, 2017). Having a few large, interconnected companies based on one brand name also goes against the typical business model used in most other countries, as it assumes that one company or country can remain competitive in all activities in the value chain. It also does not align with trends regarding lifestyle and targeted marketing.

This has resulted in significant size disparity between the chaebols and other firms in the industry which have a particularly difficult time competing. The Korean Commission for Corporate Partnership was created in 2010 to help mitigate social conflict between large enterprises (many are chaebol enterprises) and SMEs as the former group had an inordinately large share of the market and thus the power of monopoly and oligopoly. The commission was created to help ease the tension between the two groups, and to find creative ways for the chaebols to assist the growth of the SMEs (Kim, 2015).

There have been many efforts by the Korean government to support SMEs with access to domestic bank loans, SME-designated manufacturing, service sectors that prohibit chaebols from entering, as well as support in technology. Since the 2000s, SME development has been a stated focus of economic development initiatives, with policies being developed through a dedicated administration, the Small and Medium Business Administration (SMBA).

The developmental state of the 1960s and 1970s used authoritarian means to control and discipline private businesses; examples include the threat of tax audits, investigation of illicit accumulation of wealth and corruption, and sometimes North Korean sympathizing activities to investigate and prosecute private businesses that were not in line with the state's five-year economic development plans and industrial policies. The most widely used threat was withdrawal of preferential domestic bank loans if target volume and growth rate goals for manufacturing output and exports were not reached (Kim, 2015). The government held the upper hand in terms of power; it provided access to loans and resources, but curbed the power of private firms with sanctions and licenses. Private businesses needed the state for preferential access to capital and technology, and subsidies went to hand-picked private businesses for heavy and chemical industries (HCI). Government protection allowed business empires to expand into new areas without fear of potential foreign competition or failure. This growth strategy, as would be expected, has led to tight ties between the government and businesses.

Table 2-2. Industrial Planning in Korea: 1962-2016

Time	Primary Policies	Focus/Impact
1962-1966	1st FYEDP: Create a self-reliant economy by transforming from agriculture to industry by securing resources, expanding basic industry and infrastructure, improving the balance of payments (including negotiations for foreign aid), and promotion of technology.	
1967-1971	2nd FYEDP: Focus: exports. Japan's example of export-oriented industrialization (EOI) was adopted because it needed foreign capital for development. Korea focused on light manufacturing due to its rather short history of industrialization, as well as lack of capital, technology, and natural resources, combined with only a relatively well-educated labor force	**Light manufacturing**: textiles, clothing, footwear, plywood, wigs, stuffed toys.
1972-1976 1977-1981	3rd & 4th FYEDP: HCI and rural development were the two primary goals. HCI was selected as a strategy that would help solve many challenges: (1) secure domestic political support by nurturing large private businesses; (2) develop the defense industry; and (3) overcome national security challenges (related to potential threats of a North Korea invasion). To grow in HCI, a large capital base and access to technology was needed. Thus, the 1970s marked the transformation of large private businesses into major conglomerates. Target industries were chosen due to potential for **backward and forward linkages**, multiplier effect for the national economy, and earnings through exports. Emphasis on technology imports.	Six target industries (and firms) selected for **heavy and chemical industries**: (1) iron & steel; (2) non-ferrous metal; (3) machinery; (4) shipbuilding; (5) electrical appliances & electronics (E&E); & (6) petrochemicals.
1982-1986	5th FYEDP: social and welfare services took a greater emphasis and 1980s: Stabilization, liberalization. Development of the electronic sector. From creative imitation phase to innovation	Electronics
1987-1991	6th FYEDP: Government became less involved and the private sector took on more power: (1) industrial targeting changed from picking private businesses/target sectors for heavy subsidies to supporting sunset industries with a finite time limit (three years) with reduced support; (2) developmental and industrial policies took back stage to regulatory policies; and (3) incentives including state-owned banks, policy loans, and industrial licensing (for private businesses) were mostly eliminated.	Industrial and corporate restructuring and competition and regulatory policy

Time	Primary Policies	Focus/Impact
1992-1993	7th FYEDP: Replaced by the FYP for New Economy in 1993. End of official five-year plans.	
1998	"Big Deals" –chaebols reduced diversification across industries to concentrate on two (or three for the largest chaebols) core industries. This led to significant restructuring among firms and divisions.	Redefine and streamline focus areas of chaebols
1999	National Science and Technology Council created to define strategies and programs and to allocate resources (shares hierarchy with National Assembly & Ministry of Planning diluting power). It is composed of representatives of several ministries plus nine representatives from the scientific community and is chaired by the president. Prior to 2006: there is also a focus on 193 products with established high potential.	Science & Technology
2001	2001: Knowledge-based economic development. Move from a capital-driven industrial strategy to one driven by innovation, emphasizing technology and efficiency. Internationalization of small and medium firms.	R&D; SMEs, clusters, training industrial manpower; regional development
2004	National Science and Technology Council is elevated in status. Minister of S&T given Deputy Prime Minister status.	
2009-2013	Government intervention in industrial and corporate restructuring after the global financial crisis is carried out by government financial institutions led by financial authorities. Under a policy environment familiar with favorable and selective financial support for industrial and corporate support, government financial institutions are both a mechanism for realizing industrial policy objectives and a barrier to impede smooth restructuring by the market.	Green growth and convergence between industries
2013-2016	Centers for Creative Economy and Innovation (CCEIs) "Three-year Plan for Economic Innovation" in 2014	Creative economy; Co-growth of large firms and SMEs
2016	Government R&D Innovation Plan (released 2016); Future Growth Engine Comprehensive Action Plan (19 areas, 2016)	

Sources: (Kim, 2015); (KIET, 2015); (Green Growth Committee, 2009).

The most recent efforts towards industrial policy have focused on Korea becoming a knowledge economy and diversifying into more innovation based sectors. In 2016, the Ministry of Science, ICT & Future Planning (MSIP) and Ministry of Trade, Industry & Energy (MOTIE) launched the *Comprehensive Action Plan for Future New Growth & Industrial Engines*.[4] The plan presents core strategies to produce new industries for the creative economy as well as key tasks for the government's three-year economic innovation plan. MSIP and MOTIE decided to facilitate cooperation programs and strengthen policy coordination between the two ministries. They increased the practicality of the plan by supplementing it with technology and business roadmaps for each field. These are detailed in the Future Growth Engine Comprehensive Action Plan: Detailed Information (MSIP & MOTIE, 2016). The plan combined 13 future growth engines and 13 industrial engines into 19 future growth engines, detailing implementation strategies and budgets (see Table 2-3). It calls for comprehensive support for international joint research and establishment of infrastructure, along with technology development, to create an industrial ecosystem that enables shared growth of industries, academia and research institutes. The government intends to invest about $US4.7 billion (5.6 trillion won) by 2020 with a hope the new industries achieve US$100 billion in exports by 2024 (KMTI, 2014-2015).

[4] MSIP and MOTIE developed separate plans, but merged the two to form this one; namely the '15 Rolling Plan' of the 'Action Plan for Future Growth Engines' by MSIP with the participation of about 200 experts and the 'Development for Industrial Engines Project' by MOTIE.

Table 2-3. Future Growth Engine Comprehensive Action Plan Fields, 2015-2020

Industry	Field	Goal
Aerospace	High-performance Unmanned Aerial Vehicle (UAV)	World's No.3 UAV leader
Automotive	Smart cars	
Biotechnology	Smart bio production system	Up to 10 biotech production systems by 2020 (30% improvement in bio-production system technology level, securing 2% global market share)
Clean Energy	New & Renewable Energy Hybrid System Supercritical CO2 Generation System	
Electronics	5G mobile communication Intelligent Semiconductors Intelligent Robots Wearable Smart Devices Smart Internet of Things Big Data	Provide world's first 5G commercial service by 2020. Achieve 2nd largest market share (10%) by 2020. KRW 6 trillion in domestic robot production by 2020. Preempt the global creative and wearable smart device market by 2020 IoT domestic market size of 30 trillion won by 2020 Big data leap to the top 3 by 2020.
Electrical	Multi-terminal high-voltage DC transmission/distribution system	
Healthcare	Personalized Wellness Care	Reaching the world top 5 in the global wellness market based on personal health and lifestyle care by 2020
IT/programming	Realistic Content[5] Virtual (cyber) training system	Develop 10 enterprises by 2020 and 5% of global market share. $10 billion in 20 star enterprises and sales by 2021. Nurturing global "small giants" and generating new markets in the area of virtual training system.
Materials	Composite (convergence) materials	World's 4th strongest materials country through development of creative materials and industrial core materials by 2024.
Shipbuilding	Deep Sea/Extreme Environment Marine Plant (Offshore Plant)	50% localization rate and 30% market share by 2020.
Production Equipment	Advanced (High-Tech) Material Processing Systems	Realization of 4 major powers in high-tech materials processing industry in 2020.
Public Services	Disaster Safety Management Smart System	

Source: MSIP and MOTIE (2016); Industry focus areas by authors.

2.3. Trade and Investment Policy

Trade and investment policy formulation is driven by MOTIE and the Ministry of Strategy and Finance (MOSF). Other supporting functions for trade and investment are provided by various public organizations in close relationship with government ministries and administrations.

[5] Technology-based ICT-induced human senses and cognition, engaging next-generation content that provides a similar experience with real emotion and space to expand.

Korea's international trade relationships have significantly changed in recent years as the country rapidly expanded ties with its major trading partners through bilateral and regional trade agreements. Bilateral free trade agreements (FTAs) considerably increased. Most agreements have been effective since 2010. Currently, Korea has FTAs with Chile, Singapore, India, Peru, Turkey[6], Australia, Canada, China, New Zealand, Vietnam, and Columbia. Korea also has a FTA with its top exporting partners, China, the U.S. and European Union. These three markets accounted for 47% of Korea's exports and 38% of imports in 2014 (WTO, 2016). It also has a regional FTA with the Association of Southeast Asian Nations (ASEAN). This indicates the country's strong trade linkages with some of the world's largest markets (see Table A-2-2. Korea's Trade Agreements and Preferences).

In addition, Korea is in talks for several potential regional FTAs, including the Korea-China-Japan FTA, which would integrate three major Northeast Asian markets, the Regional Comprehensive Economic Partnership (RCEP), which includes China, Japan, Australia, New Zealand plus ten ASEAN countries, and the Korea-Central America FTA, whose negotiations were concluded on November 2016 (MTIE, 2016). Korea has also considered joining the Trans-Pacific Partnership (TPP), although the deal's future is now uncertain as a new U.S. administration has withdrawn from it.[7]

While Korea is currently only eligible to receive GSP benefits from Australia, Belarus, Russia, Kazakhstan, and Norway, GSP preferences played an important role in initially expanding exports. Under the system, the country expanded its exports to major advanced economies, notably the US and European Union, with preferential tariffs. In 1987, Korea's exports through GSP accounted for 15 percent of its total exports, and 90% of GSP exports were to the U.S., EU and Japan (Yonhap News, 2010). As its economy grew, Korea graduated from the GSP systems. In 1988 it graduated from the EU GSP, in 1989 from the US, along with the other Asian tigers, i.e., Singapore, Hong Kong and Taiwan (UNCTAD, 2010), and most recently from Canada's GSP in 2015.

Now Korea aims to contribute to economic development and trade expansion in least-developed countries (LDCs) through its preferential tariff system. Started in 2000, the country's GSP scheme grants preferential tariffs to 48 LDCs: 14 in Asia, 33 in Africa, and one in Central America.[8] As of 2012, it covers 95% of the Harmonized System (HS) six-digit classification. Korea has also eased the GSP value-added rule; the minimum threshold for the input value of the exporting country was lowered from 50 to 40% of the free-on-board (FOB) price of the final product in 2011 (UNCTAD, 2013).

Import tariff rates

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[6] Korea's basic and goods FTAs with Turkey has been effective since 2013, and service and investment agreements was ratified in 2015.

[7] In addition, there are several FTA negotiations that have stalled: Indonesia (since 2014), Japan (since 2008), Mexico (since 2008), and Gulf Cooperation Council (since 2009, including Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates).

[8] See

Table A-2-2. Korea's Trade Agreements and Preferences for the entire list of beneficiaries.

In 2014, Korea was the world's 9th largest importer in merchandise trade (WTO, 2015, p. 44). The country's import tariff level is higher than those of many advanced economies with a similar size of imports, and its Asian competitors such as Japan and China. According to World Bank statistics (Table 2-4), Korea's weighted mean applied tariff rate[9] was 4.8% in 2015, more than three times higher than Japan (1.4%) and even higher than China (3.4%). The US and large European economies have much lower import tariffs (less than 2%). While still comparatively high, applied tariff rates have gone down over the last decade from around 7% in 2005-07.

Table 2-4. Weighted Mean Applied Tariff (%), Selected Countries, 2005-2015

Country	2005	2010	2011	2014	2015
Korea	7.0	7.2	6.5	5.2	4.8
Japan	1.9	1.3	1.3	1.2	1.4
China	4.9	3.7	3.6	3.2	3.4
Germany	1.7	1.6	1.1	1.5	1.6
France	1.7	1.6	1.1	1.5	1.6
Netherlands	1.7	1.6	1.1	1.5	1.6
United States	1.7	1.6	1.6	1.6	1.6

Source: World Bank (2017)

Foreign investment and special economic zones

While Korea's inward FDI has been on the rise, it is still small relative to the size of the country's economy. As of 2016, Korea's inward FDI (stock-based) amounted to 13.2% of the country's GDP.[10] The percentage is low, compared to some other advanced economies where foreign investment plays a much bigger role in the economy.[11] From 1990-2007, FDI's share of GDP was less than one percent (0.7%) (Devlin & Moguillansky, 2011). Recent efforts to help attract more investment include the amendment of the Foreign Investment Promotion Act to simplify FDI registration procedures (UNCTAD, 2017, p. 100).

To attract foreign investment, three types of special economies zones (SEZs) are in operation in Korea: foreign investment zones (FIZs), foreign economic zones (FEZs) and foreign trade zones (FTZs). As summarized in Table 2-5, they share a common goal of increasing Korea's involvement with other countries through investment or trade; however each one has a different mechanism to achieve this. FIZs mainly focus on bringing in foreign firms to an industrial complex or cluster, FEZs have a wider regional development aim and seek to leverage the presence of foreign investors in a wide range of industries, from manufacturing to services, including hospitals, logistics, education, broadcasting, and financial services. Meanwhile, FTZs are dedicated to support export-oriented firms, both foreign and domestic, and enable constituent firms in designated areas to engage in international trade without being subject to customs duties. Eligibility to locate in each type of zone varies, as do the benefits (however, some benefits are common across all three as they are based on FDI-related laws). Also, different institutions are responsible for granting SEZ status and managing each type of zone (see the Appendix for maps

[9] Weighted mean applied tariff is the average of effectively applied tariff rates weighted by the product import shares corresponding to each partner country.

[10] The historical high since 2005 was in 2013 at 13.9%.

[11] Inward FDI, for instance, accounts for 78% of the Netherlands's GDP, 57% in the UK, 31% in the US and 19% in Germany's, according to a UNCTAD statistics.

of FIZs, FEZs, and FTZs). Some benefits are renewable based on the amount of investment and employment created.

Even though Korea has several SEZ options, they have not been the primary locations for foreign investment. In 2004-2014, just 7 percent of firms (749 firms) and 21 percent of a total inflow FDI ($95 billion) were through the SEZs; FIZs led the other two types in both categories (Yang, 2016, pp. 31-32).

Table 2-5. Comparison of FIZ, FEZ and FTZ Regimes in Korea

		Foreign investment zone (FIZ)*	**Free economic zone (FEZ)**	**Free trade zone (FTZ)***
Purpose		Foreign capital inducement, transfer of advanced technologies, job creation	Foreign capital inducement, international competitiveness enhancement, and balanced regional development	Foreign capital inducement, trade promotion, regional development
Eligibility		Foreign-invested firms (min 30% of equity); foreign investment over KRW 100 mil.	Foreign-invested businesses; manufacturing, logistics, hospitals, education facilities, foreign broadcasting, financial service institutions, etc.	Export-oriented domestic or foreign businesses; foreign-invested business; wholesale businesses mainly for import/export; integrated logistics businesses
Related Authority	Designation	Mayor or provincial governor**	MOTIE**	MOTIE
	Management	Industrial complex management authorities	FEZ management authority	MOTIE
Tax Reduction	Qualifications	Manufacturing: US$10 mil or higher Tourism: US$10 mil or higher Logistics: US$5 mil or higher R&D: USD 1 mil or higher		
	Corporate income tax	100% for three years; 50% for the next two years		
	Local tax	Up to 15 years		
	Customs duty	Exempted for five years	Exempted on capital goods for five years	Customs duty withheld (imported goods; capital goods)
Location support	Rent	Approx. 1% of the site value; 75-100% reduction	Approx. 1% of the site value; 50-100% reduction	Approx. 1% of the site value; 75-100% reduction
Year the program started		1994	2002	1970
Locations		24	8	7

Notes: (*) Industrial complex-type; (**) Foreign Investment Committee's deliberation required

Source: KOTRA (2016, pp. 61, 74-75)

2.4. Human Capital: Workforce Development, Education and Labor

The quality of the labor force is considered one of the most important factors in Korea's economic and industrial success. This has been driven by the government's strong commitment to education over the years, through the Ministry of Education (MOE) and the Ministry of Employment and Labor (MOEL). In 2016, Korea had 27 million people in the workforce, with an unemployment rate of 3.7 percent (Statistics Korea, 2016). Korean workers have been known for their diligence and strong work ethic while also working long hours.

In recent decades, workforce composition has significantly changed, potentially influencing the human capital element of the future national economy, and the country's potential to take advantage of new technologies. The total population continues to grow, but the growth rate is stagnating given that fertility rates have hovered around 1.2 for the last five years. Korea, as one of the countries with the world's lowest fertility rates, is confronting an aging workforce with a dwindling number entering the labor market. As post-war baby boomers are retiring with a longer period in post-retirement than their previous generation (due to longer life expectancies), the changing population structure puts constraints on the national social welfare system, with an increasing number of elderly people depending on fewer younger workers. The country's aging index has skyrocketed, from 71 to 99% in 2011-2016. This places increased pressure on the country to seek opportunities to substitute capital for labor to maintain its competitiveness.

Table 2-6. Labor Force Indicators, 2011-2016

By the structure of population	2011	2012	2013	2014	2015	2016
Total population ('000)	49,937	50,200	50,429	50,747	51,015	51,246
Percent distribution (%): 0-14 years old	15.6	15.1	14.7	14.2	13.8	13.4
Percent distribution (%): 15-64 years old	73.4	73.4	73.4	73.4	73.4	73.4
Percent distribution (%): ≥ 65 years old	11.0	11.5	11.9	12.4	12.8	13.2
Dependency ratio (Total)	36.3	36.2	36.2	36.2	36.2	36.2
Aging Index	71.0	76.1	81.5	87.0	93.1	98.6
Total Fertility Rate	1.244	1.297	1.187	1.205	1.239	n.a.

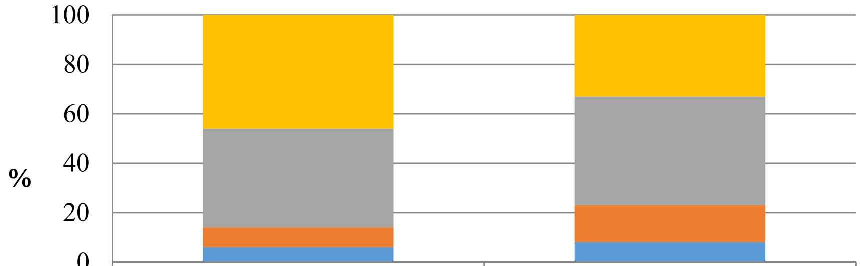
Note: n.a.: not available
Source: Population: Statistics Korea (2016); Statistics Korea (2011-2016): Total Fertility Rate.

Education

Korea is known for its well-established education system as well as a high level of education attainment. The country's school system is structured as follows: primary (six years); secondary (lower-secondary and upper-secondary for three years each); and tertiary (four years) education. Education to the ninth grade (lower-secondary) has been mandatory since 2002. Graduation rates from primary and lower-secondary schools are almost 100 percent.

When compared to the OECD average, Korea excels in educational attainment. As of 2015, 46 percent of Koreans 25-64 years old finished tertiary education and 40 percent completed upper-secondary or post-secondary schools. Combined, 86 percent of the Koreans left the formal education system with a high school diploma or above. The comparable OECD average was 77 percent in 2015, with a lower ratio of colleague graduates than in Korea (see Table 2-7).

Table 2-7. Educational Attainment of Aged 25-64, South Korea and OECD, 2015



	South Korea	OECD
Tertiary	46	33
Upper secondary or post-secondary non-tertiary	40	44
Lower secondary	8	15
Primary or less than primary	6	8

Source: OECD (2016a)

When students graduate from a lower-secondary school, they can choose from several different types of high schools. While many opt for general high schools, others go to vocational schools, which offer specialized education in various areas such as agricultural, technical, commercial, fishery and marine, and home economics, among others. Technical and commercial schools are the two most popular specializations, accounting for 86 percent of vocational high school graduates in 2016 (**Error! Reference source not found.**). While the government has launched several laws and initiatives to support vocational school education, many students are still unwilling to enroll due to deep-rooted prejudices (e.g., they are only for students from poor families), as well as a strong preference to get a college education. The number of graduates from vocational high schools has decreased for three years in a row, and remains lower than 20% that of university programs (see Table 2-8).

Table 2-8. Vocational High Schools Graduates, by Subdivision, 2014-2016

Specialization	**2014**		**2015**		**2016**	
	Graduates	**%**	**Graduates**	**%**	**Graduates**	**%**
Technical	48,162	45.6	45,631	45.2	45,302	45.1
Commercial	43,882	41.6	41,173	40.8	40,919	40.8
Home Economics	7,274	0.9	7,865	7.8	7,878	7.9
Agricultural	5,451	5.2	5,473	5.4	5,350	5.3
Fishery & Marine	843	0.8	799	0.8	849	0.8
Others	-		-		39	0.0
Total	**105,612**	**100**	**100,941**	**100**	**100,337**	**100**

Source: MOE (2014-2016)

Higher education plays a key role in educating people with proper knowledge and skills for the Korean economy and industry increasingly based on advanced technology and requiring higher human capital potential. While the percentage of high school graduates entering college declined from 83% to 71% from 2007-2015 (MOE, 2015a), more Koreans leave schools with a college diploma, compared to the OECD average, as shown above. Korea's top colleges are competitive with globally established higher education institutions. According to the latest rankings (QS, 2016), four Korean colleges were ranked within the world's top 100 universities: Seoul National University (35th), KAIST (46th), POSTECH (83th), and Korea University (98th).

As shown in Table 2-9, approximately 45% of college graduates majored in Science, Technology, Engineering and Math (STEM) fields in 2015, with the largest share coming from engineering (25%). The percentage has been slightly on the rise in recent years. Indeed, the government has encouraged more college graduates in STEM majors by allocating greater resources to those fields of education to meet the industry's high demand. Meanwhile, graduates with humanities and social sciences majors have a difficulty finding a job, indicating a mismatch between student qualifications and skill demand in the market.

Table 2-9. College Graduates by Major, 2012-2015

Majors	**2012**		**2013**		**2014**		**2015**	
	Graduates	**%**	**Graduates**	**%**	**Graduates**	**%**	**Graduates**	**%**
Humanities	52,241	9.2	50,925	9.2	50,051	9.0	53,128	9.2
Social Sciences	163,014	28.8	157,552	28.4	155,559	27.9	159,040	27.6
Education	32,526	5.7	32,590	5.9	32,199	5.8	32,823	5.7
Arts & Physical Education	71,681	12.7	70,612	12.7	71,574	12.8	73,407	12.7
Engineering	138,930	24.5	136,067	24.5	135,797	24.4	141,717	24.6
Natural Sciences	58,861	10.4	58,328	10.5	59,564	10.7	62,138	10.8
Medical & Pharmacy	49,071	8.7	49,068	8.8	52,490	9.4	53,770	9.3
*STEM Subtotal**	*246,862*	*43.6*	*243,463*	*43.8*	*247,851*	*44.5*	*257,625*	*44.7*
Total	**566,324**	**100**	**555,142**	**100**	**557,234**	**100**	**576,023**	**100**

Note (*): total of engineering, natural sciences, and medical & pharmacy graduates.

Source: MOE (2015b); since 2012, MOE provides data on college graduates by major including all types of schools (junior college, university, general graduate school, university of education, industrial university, miscellaneous school, polytechnic college). This covers more types of schools than data prior to 2012 (see below for comparison).

One of the key challenges in Korea's higher education is how to respond to a declining student population for college education. In the past, many high school graduates and a high rate of college entrance supported the growth of higher education. However, as the birth rate continues to fall, some universities and colleges increasingly find themselves with fewer applicants, which could undermine those schools' financial stability. In response, the government is seeking to overhaul the higher education system, which could mean some troubled institutions end up closing. If the current demographic trends continue, the country's higher education is expected to undergo a major structural change in the coming decade.

Minimum Wages and Compensation

In 2017, the legal minimum wage per hour is 6,470 won (US$5.77). It has increased steadily (7-8% each year) over the past four years.[12] An international comparison shows that the annual minimum wage is still slightly lower in Korea, compared to other advanced industrialized economies, as shown in Table 2-10, although wages are virtually on par with those of Japan. Also, in hourly compensation costs for the manufacturing workforce, Korea still belongs to the lower end compared to other developed economies, but the gap has narrowed in some cases.

[12] See Table 2-19 in the Appendix.

Table 2-10. Hourly Compensation Cost and Minimum Wages, International Comparison

Country	Hourly Compensation US$ (Manufacturing)			Min. Wage /Annual (US$)
	2002	2008	2015	2015
Korea	10.2	16.8	22.7	13,668
Japan*	21.5	27.5	23.6	14,347
United States	27.4	32.8	37.7	15,062
United Kingdom	22.0	33.9	31.4	16,994
Germany	27.1	46.8	42.4	24,782
Mexico	5.6	6.2	5.9	1,911
Australia	17.4	35.3	38.8	21,464
France	23.0	41.6	37.6	19,841

Note (*): current annual minimum wage is for 2014 instead of 2015.

Sources: OECD (2015b): Real Minimum Wages; OECD (2015a): Average annual wages; The Conference Board (2015) International Comparisons of Hourly Compensation Costs in Manufacturing.

2.5. Research and Development

Research and development (R&D) has been central to Korea's economic development policies and the positioning of its large firms amongst global leaders over the past few decades. Today, Korea is one of the world's most R&D intensive countries with amongst the highest R&D expenditure as a share of GDP (Deloitte, 2016; WDI, 2017). The country has ranked in the top five highest spenders on R&D for the past decade (WDI, 2017). Manufacturing accounts for 90% of this expenditure (OECD, 2016b). For much of the past two decades, R&D policy has been decentralized with each Ministry pursuing its specific agenda, although prioritization of R&D projects has been carried out by through centralized bodies, including the National Science and Technology Council. As policymakers have shifted their focus towards the creative economy, there have been further attempts to streamline this approach.

The private sector accounts for 75% of R&D spending in the country and of this, the lion's share is accounted for by a small group of very large corporations. A 2006 survey of 12,000 firms with in-house research suggests that large enterprises accounted for 78% of business R&D expenditure (the top five firms[13] representing 45%). Korean firms also rank high globally for R&D spending as a proportion of total revenue (3.4%). As such, the focus of R&D activity in the country is narrow, driven as it is by the commercial strategies of these companies and the product and service markets in which they operate. The government comparatively contributes 23%, with just 0.7% coming from universities and foreign investors alike (OECD, 2016b). Much of the publicly-funded research in the country typically focuses on projects with clear commercial implications, or is spent in public research institutions whose performance is questionable (OECD, 2016b).

Due to manufacturing's dominant share of R&D, these broader national trends are reflected in the sectors' R&D figures. R&D expenditure is concentrated in a small number of manufacturing firms and industries. Large firms accounted for two thirds of R&D spending, while smaller and medium-sized ones made up just one-third. About three-quarters of business-sector R&D is

[13] Samsung Electronics, LG Electronics, Hyundai Motors, Hynix Semiconductors and GM Daewoo Auto and Technology.

carried out in high and medium-high technology manufacturing industries; out of these three-quarters, 80% was concentrated in two sectors, ICT and automobile, one of the highest rates for OECD countries (Mittelstädt & Cerri, 2008).

R&D expenditure in the services sector, on the other hand, is comparatively very low. In 2001 and 2002 the proportion of service-sector enterprises engaged in innovation activity was 25%, well below the EU average of 40% (Mittelstädt & Cerri, 2008). By 2015, the services sector only accounted for 7% of national public and private R&D spending (OECD, 2016b).

Table 2-11. Korea's R&D Investment Trend

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Government R&D budget	7.8	8.9	9.8	11.1	12.3	13.7	14.9	16.0	16.9	17.8	18.9
Total R&D expenses	24.2	27.3	31.3	34.5	37.9	43.9	49.9	55.4	59.3	-	-
(Relative to GDP, %)	2.63	2.83	3.0	3.12	3.29	3.47	3.74	4.03	4.15	-	-

Source: KIET (2015), TBL5.2 p. 306, source: e-country index (www.index.go.kr); Unit: trillion won

ADB ranked Korea second (behind Japan) among Asian countries, and third overall on its 'Creative Productivity Index' – its measure of the efficacy with which countries transform creative inputs into outputs such as patents per capita, published scientific papers and export sophistication. But despite these accolades, Korea still spends more on importing intellectual property (IP) than it makes from exporting its own (Ellis, 2014). Korea had a deficit for IP use of -US$4.39 billion, whereas Japan had an IP royalty surplus of US$9.5 billion.

Box 2-2. Korea's Core Technologies Policy

In Korea, the "Act on Prevention of Divulgence and Protection of Industrial Technology" (KLRI, 2016a) plays a central role in ensuring core technologies, developed by government funding, remain strictly controlled. It was first issued as Act No. 8062, Oct. 27, 2006, and the current version is Act No. 14108, Mar. 29, 2016. Articles 9-11 on national core technology, pertains to the list of products developed using Government R&D where the government must give permission to export or offshore.

Table 2-12. Korea: National Core Technology Areas, 2007-2016

Area/Number	2007	2010	2011	2012	2013	2015	2016
Total	**40**	**49**	**50**	**58**	**55**	**47**	**61**
Electronics & Electrical (E&E)	4	5	5	8	11	11	11
Car/Railroad	8	8	8	8	8	7	8
Steel	6	6	6	6	6	6	6
Machines/Robots	--	--	--	--	--	--	9
Shipbuilding	7	7	7	7	7	7	7
Nuclear Power	4	4	4	4	4	3	5
Telecommunications	6	11	12	17	14	8	8
Space	5	5	5	5	2	2	4
Biotechnology	--	3	3	3	3	3	3

Source: KLRI (2016b)

The purpose of the Act is to protect industrial technology by preventing undue divulgence to strengthen the competitiveness of Korean industries and contribute to national security and development of the national economy. Defined in Article 9, a "national core technology" has high technological and economic value in the Korean and foreign market or enables high growth potential for its related industries, and could exert a significant adverse effect on national security and the development of the national economy if it is divulged abroad. In 2007 there were 40 technology areas and 61 in 2016. Electronics and electrical is the area with the highest number (11), whereas areas such as cars/railroads, steel and shipbuilding have maintained the number throughout the time frame. New areas include machines/robots and biotechnology.

2.6. Other Areas Supporting Economic Growth

Corporate taxation

Tax rates play an important role regarding foreign and domestic investments. In Korea, national taxes are collected by the National Tax Service (tax office) and the Korea Customs Service (customs office) to finance the central government. There are four types of direct taxes: income tax, corporate income tax, inheritance tax, and gift tax (KOTRA, 2016, pp. 102-103).
For businesses, the most relevant is corporate income tax, which is levied on the income of businesses. The tax rates, as listed in Table 2-13, vary by the amount of corporate income. Additionally, 10% of the corporate income tax is imposed as a local corporate income tax. While it is not simple to compare tax rates internationally, Korea's top rate of 24.2% for the highest bracket (including corporate local income tax) is slightly lower than the average of OECD countries (24.8%) but higher than the global average of 23.6% in 2016, according to the KPMG Corporate Tax Rate Table (KPMG, 2016).

Table 2-13. Basic Tax Rates for Corporate Income

Tax bracket	**Corporate income tax rate**
≤ KRW 200 million	10%
> KRW 200 mil ≤ 20 billion	KRW 20 million + 20% of amount exceeding KRW 200 million
> KRW 20 billion	KRW 3.98 billion + 22% of amount exceeding KRW 20 billion

Source: KOTRA (2016, p. 105); incomes greater than KRW 200 million pay a fixed and variable amount.

Access to finance

Access to affordable finance is important for entry and upgrading, as firms need to have working capital available to purchase intermediate inputs and for longer-term investments in machinery and equipment. The country's financial institutions, notably the Bank of Korea (BOK) and the Korean EXIM Bank, play an important part in providing access to capital for domestic and foreign businesses. Interest rates in Korea fluctuated during the economic crisis, but have gone down over the last decade. The BOK base rate, which is a basis for the interest rates banks charge on loans, dropped from 5% in 2007 to 1.25% in 2016 (Table 2-14).

Table 2-14. Bank of Korea Base Rate, 2007-2016

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Rate (%)	5.00	3.00	2.00	2.50	3.25	2.75	2.50	2.00	1.50	1.25

Source: BOK (2007-2016a)

Reflecting this trend, bank interest rates on various forms of corporate loans have gone down, especially over the last five years. In 2015, the average interest rates for corporate loans were 3.7% per annum, nearly half of the 2008 rate (Table 2-15).

Table 2-15. Interest Rates on Bank Loans, Annual Percentage, 2007-2015

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Corporate loans, overall	6.60	7.17	5.65	5.56	5.86	5.49	4.74	4.39	3.69
Large-size firms	6.09	6.79	5.61	5.25	5.50	5.18	4.46	4.10	3.40
SMEs	6.72	7.31	5.65	5.68	6.00	5.66	4.92	4.60	3.87

Source: BOK (2007-2016b)

Exchange rates

Korean firms' export performance is strongly affected by exchange rates in major currencies, notably the US dollar, Japanese yen, and European Union euro. A weak dollar or euro against the Korean won (KRW) undermines Korean exporters' price competitiveness in a respective import market and *vice versa*. Also, a weak Japanese yen against the US dollar or euro can affect Korean firms competing with Japanese firms in the U.S. or EU market because it relatively improves Japanese firms' price competitiveness in a respective market compared to that of Korean exporters. Table 2-16 shows KRW exchange rates to major currencies in 2011-2016.

Table 2-16. Korean Won Exchange Rates to US Dollar, Japanese Yen and Euro, 2011-2016

	2011	2012	2013	2014	2015	2016
USD (won/1$)	1,108.1	1,126.9	1,095.0	1,053.2	1,131.5	1,160.5
JPY (won/100 yen)	1,391.3	1,413.1	1,123.4	996.2	934.6	1,068.2
EURO (won/1 euro)	1,541.4	1,448.2	1,453.6	1,398.8	1,255.2	1,283.3

Source: BOK (2011-2016)

Infrastructure

Korea is considered to have overall well-developed infrastructure. According to the *Global Competitiveness Report* by the World Economic Forum (WEF, 2016), the country ranked 10th in the world out of 138 countries in terms of the quality of infrastructure. Korea is particularly strong in railroad and fixed telecommunication (WEF, 2016, p. 224). The Ministry of Land, Infrastructure and Transport (MOLIT) is in charge of matters pertaining to this area.

Table 2-17. Korea: Quality of Infrastructure, 2015

Items	Score (1-7)	Rank
Infrastructure (overall rating)	6.0	10
Quality of overall infrastructure	5.6	14
Quality of roads	5.6	14
Quality of railroad	5.5	9
Quality of ports	5.2	27
Quality of air transport	5.7	21
Quality of electricity supply	6.2	29
Available airline seat kilometers (millions/week)	2,631.0	18
Mobile-cellular telephone subscriptions (per 100 population)*	118.5	64
Fixed telephone lines (per 100 population)	58.1	4

Source: WEF (2016); Note (*):is greater than 100 in countries where people have multiple phones or subscriptions.

2.7. Comparison with China

Economic Planning in China

China has been shaping its significant strategies on economic development in five-year development plans since the first plan was released covering 1953-1957, and the country is now within its 13th five-year plan (2016-2020). Table A-2-4 in the Appendix for a short description of each plan.

- **National Level:** the National Development and Reform Commission (NDRC) writes the FYP. The FYP is approved at/by the National People's Congress.
- **Provincial Level:** The People's Congress of four special municipalities (Beijing, Shanghai, Chongqing, Tianjin) and provinces approve their own FYPs which are drafted based on the goals of the national FYP and the provincial stage of development (e.g., Beijing issued the 13th FYP on March 24, 2016).
- **City Level:** Cities issue their own FYPs based on provincial level goals and their own development conditions (e.g., Wuhan, capital of Hubei, issued its 13th FYP in Jan. 2017).

What it is: China's five-year plans outline national economic and social development goals with special emphasis on arranging key infrastructure projects, managing the distribution of productive forces, and analyzing the private sector contributions to the national economy (Galloway 2011).

Background: When the PRC was established in 1949, it took about two years to start economic rehabilitation and to bring the economy under central control. With embryonic government agencies to start the process of central planning, China looked to the Soviet Union for inspiration. China began its first five-year plan in 1953.

Process to create: Every FYP, which is based on the evaluation of outcomes of the previous FYP, takes two years to prepare and write up. The first step is to finish and approval guidelines of the five-year plan. Once every five years, the party's decision-making Central Committee holds a plenum to draw up guidelines for the draft of the five-year plan before planners from central government ministries and agencies and regional governments begin to work out detailed targets and policies. The second step is to write up and pass the final document. Under the direction of the party-approved guidelines, the State Council is responsible for the draft of the final document, which is tabled and debated at the annual session of the National People's Congress in the spring of the following year.

Content of the plans: The document, which generally is about 100 pages, lists the government's main policy goals, including **qualitative aims** such as promoting coordinated regional development and social harmony. It also contains dozens of **quantitative targets**, such as ones for economic growth, exports, direct foreign investment and job creation. A budget is made every year during the plans.

China and Korea Comparison

While Korea's five-year planning process started approximately a decade after China, the scope of the plans has been quite similar although the approach has been different. Both countries placed an early emphasis on developing ‘heavy industries’; however, in China this focused more on material inputs (iron and steel) and infrastructure/construction markets whereas Korea focused on commercial sectors (shipbuilding and automotive) earlier on. Both countries also used light industries to increase export opportunities, but Korea’s foray in light industries was much shorter than China’s. Both countries placed an emphasis on electronics (with Korea nearly a decade before China), although in the 2000s China made a significant push to grow the broader ‘information industry’ with a strong emphasis on the service side of IT-development. Over the last decade, China’s and Korea’s plans share many of the same focus areas and layout (for example, Korea identified 19 future growth engines in 2016, and China outlined nine manufacturing industries and seven new targets in 2011). China has also placed focus on creating and fulfilling domestic market demand, but this strategy has less application for a country the size of Korea.

Three areas of importance in China’s plans that differ from Korea include continued introduction of new industries (including service industries) with specific targets for each, continued focus on *strategically* engaging with foreign entities (inward investment, outward investment, exports, and R&D), and business and consumer adoption of IT products and services. Whereas Korea has focused on creating a few global lead firms in select industries (electronics, automotive), China engaged in GVCs by effectively and efficiently coordinating supply chains across multiple industries for foreign lead firms, often via Hong Kong or Taiwanese investors. This supply chain integrator model was an early manufacturing-based version of the platform technology providers referenced in the first chapter. While notable platform providers in ‘Industry 4.0’ today are often B2C or C2C service providers, the concept of building a company around ‘convening different groups’ originated in manufacturing by intermediaries that brought together firms from different segments of the value chain (B2B) (for example, Li & Fung is the most recognized example). Given that many of China’s companies across industries have been accustomed to working with a platform model for decades, this perhaps makes for an easier transition to developing and adopting new business models.

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Appendix

Table A-2-1. Key Institutional Actors, Korea

Name	Abbreviation	Focus	Est.	Description	Website
Ministry of Trade, Industry and Energy	MOTIE	Trade, industry, commerce and energy	2013/ 1948	Top priority is creating new value and future growth engines for Korean industries, while overcoming export difficulties by helping pioneer new and promising markets overseas. Focusing on establishing a good environment to do business and create jobs through regulatory reform as well as a stable and safe energy supply and demand system. Started as the 1948 as the Ministry of Trade and Industry (MTI).	http://english.motie.go.kr/
Ministry of Strategy and Finance	MOSF	Macroeconomic policy, budget	2008	Main tasks: macroeconomic policy formulation, policy coordination, taxation and budgeting, fiscal planning and management, public institution oversight, international finance, and multilateral/bilateral economic cooperation	http://english.mosf.go.kr/
Ministry of Foreign Affairs	MOFA	Foreign affairs	1948	Establishes and carries out foreign policies, economic diplomacy and economic cooperation, takes part in international economic communities, administers treaties and international agreements, protects and supports overseas Korean nationals, promotes cultural cooperation, and analyzes international affairs.	www.mofa.go.kr/ENG
Ministry of Education	MOE	Education	1948	Guides national education and establishes sound education policies with goal to produce talent that generates creative ideas and knowledge.	http://english.moe.go.kr/
Ministry of Employment and Labor	MOEL	Labor	1948	Responsible for establishing and coordinating employment and labor policies, employment insurance, vocational skills development training, equal employment, work-family balance, labor standards, workers' welfare, industrial relations adjustment, cooperation between labor and management, occupational safety and health, industrial accident compensation insurance, and other employment and labor-related affairs.	www.moel.go.kr/english
Ministry of Land, Infrastructure and Transport	MOLIT	Infrastructure	1948	Responsible for strengthening residential stability of low- and middle-income households, creating a strongly competitive and regionally balanced territory, providing efficient, safe and convenient transport services, and implementing regulatory reform to create jobs and improve national competitiveness.	http://english.molit.go.kr/
Ministry of Science, ICT and Future Planning	MSIP	Science, ICT, Planning	2013	Established as part of a government reorganization; spreads the vision for the creative economy based on a spirit of creativity and challenge. It supports its foundations by making continuous innovations in the fields of science, technology and ICT and aims to boost growth through convergence.	http://english.msip.go.kr/english/main/main.do
Korea Institute of S&T Evaluation and Planning	MSIP: KISTEP	S&T	1999/ 1987	Early foundations date back to 1987 when established as CSTP, an affiliated organization of KIST. In 1993, reorganized and renamed it STEPI, and since 1999 it has been known as KISTEP. It became a part of MSIP in March 2013.	www.kistep.re.kr/en/index.jsp
Small and Medium	SMBA	SMEs	1996	Primary goals: creating jobs through promoting start-ups and venture companies' growth, enhancing technological competitiveness to create new growth engine	www.smba.go.kr

Name	Abbreviation	Focus	Est.	Description	Website
Business Administration				for the future, supporting SMEs management through providing funds, human resources and market, encouraging invigoration of economic base to promote mutual growth, and generating policy environment friendly for SMEs.	
Bank of Korea	BOK	Central Bank	1950	The primary purpose is the pursuit of price stability. The Bank sets a price stability target in consultation with the Government and draws up and publishes an operational plan including it for monetary policy. Performs typical functions of a central bank: issuing banknotes and coins, formulating and implementing monetary and credit policy, serving as the bankers' bank and the government's bank. BOK undertakes the operation and oversight of the payment and settlement systems, and manages foreign exchange reserves.	www.bok.or.kr
Export-Import Bank of Korea	KEXIM Bank	Trade support	1976	Facilitates the development of Korea's economy and enhance economic cooperation with foreign countries through the provision of financial supports for export and import transactions, overseas investments projects, and the development of overseas natural resources	https://www.koreaexim.go.kr
Korea Employers Federation	KEF	Employers' organization	1970	Focused on building harmonized industrial relations and economic development. KEF's goals are restructuring the labor market structure to be future-oriented, contributing to job creation through balanced development in manufacturing industry and service industry, enhancing competitiveness of industrial relations to be a higher level, and becoming an economic organization to lead changes and innovations of companies.	www.kefplaza.com
Korea Federation of SMEs	Kbiz	Employers' organization	1962	Aims to improve the economic status and support equal opportunities for Korean SMEs. Addressing a rapidly changing global economy through making proposals on government policies, while providing support for SMEs to enhance competitiveness. As supporting SMEs' overseas marketing by participating in foreign exhibitions, dispatching overseas business delegations, and providing information concerning FTAs.	https://www.kbiz.or.kr
Federation of Korean Trade Unions	FKTU	Workers' organization	1960	Committed to implementing important global issues such as climate change, green jobs and sustainable development in close cooperation with the International Trade Union Confederation (ITUC), the Trade Union Advisory Committee to the OECD and the Global Union Federations (GUFs). Also promoting the role of labor diplomacy by strengthening solidarity and regular exchanges with workers' national centers across the globe.	http://fktu.or.kr
Korean Confederation of Trade Union	KCTU	Workers' organization	1995	In its efforts and struggles to realize its values and principles, the KCTU is committed to the political empowerment of working people and workers participation in the institutions of decision-making in all spheres of the political, social, and economic life. Committed to realizing the reunification of Korea on the basis of the principle of national sovereignty, independence, and peace.	http://kctu.org/

Sources: Ministries' and organizations' websites (see above)

Table A-2-2. Korea's Trade Agreements and Preferences

Regional Agreements	Bilateral FTAs	Generalized System of Preferences (GSP) Beneficiary Status	GSP status granted in Korea
EFTA (Sept. 2006 in effect; Jan. 2005 negotiation started); ASEAN (Sept. 2009 in effect; Feb. 2005 negotiation started); EU (Dec. 2015 in effect; May 2007 negotiation started)	Chile (2004); Singapore (2006); India (2010); Peru (2011); United States (2012); Turkey (2013, basic and goods trade agreements); Australia (2014); Canada (2015); China (2015); New Zealand (2015); Vietnam (2015)[14]; Columbia (2016)	Australia, Belarus, Kazakhstan, Norway (GSP only, not GSP+), Russian Federation.	48 least developed countries (see Note)

Note: EFTA (European Free Trade Association; 4 countries; Iceland, Liechtenstein, Norway, and Switzerland); ASEAN (Association of Southeast Asian Nations; 10 countries; Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam); EU (European Union; 28 countries; Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom);

The beneficiaries of Korea's GSP scheme include: ***Asia*** (14): Afghanistan, Bangladesh, Bhutan, Cambodia, Kiribati, Lao People's Democratic Republic, Myanmar, Nepal, Samoa, Solomon Islands, Timor-Leste, Tuvalu, Vanuatu and Yemen; ***Africa*** (33): Angola, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Guinea Bissau, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Somalia, Sudan, Togo, Uganda, United Republic of Tanzania and Zambia; ***America*** (1): Haiti.

Sources: FTAs -- http://fta.go.kr/main/situation/kfta/ov/

GSP – UNCTAD (2015).

Table A-2-3. Korea: Hourly Minimum Wages, 2010-2017

	2010	2011	2012	2013	2014	2015	2016	2017
Hourly minimum wage (KRW)	4,110	4,320	4,580	4,860	5,210	5,580	6,030	6,470
Increase rates (%)	2.8	5.1	6.0	6.1	7.2	7.1	8.1	7.3

Source: MWC (2015)

[14] Reason to have a separate FTA with Vietnam beyond the ASEAN agreement: According to the government FTA website, the Korea-Vietnam FTA provides a higher level of investment liberalization and investor protection than the ASEAN FTA. Also, it contains clauses regarding cooperation in cultural service, with a higher level of IPR protection, reflecting the increasing bilateral trade of cultural content. It was motivated by the Japan-Vietnam FTA (2009), which put Korean firms in a disadvantageous position over the Japanese in the Vietnamese market.

Table A-2-4. China's Five-Year Plans (FYP): General Economic Development: 1953-2020

Name (Leader)	Description	Time	Focus/Impact
1st FYP (Mao)	To concentrate efforts on the construction of 694 large and medium-sized industrial projects, including 156 with the aid of the Soviet Union, to lay that the primary foundations for China's socialist industrialization; to develop agricultural producers' cooperatives to help in the socialist transformation of the agriculture and handicraft industries.	1953-1957	Heavy industries: iron, steel, coal mining, cement production, electricity generation, machine building; agriculture
2nd FYP: Great Leap Forward (Mao)	(1) Continue focus on heavy industry, (2) consolidate and enlarge the shares of collective ownership and ownership by the people; (3) further boost industry, agriculture, handicrafts, transportation and commerce; (4) cultivate talent, strengthen scientific R&D to fill needs of economic and cultural development.	1958-1962	Heavy industries, agriculture; national defense
3rd FYP	Strengthen national defense, and endeavor to make breakthroughs in technology; support agriculture; enhance infrastructure, continue to improve production quality, increase production variety and quantity; build an economy of self-reliance, and develop transportation, commerce, culture, education and scientific research.[15]	1966-1970	National defense; infrastructure; agriculture; **science and technology**
4th FYP	Goal: average annual growth rate of gross output value of industry and agriculture 12.5%; 130 billion yuan budgeted for infrastructure construction within five years (US$62.5 billion).	1971-1975	Infrastructure; commodities
5th FYP: (Xiaoping)	Actual timeframe for the 5th FYP was three years, 1978 to 1980.[16] Two key differences are the introduction of the one child policy and market reforms that initiated a gradual movement away from the Soviet-style command economy. **Outcome:** GDP growth rate 6.5%[17]. In April 1979, formally put forward new principles of readjustment, reform, rectification and improvement.[18]	1976-1980	One child policy Allowed FDI (1979) Set up SEZs (1980)
6th FYP[19]	Mandatory targets for production and investment were removed. **Goals:** 2). Keep supply and quality of consumer products in line with growth of purchasing power and changes in consumption structure; keep market prices stable. 3). Cut down material consumption, particularly energy, and keep production in line with the availability of resources. 4). Encourage and implement enterprise technological updating, with energy savings as a priority, and gather capital necessary to strengthen key projects 5). S&T research and promote application of new technologies; 8). Develop trade, make effective use of foreign capital and actively introduce advanced technology to meet domestic needs. 9). Control population growth, 10). Strengthen environmental protection efforts. **Outcomes:** Total investment in fixed assets for publicly-owned enterprises reached **530 billion yuan (US$254 billion).** Foreign trade and technological exchange entered a new phase. China rose from the No.28 global exporter in 1980 to No.10 in 1984.	1981-1985	Light Industries (incl. **T&A**); national defense; first FYP that took economic and social development simultaneously into consideration
7th FYP	4) Adapt to the changing structure of social demand and the demands of economic modernization, and to further adjust the industrial structure; 5) Regulate fixed asset investments, readjust the investment structure, and speed up the construction of the energy, communications, telecommunications and raw materials industries; 6) Shift focus to	1986-1990	Product quality; improve technology of existing firms

[15] www.china.org.cn/english/MATERIAL/157608.htm
[16] http://dangshi.people.com.cn/GB/151935/204121/205062/12925543.html
[17] http://baike.baidu.com/item/%E7%AC%AC%E4%BA%94%E4%B8%AA%E4%BA%94%E5%B9%B4%E8%AE%A1%E5%88%92
[18] www.china.org.cn/english/MATERIAL/157615.htm
[19] www.china.org.cn/english/MATERIAL/157619.htm

Name (Leader)	Description	Time	Focus/Impact
	technical updating, reforming and extending of existing enterprises (instead of new ones); 7) Further development of science and education; 8) Open further to outside world, combining domestic economic growth with **expanding external economic and technologic exchanges**.[20] **Outcome**[21]: GDP growth rate 7.9%. International trade $115.4 billion, surpassed expected $84 billion.		
8th FYP	Optimize industrial structure; strengthening agriculture, basic industry and infrastructure, improve processing industry; give priorities to science, technology and education. Transform economic development through quality of labor and technological progress. Increase exports, introduce advanced technology; **make use of FDI efficiently and rationally.** Develop costal regions' economy.[22] **Outcome: Total investment in fixed assets during this time was 3.89 trillion yuan (US$606 billion).** More than 1,100 cities at county level were opened to the outside world; 13 bonded zones and other zones set up.[23]	1991-1995	**Electronics** (especially ICs in large scale and computer), tourism, construction; significant transportation infrastructure investment; EPZs
9th FYP[24]	Called for the introduction of private property and corporation laws (Galloway 2011). The nine major principles are as follows (Peng, 1996) energetically promote a shift in the mode of economic growth by making higher economic returns the focus in our economic work; help forge close ties between science, technology, education and economy; give top priority to agriculture in national economic development; **focus on the reform of SOEs as being central to economic restructuring**; open up to the outside world; integrate the market with macro-control holistically and give proper guidance, **protection** and full play to the initiative of the various parties concerned; stick to coordinated economic development among different areas and gradually narrow the gaps between them; **Outcomes**[25]: Most key SOEs were converted into corporations. Reform of the foreign trade system progressed, and an export-oriented economy grew rapidly. China's total exports: **US$249.2 billion in 2000**, a rise of 67% over 1995.	1996-2000	Agriculture, machine-building, **electronics**, petrochemicals, automobiles, construction. Light industry and **textiles** for domestic demand, **expanding exports**. Improve product quality, increase variety thus enhancing product competitiveness (Peng, 1996).
10th FYP: Western and Central Region Development	In 2001, China joined the WTO. Main policies: (1) develop infrastructure (transport, hydropower plants, and telecommunications), such as the "West-East Gas Pipeline" and Qinghai-Tibet Railway (Beijing to Tibet); (2) adjustment of industrial structure; and (3) deepening the reform and increasing openness of the economy to entice **foreign investment to the western region.** **Focus**[26]: Achieve an average annual economic growth rate of 7%; increase the number of urban employees and surplus rural laborers transferred to the cities to 40 million each, thereby controlling registered urban unemployment rates at about 5%. **Optimize and upgrade the industrial structure**, and strengthen China's international competitiveness. Improve the national economy and social IT levels. Kick-start the operations of more infrastructure facilities. **Bring the development disparity between regions under effective control**, and raise levels of urbanization. Raise R&D funding to more than 1.5% of	2001-2005	**Information Industry;** covers two broad sectors, telecommunications and IT/electronics. Information industry will grow three times the rate of the national economy. **In 2005:** value added will be >7% of GDP; **electronics and IT products will be 30% of total exports;** Info

[20] www.china.org.cn/english/MATERIAL/157620.htm
[21] www.hprc.org.cn/gsyj/jjs/jjszht/201211/P020121129394287501115.pdf
[22] www.ndrc.gov.cn/fzgggz/fzgh/ghwb/gjjh/200709/P020070912638554392927.pdf
[23] www.chinadaily.com.cn/china/2013npc/2011-02/23/content_16261368.htm
[24] www.chinadaily.com.cn/china/2013npc/2011-02/23/content_16261367.htm
[25] http://en.people.cn/features/lianghui/2001030600A185.html
[26] www.china.org.cn/english/MATERIAL/157629.htm

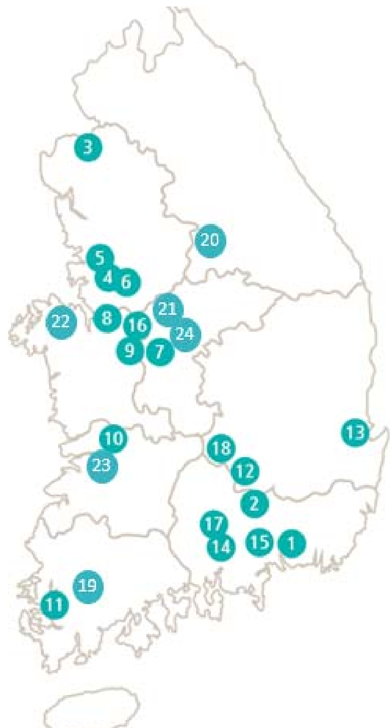
Name (Leader)	Description	Time	Focus/Impact
	GDP, and strengthen sci-tech innovation capabilities, thereby speeding up technological progress (Rongji, 2005).		industry to become the leading industry, and China's largest (UNPAN, 2005,).
11th FYP:[27, 28] (Jiabao)	National economy is expected to grow at an annual average rate of 7.5%. Breakthroughs in reform and institutional building of areas such as administrative governance, SOEs, taxation, finance, S&T, education, culture and public health. Opening to the outside world and domestic development will be further balanced. **Promote development by relying on the expansion of domestic demand, take the expansion of domestic demand, especially consumption, as a major driving force.** Shift economic growth from relying on the input of capital and substance factors to relying on S&T advancement and human resources.	2006-2010	Focus on **strengthening industry,** rather than increasing scale. Strengthen **service industries. Self-innovation** and training of talent are also prominent[29]
12th FYP (Jintao)	Restructure economic strategies and emphasize technological advancement and innovation as the pivot of economic development. One of the top priorities is to accelerate the building of a resource-saving and eco-friendly society through stepping up environmental protection efforts. The share of the service sector in China's GDP should rise to 47% in 2015.[30] **One child policy repealed** GDP to grow 7% per annum in real terms. Major breakthroughs in seven strategic new industries (called for utilization of national resources to capture the frontiers in these industries). **Strategic New Industries:** (1) energy savings and environmental protection, (2) **New Generation of IT[31]**, (3) biology, (4) high-end equipment manufacturing, (5) new energy, (6) new materials, and (7) energy-powered automobiles.	2011-2015	**Key Manufacturing Industries** (Gang and Liping 2013): (1) Equipment making; (2) Shipbuilding, (3) Automobiles; (4) Metalmaking and Building Materials; (5) Petrochemicals; (6) Textiles and Light Industry; (7) Packaging & Paper; (8) Electronic information; (9) Construction.
Made in China 2025 Plan & Internet Plus Plan	**Internet Plus Plan:** Capitalize on China's huge online consumer market and optimize manufacturing, finance, healthcare, and government; aimed at building up the country's domestic mobile Internet, cloud computing, big data, and IoT sector firms and creating global competitors by **assisting domestic firms' expansion abroad.** Accelerate transition to higher-value-added, intelligent manufacturing by focusing on emerging industries. Government fund: 40 billion yuan for emerging industries (US$6.4 billion)[32]	2015	Innovation and upgrading in emerging industries, such as high-end equipment, **ICs,** biomedicine, cloud computing, mobile Internet, and e-commerce.
13th FYP (Jinping)	Continues shift from 11th FYP **away from infrastructure and export-led growth and toward more consumption-led, higher-value-added growth. Innovation-driven developmen**t. Seeks to use innovation to accelerate efforts to move manufacturing up the value-added chain, reestablish China as a global center of innovation and technology, and ensure long-term productivity. By 2020, increase global innovation rank from 18 to 15, raise R&D spending as a percent of GDP from 2.1 to 2.5,	2016-2020	**Higher-Value-Added Manufacturing**. Reiterates support for "Made in China 2025" and "Internet Plus" initiatives as

[27] www.gov.cn/english/special/115y_index.htm
[28] http://en.ndrc.gov.cn/newsrelease/200603/t20060323_63813.html
[29] www.chinadaily.com.cn/bizchina/2006-03/07/content_585089.htm
[30] http://english.gov.cn/12thFiveYearPlan
[31] Chinese firms should catch up with the world frontiers in technology and applications and build up their own capacity and networks for all major new generation IT breakthroughs.
[32] Li Keqiang, Report on the Work of the Government (Third Session of the 12th National People's Congress, Beijing, China, March 5, 2015. http://online.wsj.com/public/resources/documents/NPC2015_WorkReport_ENG.pdf

Name (Leader)	Description	Time	Focus/Impact
	the number of patents filed per 10,000 people from 6.3 to 12. Expand **Internet usage**; increase fixed broadband household penetration ratio from 40% in 2015 to 70% in 2020 and mobile broadband subscriber penetration ratio from 57% to 85% by 2020.[33] Aligns with the broader push to leverage interconnectivity and data from the Internet to optimize manufacturing, finance, healthcare, and government (CTB, 2016). Improve rural Internet access to increase China's consumer base.		key policies to move up the value-added chain.

Sources: authors; based on Frederick (2017); other sources within table.

Figure A-2-1. Complex-type Foreign Investment Zones (FIZs)



1 Jisa Foreign Investment Zone
2 Dalseong Foreign Investment Zone
3 Dangdong Foreign Investment Zone
4 Oseong Foreign Investment Zone
5 Jangan High-tech Foreign Investment Zone 1
6 Jangan High-tech Foreign Investment Zone 2
7 Ochang Foreign Investment Zone
8 Inju Foreign Investment Zone
9 Cheonan Foreign Investment Zone
10 Iksan Foreign Investment Zone
11 Daebul Foreign Investment Zone
12 Gumi Foreign Investment Zone
13 Pohang Foreign Investment Zone
14 Changwon Foreign Investment Zone
15 Busan Mieum General Industrial Complex
16 Cheonan Foreign Investment Zone 5
17 Sacheon Foreign Investment Zone
18 Gumi (Parts) Foreign Investment Zone
19 Woljeon Foreign Investment Zone
20 Munmak Foreign Investment Zone
21 Jincheon-Sansu Foreign Investment Zone
22 Songsan Foreign Investment Zone 2
23 Nat'l food industry complex
24 Chungju Foreign Investment Zone

Source: Invest Korea (2016a); www.investkorea.org/en

[33] Xinhua, "China to Invest 1.2 Trillion Yuan in Information Infrastructure," China Daily, January 13, 2017.

Figure A-2-2. Free Economic Zones (FEZs) in Korea

FEZs	Sector focus
Chungbuk FEZ (CBFEZ)	Information technology, bio-medical, complex aerospace
East Coast FEZ (EFEZ)	High-tech green material, tourism and leisure, logistics and business service
Yellow Sea FEZ (YESFEZ)	Advanced technology, added-value logistics
Saemangeum-Gunsan FEZ (SGFEZ)	Knowledge creative and eco-friendly, future-oriented new industry, tourism and leisure
Daegu-Gyeongbuk FEZ (DGFEZ)	Knowledge-based industry
Gwangyang Bay Area FEZ (GFEZ)	Future new industry, cultural tourism, steel, petrochemical, parts and materials, logistics, tourism
Busan-Jinhae FEZ (BJFEZ)	Port logistics, advanced technology, international business and resort.
Incheon FEZ (IFEZ)	Business information technology-bio-technology, logistics, tourism, business service & finance, tourism & leisure, advanced industries

Source: Invest Korea (2016b); www.investkorea.org/en

Figure A-2-3. Free Trade Zones (FTZs) in Korea

FTZs	Sector Focus
Masan FTZ	Electric and electronic, precision equipment, metal, textile & clothing
Yulchon FTZ	New material and information technology, fine chemical and steel
Daebul FTZ	Shipbuilding and new and renewable energy
Gimje FTZ	High-tech industry
Gunsan FTZ	Automobiles, metal and machinery
Donghae FTZ	Displays, machinery and chemical
Ulsan FTZ	Shipbuilding, offshore plants, automobiles and machinery

Source: Invest Korea website (http://www.investkorea.org/en)

Chapter 3: Korea and the Electronics Global Value Chain[1]

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[1] Chapter prepared by Stacey Frederick and Joonkoo Lee.

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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.

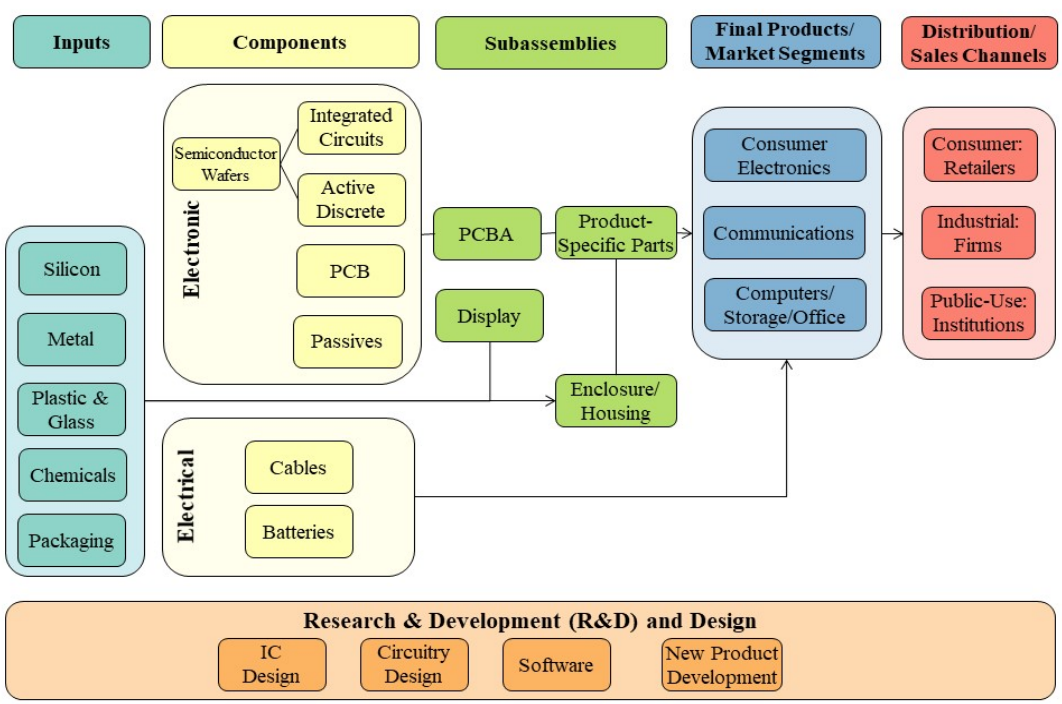
3.1. The Electronics Global Value Chain

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.

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[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

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

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

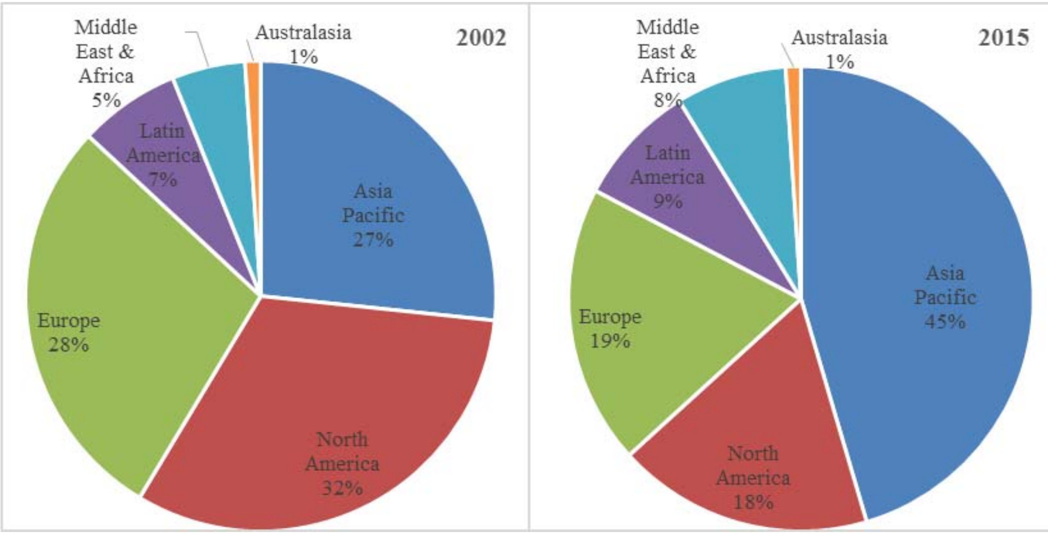
Reporter	Export Value ($, US Billions)			Country Share of World Exports (%)			Change (%)
	2000	2007	2014	2000	2007	2014	2000-14
World	**433**	**747**	**1,006**				**132%**
China	28	228	405	6%	31%	40%	1339%
EU-15	143	165	139	33%	22%	14%	-3%
US	53	54	74	12%	7%	7%	41%
Hong Kong	18	38	65	4%	5%	6%	259%
Mexico	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.

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[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

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[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

<table>
<tr><th>Categories</th><th>Capabilities/Tiers</th><th>Countries</th><th>End Markets</th></tr>
<tr><td>Production Equipment</td><td>--</td><td>Japan, Europe, US</td><td>--</td></tr>
<tr><td rowspan="2">Component suppliers: Semiconductors</td><td>A&T</td><td>Philippines, Malaysia, Thailand, Taiwan (esp. SATS)</td><td>--</td></tr>
<tr><td>Wafer fabrication; IC design and/or R&D</td><td>Taiwan, Singapore, China, Korea, US, Malaysia</td><td>--</td></tr>
<tr><td>Displays</td><td></td><td>Korea, China</td><td>--</td></tr>
<tr><td>HDD</td><td></td><td>Singapore, Philippines</td><td>--</td></tr>
<tr><td rowspan="4">EMS/
Tier 1 MNC Branch Plants</td><td>Regional</td><td>For US: Mexico
For Western EU: Hungary, Poland, Czech Republic, Germany, Romania
For China: China</td><td>All</td></tr>
<tr><td>Global: Tier 3</td><td>Laos, Myanmar (very recent)
Indonesia (entered 1990s)
Philippines (entered 1970s)</td><td>--
Consumer, Industrial
Storage/Office, Automotive</td></tr>
<tr><td>Global: Tier 2</td><td>Vietnam (entered 2000s)
Thailand (entered 1980s)
Malaysia (entered 1970s)</td><td>Cell Phones, Computers
Computers/Storage
Computers, Consumer</td></tr>
<tr><td>Global: Tier 1</td><td rowspan="2">China</td><td>3C, All</td></tr>
<tr><td rowspan="2">ODM</td><td rowspan="2">Design and NPD</td><td rowspan="2">Computers
Communications
Consumer Electronics</td></tr>
<tr><td>US, Taiwan, Singapore</td></tr>
<tr><td>Global Lead Firm (OBM)</td><td>Global brand owners; marketing, branding and manufacturing (for some)</td><td>Western Europe
US
Japan
Korea
China</td><td>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))</td></tr>
</table>

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)

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[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).

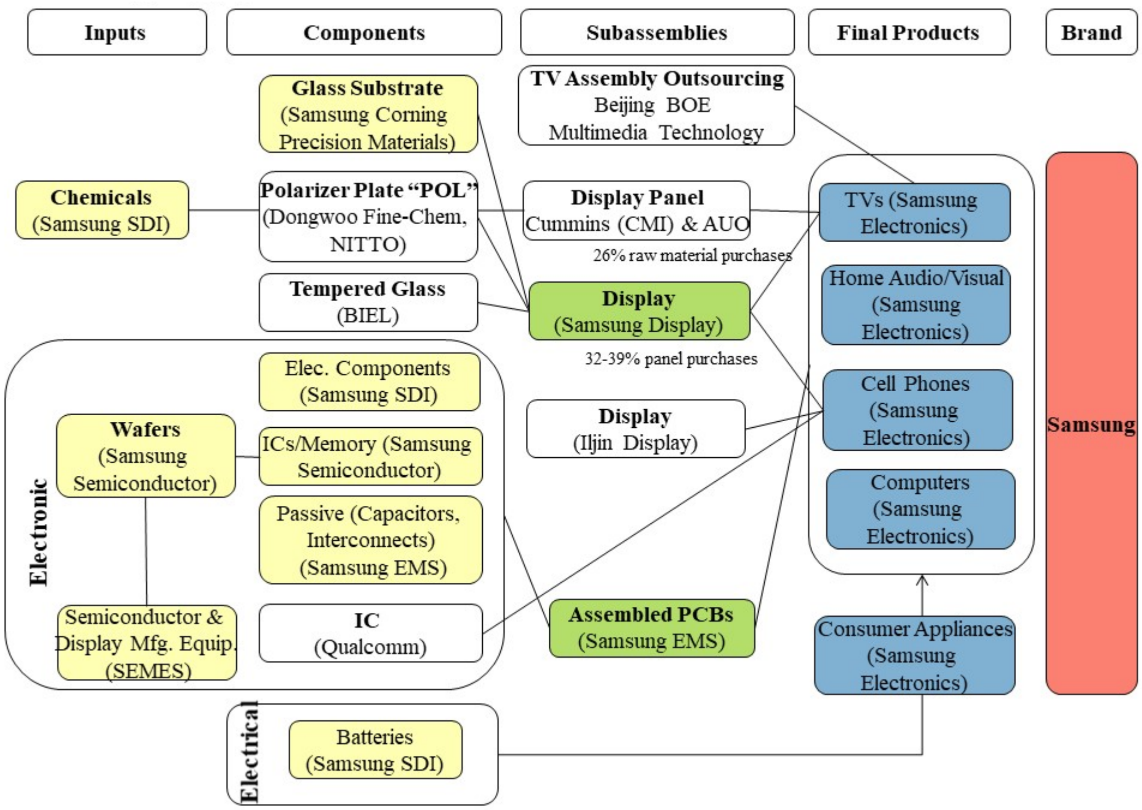
Focusing on the case of mobile phones, the following examples illustrate how the dynamics of cooperation and competition unfold in Asian electronics RVCs.[11]

(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)

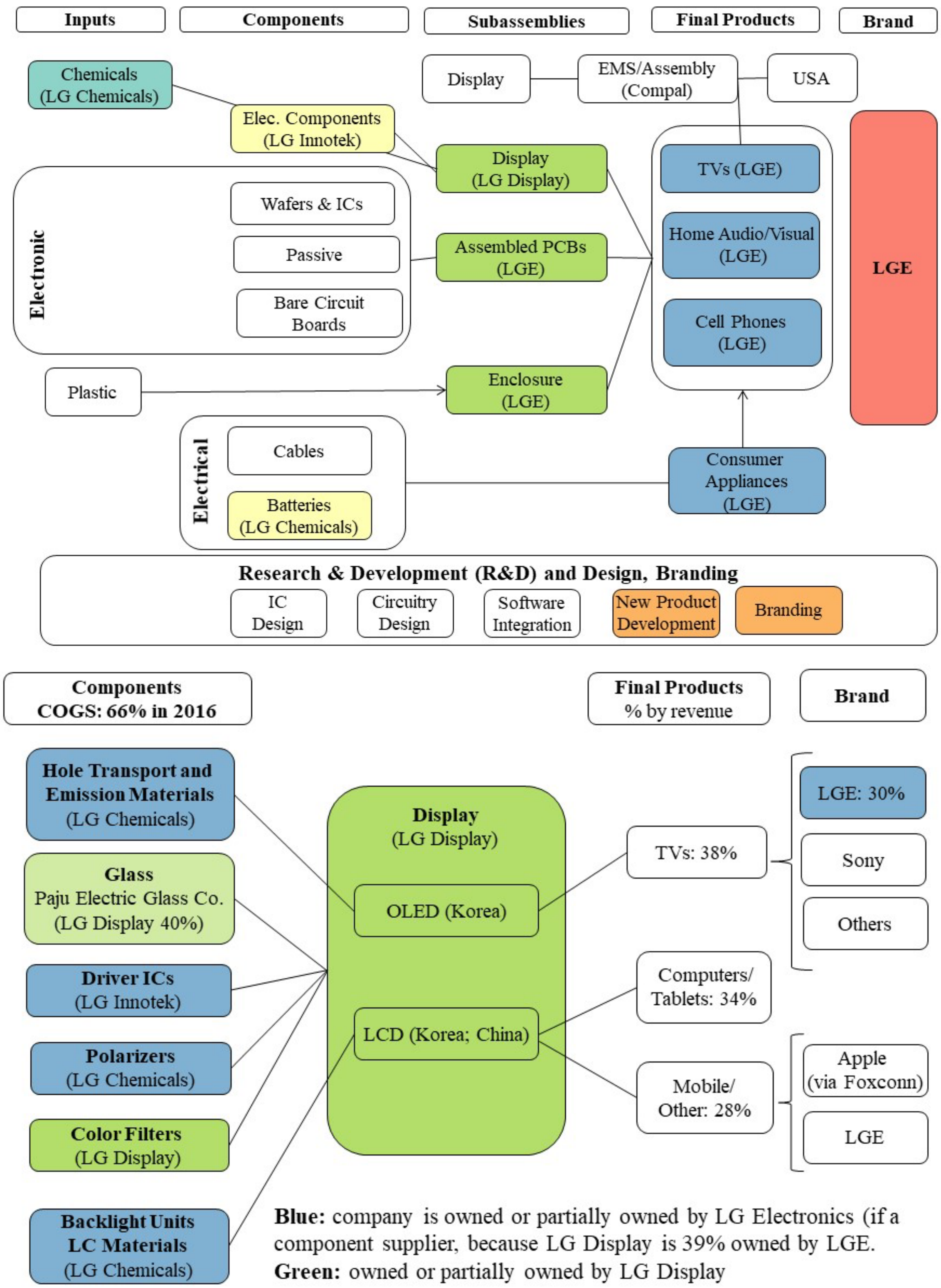
of internalization. Many key components, such as display panels, memory chips and processors, are sourced from other divisions of the diversified electronics firm or its related firms (Figure 3-3; includes other consumer electronics in addition to phones.). Samsung assembles phones in its own factories, 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)

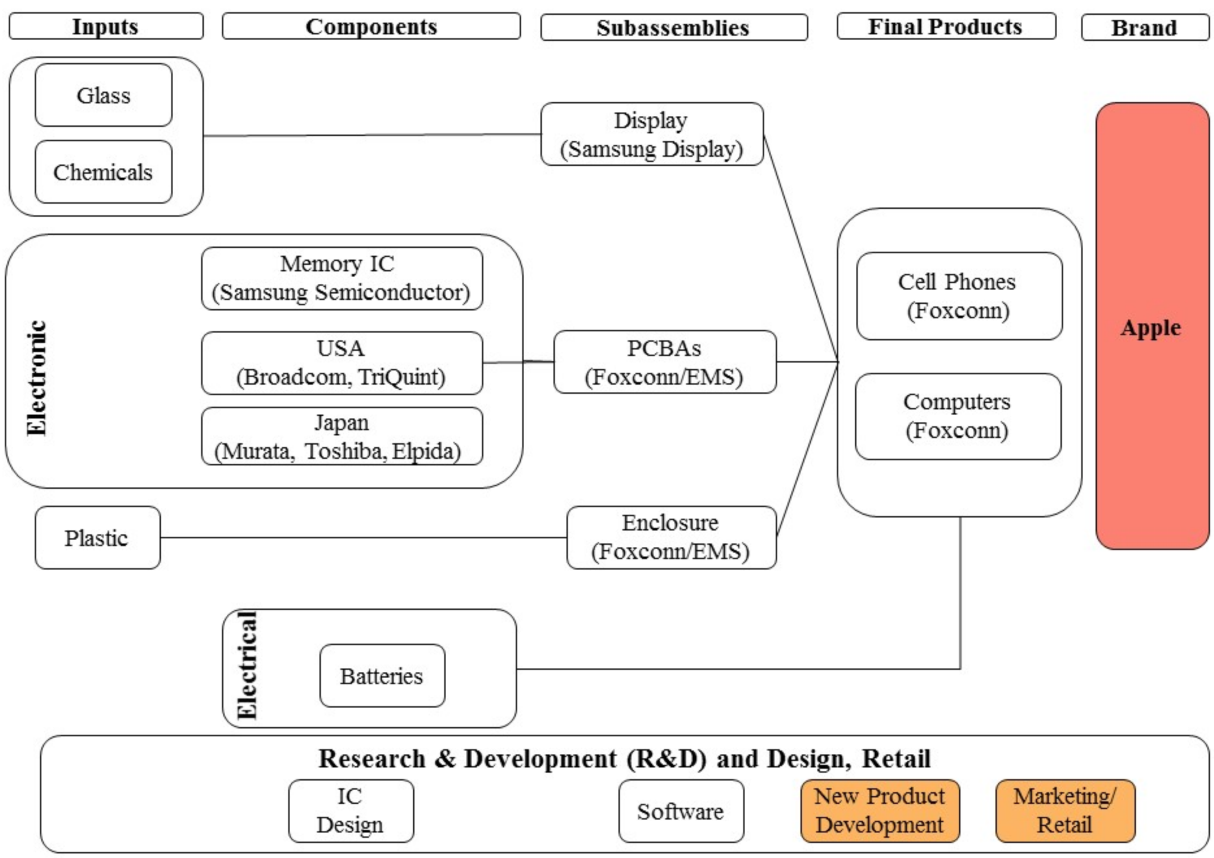
Figure 3-4. LG Electronics (top) and LG Display (bottom) Value Chains



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

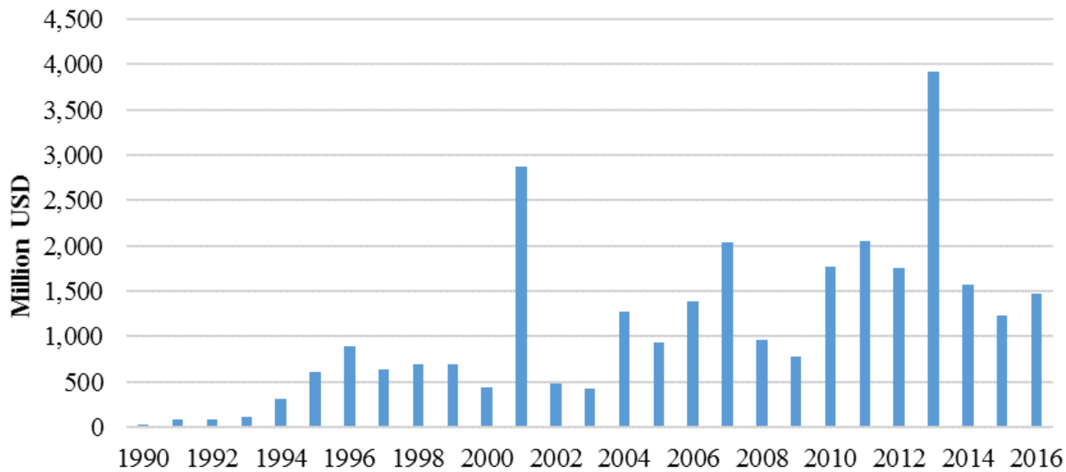
Korea’s electronics industry has developed over the past few decades with a strong focus on developing global brands for consumer markets. Industrial upgrading has focused on deepening engagement along the chain into key intermediates.

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]

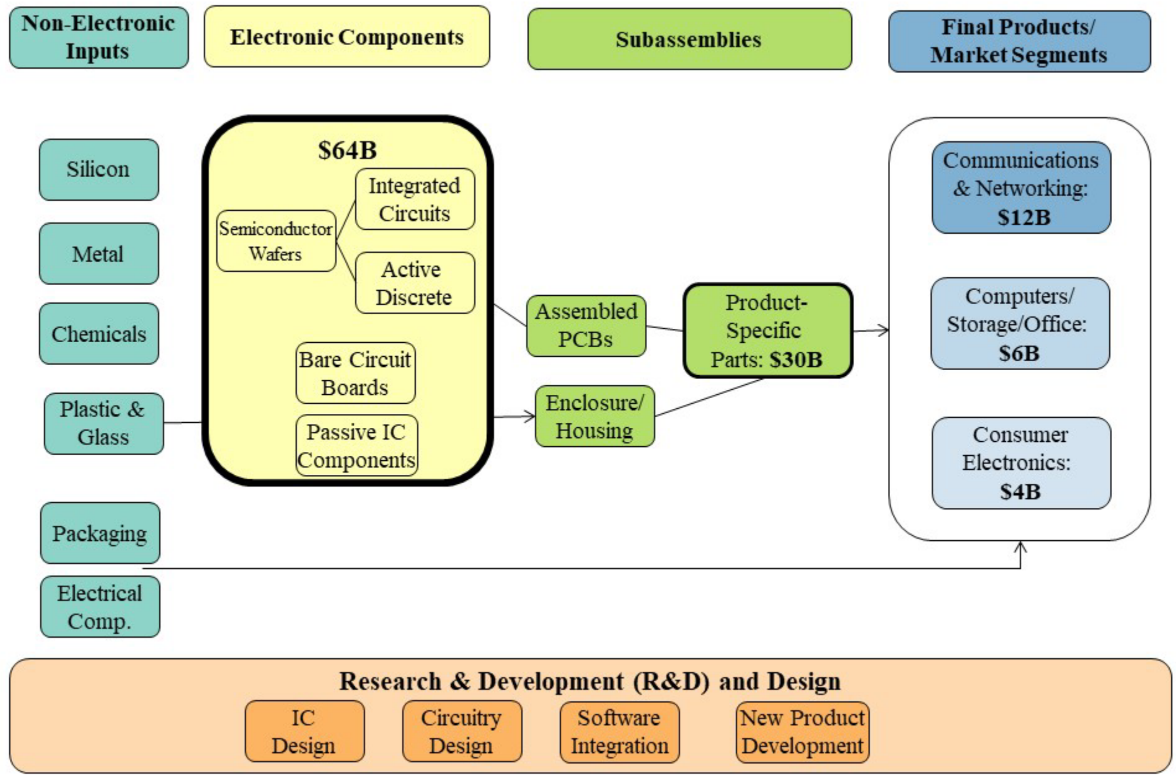
3.3.3. Product Profile and End Markets

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.

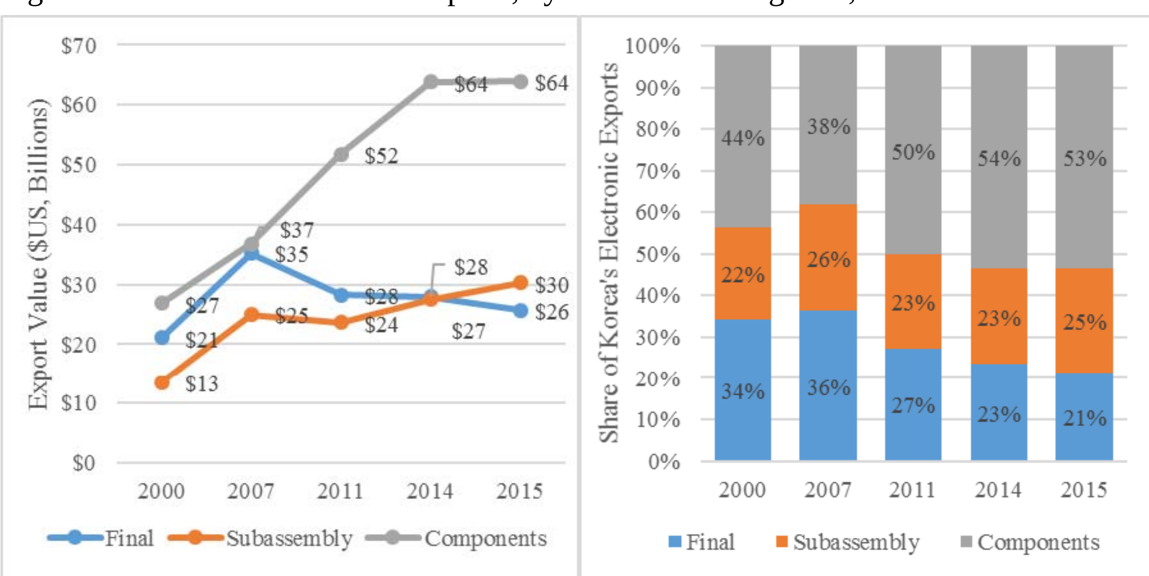
Figure 3-7. Korea's Participation in the Electronics Global Value Chain, 2015



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.

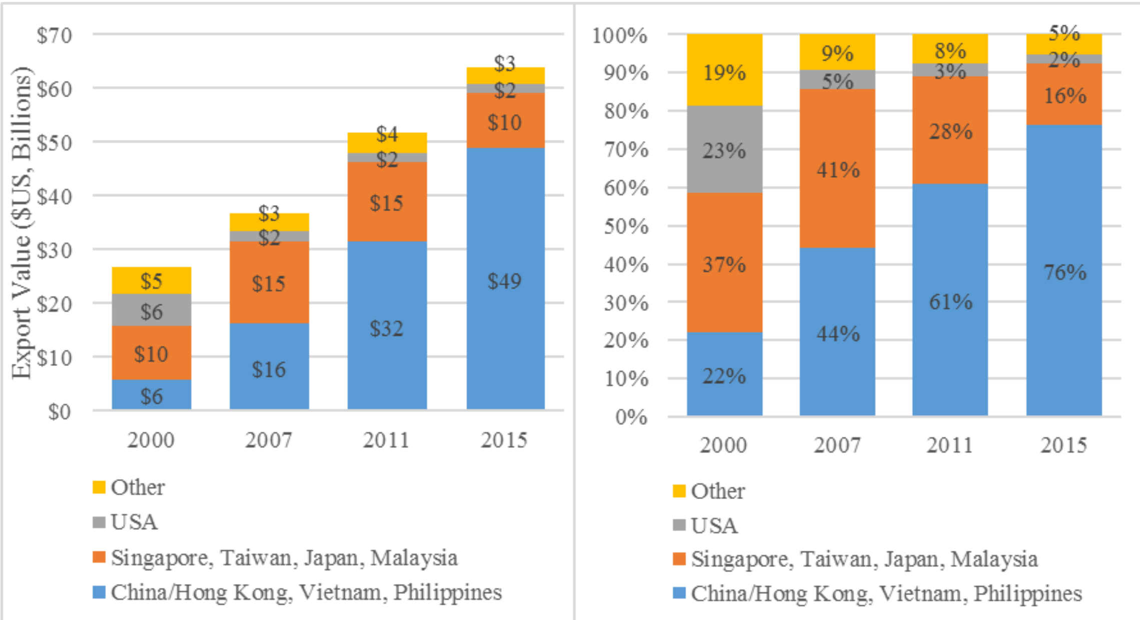
Table 3-16. Korea Electronics Exports: Final, Subassemblies and Components, 2000-2015

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).

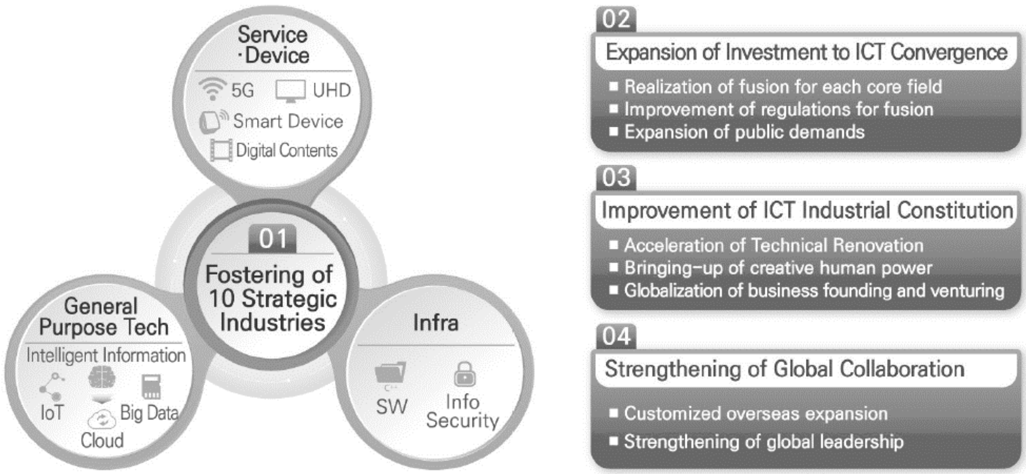
Table 3-18. Major Policy Measures Supporting the Korean Electronics Industry

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)

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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	Semiconduc tors		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

Chapter 4. Korea and the Shipbuilding Global Value Chain[1]

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[1] Chapter prepared by Lukas Brun and Stacey Frederick.

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Acronyms

AHTS	Anchor Handling Tug Supply
ANSI	American National Standards Institute
API	American Petroleum Institute
ASEAN	Association of Southeast Asian Nations
ASME	American Society of Mechanical Engineers
AWS	American Welding Society
B2B	Business to Business
CGT	Compensated Gross Tonnage
COGS	Cost of Goods Sold
DAB	Design and Build
DGPS	Differential Global Positioning System
DP	Dynamic Positioning
DSV	Dive Support Vessel
DWT	Dead Weight Tonnage
EPC	Engineering, Procurement and Construction
ERRV	Emergency Response and Rescue Vessel
ESWBS	Expanded Ship Work Breakdown Structure
EU	European Union
FLNG	Floating LNG Liquefaction Plant
FPSO	Floating Production, Storage and Offloading Vessel
FPSS	Floating Production Semi-Submersible
FPSU	Floating Production and Storage Unit
FPU	Floating Production (or Point) Unit
FSO	Floating Storage and Offloading Vessel (no production plant)
FSRU	Floating Storage and Regasification Unit
FTA	Free Trade Agreement
GT	Gross Ton/Gross Tonnage
GVC	Global Value Chain
HS	Harmonized System
HVAC	Heating, Ventilation and Air Conditioning
IACS	International Association of Classification Societies
ILS	Integrated Logistical Support
IMO	International Maritime Organization
IRM	Inspection, Repair & Maintenance
ISS	In-Service Support
KSE	Korea Stock Exchange
LGC	Large Gas Carrier
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LPH	Landing platform helicopter

LR2	Long Range 2
LSF	Landing ship fast
LST	Landing ship tanker
MGC	Medium Gas Carrier
MNC	Multinational Corporation
MODU	Mobile Offshore Drilling Unit (drillships)
MPSV	Multi-Purpose Support Vessel
MR	Medium Range
MSV	Multi-Support Vessel
NPD	New Product Development
OBO	Ore-bulk-oil
ODM	Original Design Manufacturer
OEM	Original Equipment Manufacturer
OSV	Offshore Support Vessel
PSV	Platform Supply Vessel
R&D	Research and Development
RoRo	Roll-on/Roll-off
SBSR	Shipbuilding and Ship Repair
SGC	Small Gas Carrier
SOLAS	International Convention for the Safety of Life at Sea
SPAR	Single Point Anchor Reservoir
STEM	Science, Technology, Engineering and Mathematics
SURF	Subsea, Umbilicals, Risers, Flowlines vessels
TEU	Twenty-foot Equivalent Unit
TLP	Tension Leg Platform
ULCC	Ultra Large Crude Carrier
US	United States
VLCC	Very Large Crude Carrier
VLGC	Very Large Gas Carrier
WTIV	Wind Turbine Installation Vessel

4. Korea and the Shipbuilding Global Value Chain

Shipbuilding in Korea has been a lynchpin of industrial development, national security, and source of employment and foreign exchange for the country since the 1970s. From relatively humble beginnings in 1972, when Korean national economic development plans identified shipbuilding as a key industrial sector for development, the big three Korean shipbuilding firms, Hyundai Heavy Industries, Samsung, and Daewoo have become dominant firms in the global shipbuilding industry, producing sophisticated commercial vessels for customers around the world. Today, the shipbuilding industry contributes about 2% to Korea's GDP (OECD 2015), directly employs approximately 200,000 workers, particularly in rural areas, and makes up between 7-8% of total exports (KOMEA 2016). Shipbuilding is routinely among the top three most valuable Korean export industries, competing with automobiles and electronics for the top spot (KOMEA 2016).

However, key market and competitive trends are affecting this important industry for Korea. China has emerged as an important producer of commercial vessels and is rapidly increasing its capability to produce large and sophisticated ships. China's global market share of commercial shipbuilding has grown from about 15% in 2006 to more than 35% in 2015 (IHS 2009-2016) and is increasingly entering the "very large" category of some commercial vessel types (i.e., containers and oil carriers) that have historically been the purview of Korean shipbuilders. As a result, Korean shipbuilders must remain at the forefront of technology development and production methods to ensure they remain the most competitive shipbuilder in higher value ship categories, like gas carriers, oil tankers, and the very large container ships they have traditionally dominated, while at the same time investing in ice-classed and oil-extraction related production vessels to diversify their product portfolio.

Increased competition from China is happening at a time of global shipbuilding overcapacity resulting from the aftereffects of the global financial crisis. Reductions in new orders have led to intense global competition, resulting in lower prices. While there are emerging signs of recovery, thanks to improved economic conditions and the need to comply with environmental regulations, shipbuilders across the world have shuttered docks and closed shipyards to reduce overcapacity. This has exacerbated the shift from higher cost shipyards to lower cost shipyards historically serving as periodic inflection points in the industry. For Korean shipbuilders to remain globally competitive, and not see their industry leadership fade as Japanese, European and American ones before them, the country has focused on production technology to increase productivity, emphasized ship component technology development and trade, and has continued to invest in workforce development in the shipbuilding industry. As it moves forward, in addition to product and process upgrading, Korean shipbuilders may also need to pay more attention to financialization and other business model changes occurring in the industry. In particular, servicificaiton of the chain, through ship financing and leasing may become increasingly important competitive factors in the industry.

In the upcoming sections, we investigate the shipbuilding value chain and Korea's position in the regional and global industry. In section 2, we expand on the market and competitiveness issues faced by the global industry, map the value chain, identify leading shipbuilders and component firms, discuss important standards and institutions in the value chain, and identify skill requirements and upgrading trajectories. In section 3, we turn our attention to discussing how different countries in the region have developed unique niches in the shipbuilding value chain. This is followed by section 4, in which we focus on Korea's position in the chain and suggest approaches to industry upgrading. One important lesson about Korea's shipbuilding industry is that it is well-positioned in the industry to remain globally competitive in certain final product categories and component parts; in many ways, the industry remains the envy of many of its competitors in other countries. However, the changing dynamics of the chain could very possibly affect the ability of its builders to remain attractive to customers and retain its global leadership.

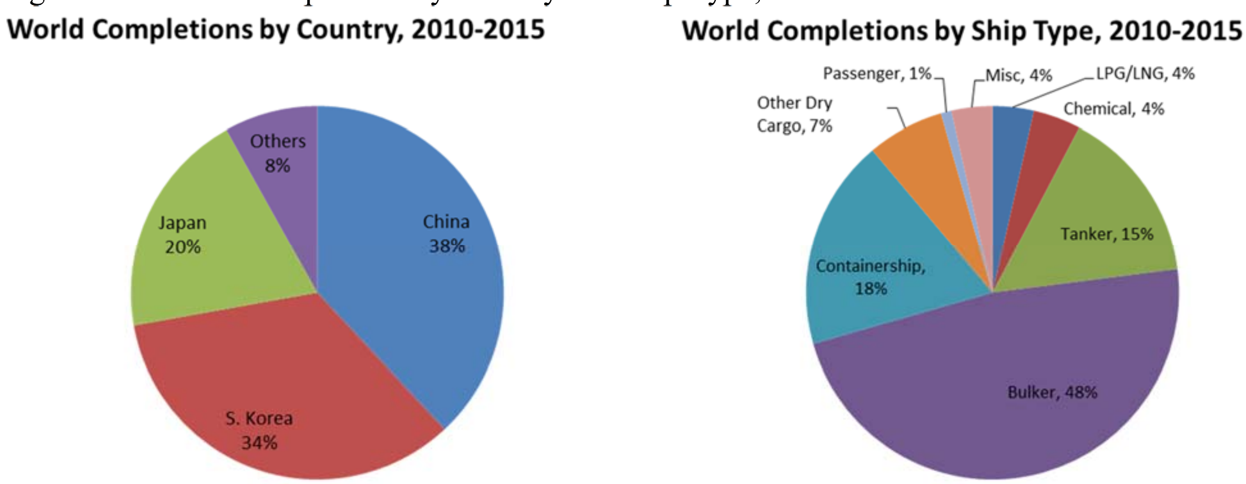
This chapter analyzes commercial shipbuilding and the role of Korea in the industry. The chapter is structured as follows: First, it analyzes the shipbuilding value chain, including an extended discussion on market and competitiveness issues in the shipbuilding industry, followed by a description of the key segments of the chain, the countries that participate in each, and how key stakeholders in the chain interact. It then offers a focused discussion of the role of China, Japan, and Korea in the industry and concludes with an assessment of the industry in Korea.

4.1. The Shipbuilding Global Value Chain

4.1.1. Introduction

In the 20th century, shipbuilding was dominated by European nations and the US until the mid-1960s, when Japan became the premier shipbuilding nation, followed by Korea in 1999, and China in 2010 (Stopford, 2015). Today, commercial shipbuilding – the construction of seaborne vessels with the primary purpose of moving large quantities of goods, commodities, or people – is controlled by these three East Asian countries each completing about a third of the global commercial shipbuilding market, for a combined 90% of global commercial ship production (based on gross tons) (Figure 4-1). This report is primarily about commercial shipbuilding, which is distinct from naval shipbuilding, used for national defense and other sovereign purposes, and recreational vessels, which are ships used for personal use.

Figure 4-1. World Completions by Country and Ship Type, 2010-2015



Note: Completions measured as percent of global gross tonnage. Ship coverage is 100GT or over.
Source: Authors, calculated from (IHS, 2009-2016)

Commercial shipbuilding is comprised of several vessel categories. Most production (80% based on GTs) occurs in three types of vessels: containerships, oil (crude) tankers, and dry bulkers. Containerships, making up about 18% of annual commercial ship production, are vessels optimized to carry containers (called TEUs, for Twenty-foot Equivalent Units) that hold components and final goods used in international commerce and production. Crude tankers, making up about 15%, carry crude oil from global production sites to national and regional refinery sites. Dry bulkers, making up approximately 48%, are designed to transport unpackaged bulk cargo, such as grains, coal, ore, and cement in large cargo holds. The balance of production (20%) within the commercial shipping category are general cargo ships used to transport refrigerated goods (“reefers”) and cars (“RoRos”), gas tankers carrying compressed gasses (LPG/LNG carriers) used for energy production, passenger and fishing vessels, and “offshore” vessels used primarily to support oil extraction and undersea construction.

4.1.2. Market and Competitiveness Issues

Five major trends shape the current commercial shipbuilding market. They are:

- overcapacity and declining prices
- lower order volumes and changing product mix
- financing new orders
- changing ship design and environmental regulations.
- production technologies.

<u>Overcapacity and declining prices:</u> Overcapacity is a major trend affecting prices and profits in the shipbuilding industry. Persistent overcapacity, in two (container and dry bulk) of the three major market segments is the result of a related stream of events including reduced transportation prices, reduced profits for shippers, cancelled ship orders, increased idling and demolition of existing ships, and market consolidation among shippers occurring as the result of the 2008 global financial crisis.

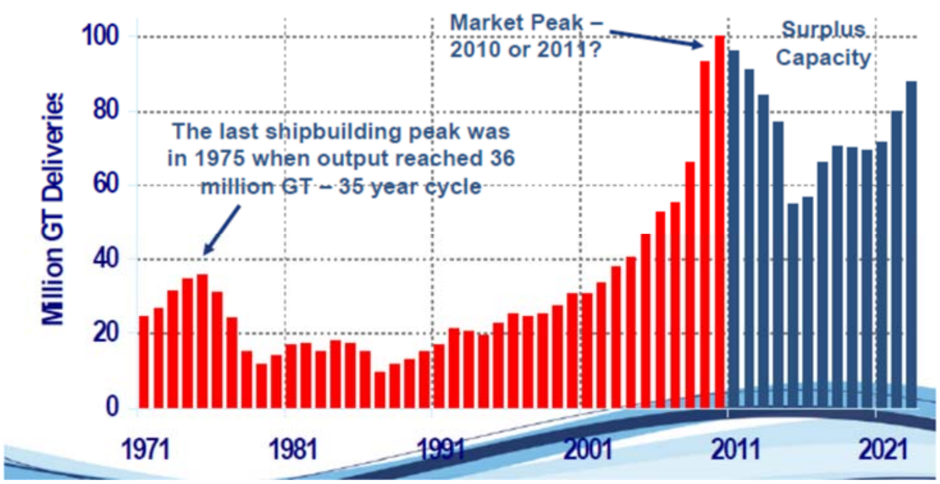
The global shipyard capacity utilization rate in 2016 is estimated at approximately 78%, down from 92% in 2008 (DSF, 2016). Of the three major shipbuilding countries, China utilized 68%, Japan 83%, and Korea 94%, of its shipyards in 2016. Major shipbuilders around the world are reducing the number of active yards through complete shutdowns and bankruptcies. The number of active yards is predicted to decline to 260 in 2017, down from 1,130 in 2010 and 780 in 2015. Newbuild prices for all major vessel categories have declined by at least 25% since their highs in 2009 (DSF, 2016).[2]

A major cause of overcapacity in the shipbuilding industry is weak demand for shipping and the existing stock of relatively young vessels in the three major shipbuilding market segments. As shipping demand declines, freight rates drop, ship prices decrease, newbuild demand decreases, demolitions increase, leading to an eventual recovery in freight rates and newbuild demand

[2] Newbuild and secondhand prices for major vessel categories are provided by DSF (2016). Newbuild prices in 2015 declined by 2% for containerships, crude carriers, and gas carriers; 11% for bulk carriers.

(OECD, 2015a). These long-term market cycles may be 30-40 years, with the current period indicative of a cycle which saw its last 2011 peak in 1975 (see figure below).

Figure 4-2. Cyclical Demand in the Shipbuilding Sector



Source: *World Shipbuilding Scenario* from Clarksons (2013)

Reduced prices for transportation services have led to container and dry bulk shippers operating at or below operating costs, creating ripple effects throughout the shipbuilding market. Shippers have responded to excess supply by reducing demand (or cancelling orders) for newbuilds, and increasing the demolition rate of older ships. Increased demolition rates in containerships removed 201,000 TEUs of older ships from the global fleet (BRSGroup, 2016), but still only accounted for 12% of newbuild deliveries over the same period, exacerbating overcapacity. In the dry bulk segment, scrapping accounted for almost three-fourths of global scrapping activity, reducing fleet growth to its lowest level in 15 years (Clarksons, 2016; UNCTAD, 2016b). Idling ships has also been used in the bulk market, accounting for a reduction of 5 million DWT (DSF, 2016; UNCTAD, 2016b). However, these responses were still unable to balance supply and demand and return the container and dry bulk shipping sectors to profitability.[3]

To increase profitability, market consolidation among shippers has occurred. Japan's three biggest shippers, Nippon Yusen KK, Mitsui OSK Lines, and Kawasaki Kisen Kaisha, announced a merger in November 2016 as a way to remain competitive and avoid bankruptcy.[4] Additional consolidation among shippers is ongoing, both in Asia and Europe (Park, 2017). Insolvencies and liquidations among shipping companies, including those of Hanjin Shipping in August 2016, has led to greater concentration in the market, reducing the ability of smaller companies to operate, and which may result in an oligopolistic market (UNCTAD, 2016b). Strategic partnerships have also occurred, with shipping alliances developing in both the container and dry bulk markets to coordinate chartering and transportation services. Capesize Chartering, for example, originated in the bulk carrier market during 2015 to share information and optimize fleet costs (Alix Partners, 2016; UNCTAD, 2016b).

[3] Information about profitability levels across major market segments is provided in (DSF, 2016).
[4] Nippon Yusen president Tadaaki Naito stated "the aim of becoming one this time is so none of us become zero" as reported in (Chandran, 2016).

In addition to the cyclical decline in demand, there are structural and non-market causes for overcapacity in shipbuilding. Among structural causes of overcapacity are factors common in capital-intensive industries with long investment horizons. These include the long delivery times of vessels (approximately two years), long lead times in adding or reducing shipyard capacity, and push from buyers to add shipbuilding capacity during periods of tight capacity. Non-market factors causing overcapacity in the shipbuilding sector include strategic capacity expansions by incumbents to discourage new entrants, industrial policies favoring new capacity investment or limiting restructuring, and protectionist policies, including cabotage polices. In the current period, policies providing government financial support for maintaining capacity, including production subsidies, capital participation, tax benefits, and lax regulations on the use of lands and facilities are limiting the elimination of shipyard overcapacity (OECD, 2015a). Overcapacity in the shipbuilding and shipping industry will exist for the foreseeable future (Clarksons, 2013; DSF, 2016; UNCTAD, 2016b), recovering only as existing in-service vessels are scrapped or retired after an average of 23 years of service (OECD, 2015a).

Lower volumes and changing product mix: Future vessel requirement estimates by OECD indicate that the major shipbuilding sectors – tankers, bulkers, and containers – will not return to levels seen in the last decade until the 2030's, if at all. Tanker completion volumes of those seen in 2008 (20 million GT) are not expected to return until 2028. Bulker deliveries peaked at 50 million GT in 2011, and are not expected to return through the predictable future (2035). The high containership volumes of 2008 and 2014 (approximately 15 million GT) are not expected to return until 2033. While reduced vessel requirements are partly the result of the existing inventory of vessels discussed above, more persistent changes are expected with longer-term trends reducing the linkage between GDP and trade growth (UNCTAD, 2016b). These trends include demographic shifts, shortened GVCs, and IT-related efficiency and productivity gains occurring as the result of Industry 4.0 technologies which could signal structural changes in the demand for shipborne transportation (DSF, 2016; UNCTAD, 2016b). These changes will impact the product mix; although the majority of production in commercial shipbuilding has been in bulkers and oil tankers, growth will likely be in LNG/LPG gas carriers, RoRos and ferries, and the offshore market (Kent, 2016).[5] Although participation in the offshore market involves large risks (OECD, 2015a), it is an increasingly large share of shipyard production, and is composed of vessels that tend to have higher unit values.

Financing new orders: Access to finance has been a limiting factor in the shipbuilding industry since the 2008 economic crisis when Western commercial banks reduced their exposure to shipbuilding finance (Albertijn et al., 2011; Liu, 2016). This was in part due to capital requirements under the Basel III Accords (Liu, 2016) which introduced new banking regulations to enhance the sector's ability to absorb financial and economic shocks (BIS, n.d.). Stepping into the breach have been Asian lenders, typically with state-backed funds (Aw et al., 2016; Liu, 2016) and shipbuilders seeking to secure orders in a buyer's market (DSF, 2016). Shipbuilders have provided generous payment terms to potential shipowners to maintain their orderbooks and shipyard activity. New terms reduce payments from the traditional 20% payments over five years to four 10% payments and one 60% payment at the end of five years, resulting in a "heavy tail" for ship finance (Hyun, 2013). However, these payment and financing arrangements have affected shipbuilders' profitability. Shipyards with limited ability to provide financing options,

[5] The fleet age for RoRos is higher than other product categories, with about half older than 20 years (p. 18).

particularly refund guarantees and export credit guarantees, are at a disadvantage when compared to large, state-affiliated shipyards with better financing options.[6] Nevertheless, even shipyards in countries traditionally providing state-backing are experiencing financial challenges in the current environment. In Korea, the "big three" shipyards - Samsung Heavy Industries (SHI), Hyundai Heavy Industries (HHI), Daewoo Shipbuilding and Marine Engineering (DSME) - and STX Offshore & Shipbuilding all announced the need to restructure. In China, five shipyard bankruptcies were announced in 2016 with a sixth restructuring (Kent, 2016).

Changing ship design to increase efficiency and comply with environmental regulations: Ships have become larger, more fuel efficient, and compliant with stricter environmental standards since the early 2000s. Larger vessels have become attractive to shipowners because they can achieve economies of scale in transportation, which have been made possible by the physical expansion of the Panama Canal and Suez Canal. Ship designers have also increasingly focused on fuel efficiency as an important factor affecting profitability, as ship fuel costs ("bunker prices") have become an increasingly large portion of operating costs, especially before the rapid decline in bunker costs from 2014 to the current period. As a result, vessels in the global fleet have become more fuel efficient, while the use of alternative fuels, especially LNG, to power ships may also become increasingly common.[7]

Finally, the implementation of environmental regulations has affected shipbuilders. Most notable of these is the ballast water convention (2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments) requiring the bilge to be free from fouling organisms by September 2017, and the International Maritime Organization's (IMO) adoption of enhanced environmental regulations, including reductions in the emission of air pollutants from ships. Marine pollution ("MARPOL") conventions, including the Energy Efficiency Design Index (EEDI), require reductions in carbon dioxide (CO_2) emissions. Specifically, the EEDI requires stepwise reductions in CO_2 emissions from 2000 levels, including 10% in 2015, 20% in 2020 and 30% in 2025.[8] Conventions under MARPOL Annex VI also establish emission control areas (ECAs) for sulphur oxide and nitrogen oxide emissions in specific geographic areas.[9]

Construction Technologies: since the 1980s modular approach to shipbuilding ("block construction") developed in Asia. In modular shipbuilding, pieces of the hull of up to 300 tons are separately built and assembled in blocks on land before assembled in docks, dramatically increasing efficiency and reducing the costs of shipbuilding. Korean firms, like HHI and SHI, rose to prominence by building large shipyards capable of block construction and vertically integrating the steps of the shipbuilding process, including the integration of major systems. Today, the efficiency of the block construction method has been enhanced by automated welding. Large ship blocks are quickly constructed by programmable robots made by ABB and

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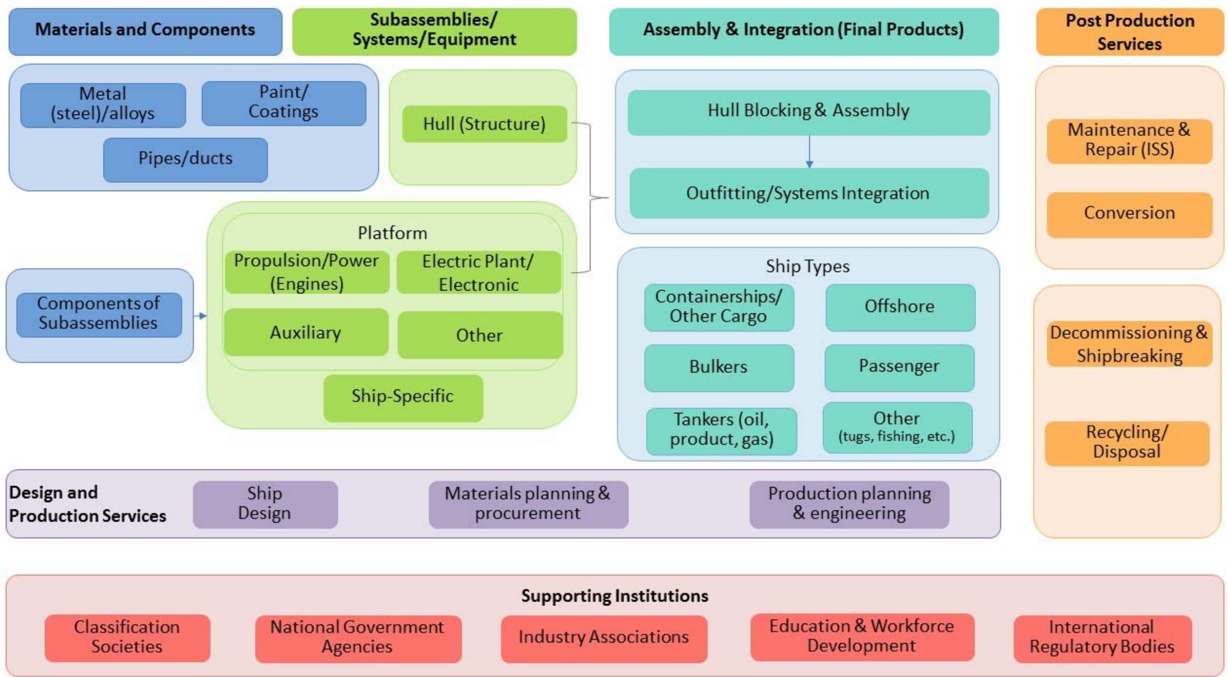
[6] Refund guarantees provide for a return of pre-delivery payments made by the shipowner to the shipbuilder, typically as security against the insolvency of the shipbuilder (Heward, 2010). Export credit guarantees, typically provided by governments or quasi-governmental entities, ensure that an exporter receives payment for goods shipped overseas in the event the customer defaults, reducing the risk to the exporter's business (Davis, 2012).
[7] See www.marineinsight.com/future-shipping/shipbuilding-technologies
[8] The Ship Energy Efficiency Management Plan (SEEMP) is a complimentary convention regarding the energy efficient operation of ships.
[9] For more information, see www.imo.org/en/MediaCentre/hottopics/ghg/Pages/default.aspx

Inrotech, among others. SHI's [Geoje shipyard](#) in Korea is particularly well known for achieving efficiency gains in shipbuilding due to its adoption of these welding robots.[10]

4.1.3. Mapping the Shipbuilding Global Value Chain

Modern shipbuilding involves multiple actors to design, construct and maintain a ship. Figure 4-3 illustrates the complex set of design, production, and post-production activities involving multiple actors across the shipbuilding value chain. The purpose of this section is to illustrate the shipbuilding process using the value chain as an orienting framework.

Figure 4-3. Shipbuilding Global Value Chain



Source: Authors

The shipbuilding value chain is comprised of three major phases: pre-production, production, and post-production. The *pre-production* phase of shipbuilding includes the phases of design and project management. The *production* phase includes hull construction and equipment/systems purchasing and integration. Hull construction components and activities are those required to build the structure of the ship. All ships require these systems, however their relative importance varies by ship type. *Platform or standard* systems/equipment account for a similar share of equipment purchases on most types of ships. *Ship-specific* systems are those needed to make the vessel perform the tasks for which it is designed and account for a larger share of total equipment purchases Finally, *post-production* activities include in-service support (ISS) of the vessel after its final construction, customer support. ISS may be comprised of repair, conversion and maintenance activities. As a ship reaches the end of its service life, which for commercial vessels

[10] See for example, [www.kranendonk.com/shipbuilding/double-hull-welding-line](#)

is about 25 years, they are disassembled ("ship breaking") and recycling/disposal occurs. Next each major segment is described in turn.

Design: The major design phases, comprising of concept, preliminary, contract, and detailed designs, have different objectives and may be conducted by different firms. In the *concept phase*, the design process begins with a decision, usually by the ship owner, about the mission requirements of the vessel. A ship architect can then begin the process of defining the parameters and features of the ship. In the *preliminary design phase*, major equipment needs are determined, and the general arrangement of the hull and equipment is made. In the *contract design phase*, specification of the hull form is conducted and initial selection of systems and major equipment suppliers is made. In the *detailed design phase*, the goal is to design the construction of the vessel. This design phase includes designing the details of compartment arrangements, specifications of equipment integration, shock specification and maintainability. For some vessels,[11] a full engineering analysis may be conducted, including analysis of the ship's structure, noise and vibration, weight and stability. This phase also covers construction standards, including how factory automation, cutting of parts in the factory, and data management will be conducted in a specific shipyard as part of the construction (or "build") design.

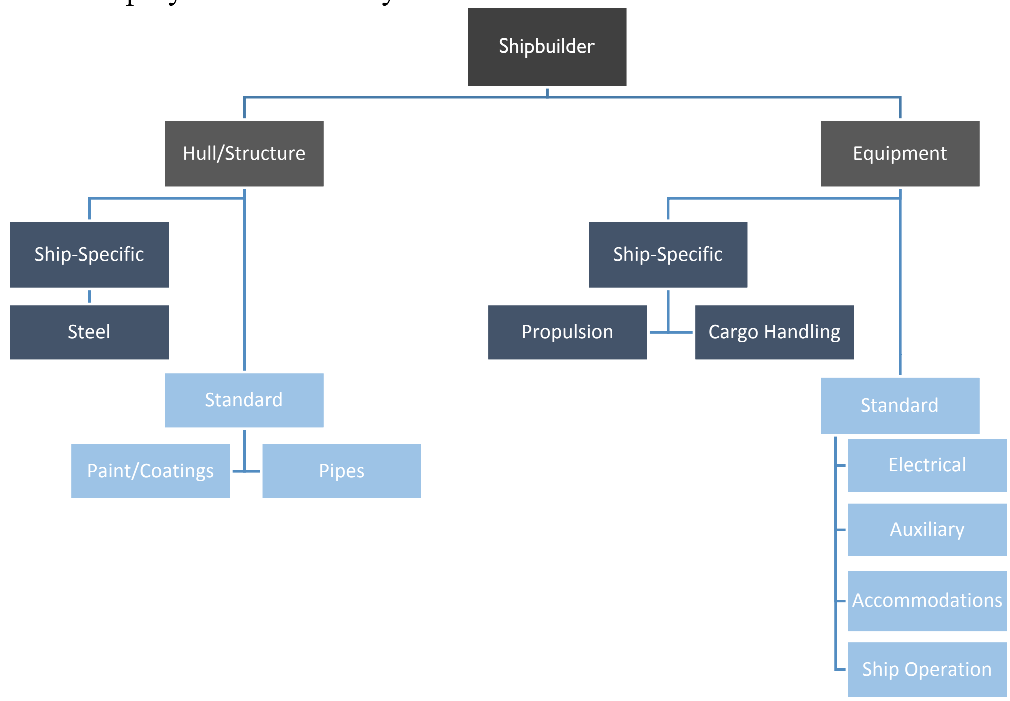
Component production and subsystems assembly: The main systems and subsystems for a ship are illustrated in Figure 4-4. The three main categories are:[12]

- **Hull**: Hulls are built in sections called blocks, primarily from steel. Hull fabrication is a labor-intensive process involving welding. Steel plates are cleaned, straightened, shaped, and cut by specialized plate-burning machines to build the ship's outer surface, or "skin". The framework, to which the skin is attached, consists of the ship's structural components, specifically the keel, girders, frames and beams.
- **Standard/Platform Systems**: These, for the most part, will be found on all ships. They are labeled here as 'standard' because they account for a lower, more stable share of equipment purchases across ship types. These include ship operation, basic accommodations, electrical systems/plant and electronic navigational and communication systems, and auxiliary systems, notably HVAC and environmental pollution control.
- **Ship-Specific Systems:** These depend on the intended use and purpose of the vessel. In large commercial carriers, the propulsion system is the most important, because the purpose of the ship is to move as quickly and efficiently as possible for long distances. Alternatively, cargo handling equipment is more important on offshore production and drilling vessels as these primarily remain stationary. Accommodations (e.g. furniture) are more important in cruise ships and passenger vessels (Brodda, 2014). For research/survey vessels, advanced sensing, navigation and communication technologies are needed (e.g. radar apparatus, radio navigational aid devices, and radio remote control apparatus).

[11] Military and passenger ships in particular.

[12] Additional information on each of the assemblies and subassemblies may be found in Gereffi et al. (2013). An alternative categorization is offered in (EC, 2014). It divides materials, major systems and services into three segments: 1) external services and contractors; 2) materials (steel, pipes, ducts, paint/coatings); and 3) ship operation systems, cargo handling and processing equipment, accommodation systems/equipment, propulsion/power generation systems, auxiliary systems, electrical plants and electronic systems.

Figure 4-4. Ship Systems and Subsystems

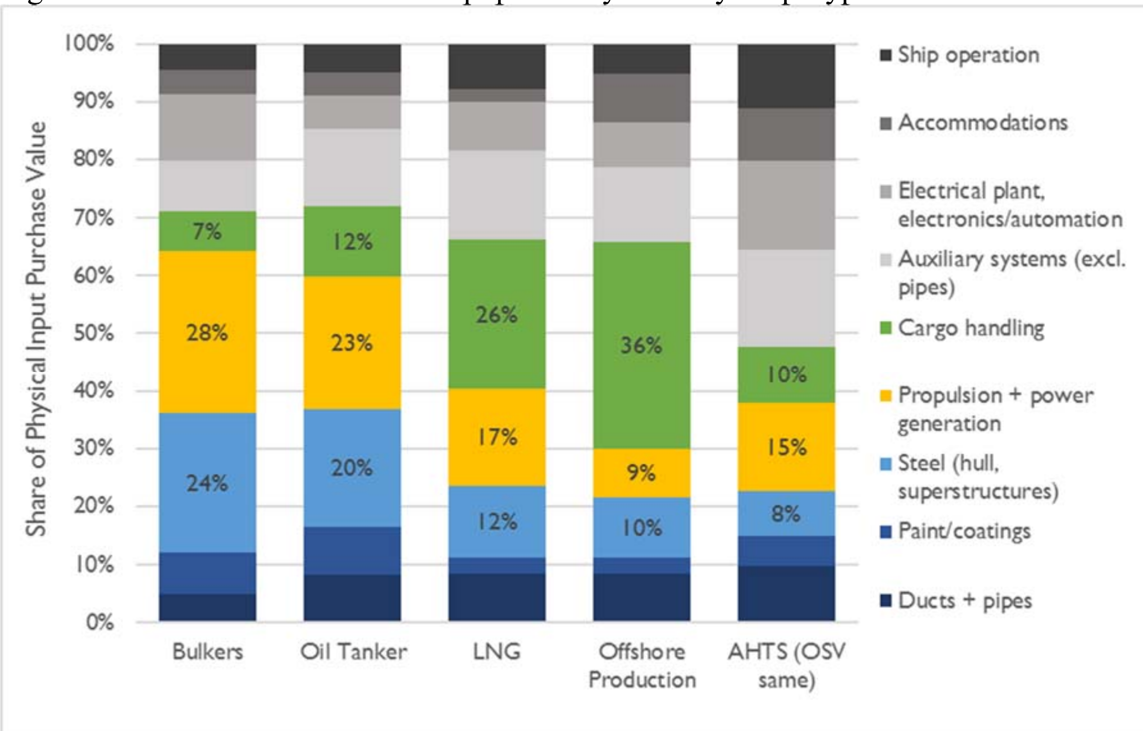


Source: Authors; ship-specific subassemblies and components account for the largest shares of input costs, but the specific ones of most importance to a particular ship depend on the type of ship produced.

The distribution of physical input costs can be divided into two parts: materials (steel, pipes and ducts, paint and coatings) and systems and equipment. Materials account for approximately 25% of goods purchased and systems and equipment 75% (EC, 2014). These shares vary depending on the size, configuration and purpose of the ship. Within materials, piping and paint make up relatively stable shares of input costs across all ship types, and in equipment/systems, all ships have similar shares for ship operation, accommodations,[13] electrical plant and auxiliary systems. The main variations are in steel/structural components, propulsion and cargo handling. Steel and propulsion systems are the primary inputs for bulkers, containerships and oil tankers, whereas cargo handling equipment is significant for LNG and offshore production vessels. Smaller offshore vessels (AHTS and PSV) have the lowest share for material components, and the widest variety/most eventually distributed need for equipment (Figure 4-5).

[13] For passenger vessels, the share for accommodations is significantly higher, but these are not a particular focus in this report.

Figure 4-5. Cost of Materials and Equipment/Systems by Ship Types



Source: Authors, calculated from (EC, 2014), which is based on purchase forecasts for 2013-17. Note: The "materials" category consists of steel, painting/coating, and pipes + ducts. The "equipment/systems" category consists of all other physical input categories.

Ship assembly and integration: The main activities in assembly and integration are:

- **Hull blocking and assembly**: Hull subassemblies are coated with protectant or specialized marine coatings, welded together to form large prefabricated units, and welded into position to form the ship. Once assembled, the ship is ready for launch and outfitting.
- **Outfitting:** After launch, the ship is berthed for completion. The main machinery, piping systems, deck gear, lifeboats, accommodation equipment, insulation, rigging and deck coverings are installed. The tendency is to schedule the outfitting of a vessel in sections, to synchronize fitting work in the different sections and compartments.
- **Systems integration:** Systems integrators install platform and ship-specific systems and ensure cross-functionality of subsystems. As subsystems become increasingly complex, the integrator's role becomes increasingly important.

Production support services: Production support consists of materials selection and procurement, and production planning and engineering.

- **Materials selection and procurement (sourcing)**: As the design for a ship develops, the shipbuilder identifies suitable suppliers or subcontractors to supply items the shipyard does not produce. Materials planning and procurement requires coordination between the design and procurement functions of the shipbuilding value chain. The design team provides the material needs and estimates for steel, pipes, and cables, subsystems, mechanical and electronic components, and optional equipment, while the procurement team gathers technical product information to create a database of potential suppliers. Selection of equipment in the design and build (DAB) phase has implications for post-production services. For example, propulsion systems made by two manufacturers may have similar prices, meet design specifications, yet have different maintenance costs and schedules. Evaluating systems based on total cost of ownership is one reason why coordination between the DAB team and ISS provider has become increasingly common. A second reason is the creation of the technical data package; this "owner's manual" lists the specifications and maintenance schedules for the ship's systems and subsystems.

- **Production planning and engineering**: Given the long build time for large commercial vessels, production planning is a critical and complex undertaking involving design, assembly, and installation. It ensures that individual parts and equipment are allocated to the appropriate stage in the production hierarchy of assemblies and subassemblies. Production planning and engineering includes assembly and production planning, cut and weld planning, and approval and release of designs. Specialized firms are often retained for production planning and engineering, though some shipbuilders maintain this capability in-house.

Post-production services and end-of-life: Post production services include in-service support (ISS), conversion, and technical training. ISS provides the maintenance, conversion and repair of the vessels, and generally occurs at planned intervals required by classification societies to ensure the ships remain seaworthy and in good condition. ISS is the responsibility of the ship owner, and typically performed by the original shipbuilder or specialized service provider contracted to conduct maintenance and repair. Under normal operation, post production services in the commercial shipbuilding sector account for approximately 30% of the selling price of a ship. This percentage does not include significant conversions, for example, those required for LNG bunkering or for meeting MARPOL standards. Technical training is needed to teach personnel on the operation and maintenance of the vessels' systems. The operational expense of onboard training makes companies specialized in virtual reality and training simulation attractive alternatives.

Shipbreaking and recycling: At the end of ship's useful life, it is purchased by a shipbreaking or demolition shipyard where it is disassembled. Largely due to the high quality standards for materials used in shipbuilding, nearly all of a ship (estimated 95%) can be recycled or reused (SBC, 2008). Ships are recycled primarily to recover their steel, which makes-up approximately 75% to 85% of a ship's weight, or "lightweight."[14] Some steel plates and beams can be extracted and directly reused by the construction industry or they can be re-rolled and reused (without melting),[15] and irregular scrap pieces can be melted into crude steel and reprocessed using an electric arc furnace (EAF) method. Ship steel scrap is attractive for steelmaking because it is high quality steel due to its high yield strength, ductility and impact strength. The annual average of 3.6 million tons of melting steel scrap from the global ship recycling industry (not including steel that is reused or only rerolled) accounts for around 1.5% of the global steel making industry

[14] Lightweight (LDT) is the mass of the ship's structure, propulsion machinery, other machinery, outfit and constants. Another way of defining LDT is as the displacement of a ship when fully equipped and ready to proceed to sea but with no crew, passengers, stores, fuel, ballast, water or cargo on board.
[15] The re-rolling process is simpler and uses less energy compared to melting steel scrap.

from old steel scrap (Mikelis, 2013). Other equipment still operational can be taken offboard and repurposed in another vessel.

Types of Ships/Vessels and Ship Owners/Buyers

There are several types of oceangoing vessels that can be described in terms of purpose or the type of cargo they are intended to carry (which relates to construction), size, and the main ship buyers or owners. Ships are typically designed to serve one of the following purposes: transport various types of cargo, conduct an activity at sea (extract oil or other resources, construction, research), and defense. In terms of cargo, ships are designed to transport dry goods (bulk raw materials, component/intermediate goods in containers, or large unpackaged general cargo), liquids/gases (oil, natural gas/petroleum, chemicals, beverages), and/or people.

Categories of ship owners/buyers are aligned with the different ships functions and types of cargo. Commercial shipping companies buy ships that transport dry goods (particularly containerships), oil and gas companies purchase liquid/gas carriers and offshore oil exploration units, and cruise lines purchase large passenger ships. Governments purchase a range of vessels used to conduct various duties and activities related to defense (warships, destroyers, frigates, corvettes, patrol vessels, fast attack crafts), research/survey (research vessels, icebreakers, and search and rescue), offshore oil exploration, and smaller passenger vessels for domestic transportation and shipping needs (Table 4-1).

The scope and terminology used to describe the shipbuilding industry varies based on the data provider. For example, the term ‘tanker’ may refer to any ship carrying liquids/gas, including oil, gas, chemicals or other products. Similarly, the term ‘cargo ship’ may combine containerships and general cargo ships or even bulk carriers. Offshore vessels are often included in an ‘other’ category, however this also often includes large passenger ships, ferries, fishing boats or smaller, multipurpose cargo/passenger vessels. Some sources include recreational vessels and boats (or more generally smaller vessels less likely to be used to travel across the ocean), research vessels or government/military-related production (see Box 4-1).

Table 4-1. Ship Types and Characteristics

Type	Sub-Type/Alt. Names	Description	Type of Cargo	Size (Unit, Range, Terms)	Newbuild Price (US$, Mil, 2016)
Bulk Carriers	Bulkers	Unpackaged bulk cargo; separate areas if more than one product	Dry-grains, coal, ore	DWT: 10-100,000 Handysize, Handymax, Panamax, Capesize	$20-42
Container		Carry load in truck-size containers, in a technique called containerization.	Dry-containers	TEU: < 1-12,000 Feeder, Intermediate, Neo-Panamax, Post-Panamax	$12-$109
Tankers	Gas LPG, LNG, FSRU	LNG larger than LPG	Liquid/Gas	Cu.M/m3: < 5-160,000 SGC, MGC, LGC, VLGC	$42-71; $192
	Oil/Crude		Liquid/Gas	DWT: < 55-320,000 Handy, Panamax, Suezmax, VLCC,	$33-85

Type	Sub-Type/Alt. Names	Description	Type of Cargo	Size (Unit, Range, Terms)	Newbuild Price (US$, Mil, 2016)
				ULCC	
	Chemical/Product		Liquid/Gas	DWT: < 25-125,000 SR, SH, MR, LR1, LR2	--
General Cargo	Cargo; other dry cargo; barge; reefer (refrigerated); Pax/General/ RoRo; RoRo	Carry various forms of cargo or cargo and ≤ 12 fare paying passengers (Pax). Barges are non-propelled (must be towed or provide stationary support).	Dry/People	# of cars Reefer: cubic feet RoRo: Lane m.	RoRo: $45-58
Passenger	Ferries, Cruise ships	Carry passengers; for transport purposes only or where the voyage itself and the ship's amenities are part of the experience.	People	Cruise: # of berths	
Other	Fishing		N/A	Generally below size threshold to be included. Small, 30 up to 100 meters	
	Tug	Designed for towing or pushing; increasing share used in the offshore segment.	N/A		
Offshore	See Box	Designed for exploration and extraction of natural gas and oil.	N/A	Drillship: water depth AHTS: HP Dredger: GT	

Source: Authors. Newbuild Prices: 2016 (Dec) based on average of all sizes: Clarksons (2017b).

Newbuilding prices increased during the early 2000s, but have declined across ship types since 2009 (Clarksons, 2017a; UNCTAD, 2011). The decline has more significant for bulkers and mid-size containerships than tankers and LNG. LNG carriers are the most expensive (US$192 million) and bulkers are the least expensive (US$20-42 million). Oil tankers and LPG carriers have similar price ranges (US$40-80 million), and containerships have the largest variation based on size (US$12-109). Bulkers and general cargo ships can be constructed in roughly 6-9 months and tankers in 14-16 months. A large passenger ship or LNG/LPG carrier may take two years to complete.

In terms of complexity, bulkers and general cargo ships are the most basic, followed by tankers, then containerships, and lastly LNG/LPG carriers as the most complex (G. Collins & M. Grubb, 2008). Offshore vessels, particularly large platforms research vessels, can be quite complicated and would be on par with LNG/LPG. The level of complexity is reflected in average newbuild prices, time to complete, as well as the type and cost of materials. For instance, over half of the cost of materials in bulkers and oil tankers are steel and engines, whereas LNG/LPG and offshore have higher shares in ship-specific systems.

4.1.4. Global Production and Trade in the Shipbuilding GVC

Most commercial shipbuilding and construction activity occurs in three countries. Japan, Korea, and China routinely account for over 90% of annual commercial ship production, a competitive advantage resulting from the continued development of block construction techniques during the 1980s in which large pieces of a ship are constructed on land before assembly, and more recently, access to inexpensive inputs, including steel (China). Within the "big three" segments of commercial shipbuilding - containerships, bulkers, and oil tankers - Japan and China specialize in building containerships and bulkers, while Korea is especially competitive at building tankers. European shipbuilding nations are specialized in passenger ships, dredgers, and ice classed vessels, which are typically higher value vessels (per CGT) than other commercial vessels. Italy, and to a lesser extent Germany, is particularly strong in designing and building passenger cruise vessels, the Netherlands and Belgium are specialized in dredgers, while Norway has particular strengths in designing and building ice-classed vessels and offshore vessels (EC, 2014). Shipbreaking, the demolition and scrapping of vessels, occurs primarily in South Asian countries, especially Bangladesh, India, and Pakistan, and China.

Box 4-1. Unique Aspects of Shipbuilding Data

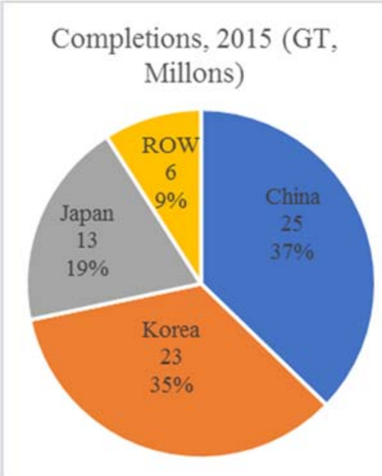
There are several caveats to measuring the size and scope of the global shipbuilding industry that are important to take into consideration when evaluating this GVC.

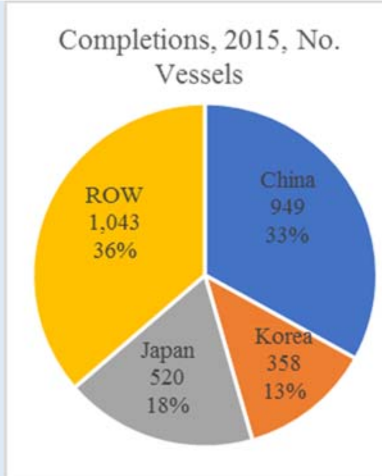
The first is related to data providers. Generally, the primary source of industry statistics related to production, trade, number of firms and employment is typically compiled by national statistical offices and customs (trade) based on international classification systems. While these are available for shipbuilding, the main sources used are private, third parties such as Clarkson, IHS, Lloyds, and Dewry that have access to ship production data. Due to the strong regulatory requirements for oceangoing commercial vessels, detailed production, ownership and service information must be collected by international classification societies. This data is collected for safety purposes, but it also useful for market research purposes. As such, several of these societies have separate units that sell this information via a separate business unit. That data collected by these agencies covers the entire population of shipyards (as opposed to samples in national statistics), and the level of detail is much higher. All three types of data are used in this report, and efforts to point out differences are made when possible.

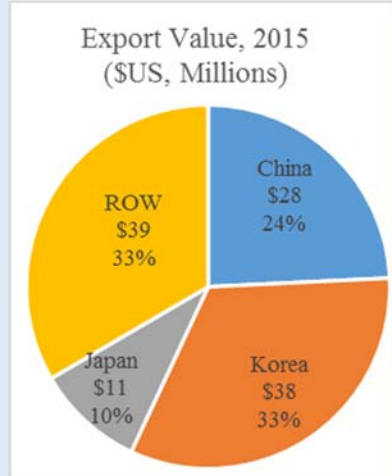
Second, the size of any segment also varies depending on the unit of measurement; the market is commonly described in terms of weight/carrying capacity of ships with common units including GT, CGT, DWT or TEUs. Market statistics are also produced based on orders, completions and deliveries (which can alter top categories and countries as well). The actual number of vessels produced and value are less commonly used, however the importance of the relative segments and top companies changes when using these indicators. Employment data also varies due to high use of temporary or contract workers (subcontractors). The minimum size of a ship to be included in statistics from IHS, UNCTAD and Clarkson's is typically 100GT.

The third important feature is geographic concentration of both demand and supply. Production is highly concentrated in a few countries, and a significant share of this is purchased by domestic buyers. As such, production and trade data will provide different perspectives. Furthermore, 'ship exports' are convoluted by the fact that ships are often 'flagged' by a country that is not the ship owner/buyer, and the fact that ships are never 'consumed' in one country. Therefore, import statistics are not particularly pertinent.

Figure 4-6. Leading Producers and Exporters in Shipbuilding, 2015







Sources for figures above: Completions from IHS (GT and #); Exports (UNComtrade)

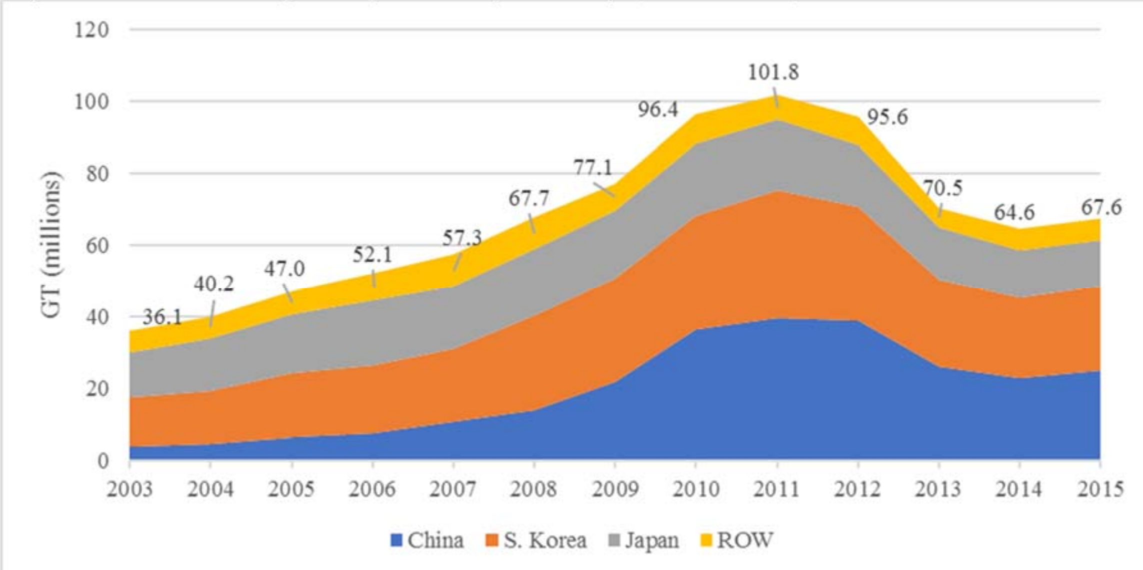
Global Statistics on Shipbuilding

- Deliveries (2016): 1,664 vessels; 66.3 million GT; 34.7 million CGT; 100.5 million DWT; value: US$80.2 billion (Clarksons, 2017b)
- Exports (2015): US$117 billion (UNComtrade, 2016)
- Revenue (2016): US$175 billion (IBIS, 2016)
- Production (Completions, 2015): 67.6 million GT; 2,870 ships (IHS, 2009-2016)
- Production (Deliveries, 2015): 64.1 million GT (UNCTAD, 2016b); based on Clarkson (UNCTAD matches Clarkson in 2014; IHS matches in 2015)
- Contracted (2015): 38 million CGT (DSF, 2016)
- Active Shipyards (2015): 730 (DSF, 2016)
- Shipyards with new orders (2015): 240 (DSF, 2016)

The expansion of global new ship orders since the early 2000s was hit by the 2008-2009 economic crisis. New orders dropped from 170 million GT in 2007 to 34 million GT in 2009.[16] The economic recovery since 2010 has rekindled demand for new ships, raising new orders to 77 million GT in 2015.[17]

[16] Gross tonnage (GT), a measure of ship size, is calculated based on "the molded volume of all enclosed spaces of the ship" and is used to determine a ship's manning regulations, safety rules, registration fees and port dues.
[17] Based on IHS (formerly Lloyd's Register) *World Shipbuilding Statistics*, which only includes ships 100GT or over.

Figure 4-7. World Ship Completions by Country (GT, million), 2003-15



Sources: IHS (2009-2016)

In terms of vessels completed, China (37%), Korea (34%), and Japan (19%) accounted for 91% of the world's approximately 68 million GT of ships completed in 2015 (see Figure 4-7). Korea completed 358 ships totaling approximately 23.3 million GT, equivalent to 34.4% of the world's total tonnage (see Table 4-2).

Table 4-2. Top 10 Shipbuilding Countries (based on GT Completed), 2015

Rank	Country	No.	'000 GT	No. Share (%)	GT Share (%)	No. Change	GT Change	GT (000)/ Ship
		2015	2015	2015	2015	2010-15	2010-15	2015
	World Total	**2,870**	**67,566**			**-23%**	**-30%**	**24**
1	China	949	25,160	33.1	37.2	-33%	-31%	27
2	Korea	358	23,272	12.5	34.4	-32%	-27%	65
3	Japan	520	13,005	18.1	19.2	-10%	-36%	25
4	Philippines	42	1,865	1.5	2.8	24%	61%	44
5	Taiwan	56	749	2.0	1.1	167%	29%	13
6	Vietnam	90	591	3.1	0.9	-32%	6%	7
7	Romania	39	485	1.4	0.7	-9%	-21%	12
8	US	75	427	2.6	0.6	-1%	79%	6
9	Germany	10	384	0.3	0.6	-72%	-59%	38
10	Brazil	32	361	1.1	0.5	52%	668%	11
Top 10 (based on GT) Share				76	98			

Source: IHS (2016)

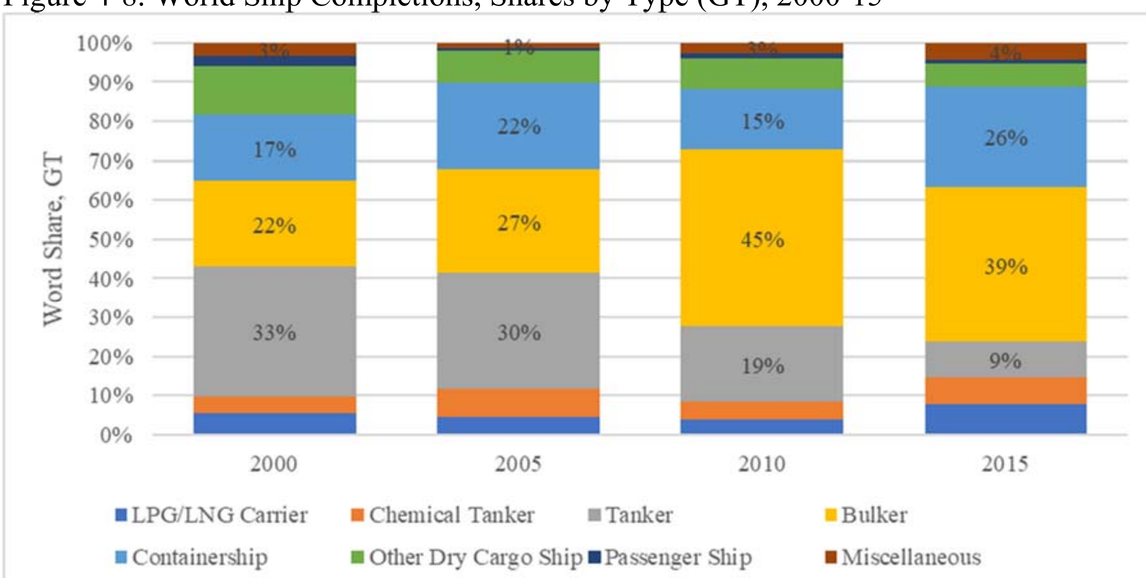
Regarding the type of vessels completed in 2015, product carriers dominated the market. Bulkers (39%), containerships (26%), and oil tankers (9%) are the top three vessel types in terms of world ship completions by gross tonnage (see Table and Figure). The share of LPG/LNG gas carriers has been rising in recent years (based on GT and numbers), indicating the growing markets for these vessel types. Offshore vessels account for less than 5% of GT, however, they are much more important based on value.

Table 4-3. World Completions by Type (No. & GT), 2015

Rank	Type	No.	GT ('000)	No. Share (%)	GT Share (%)	No. Change	GT Change	GT (000)/ Ship	Countries
		2015	2015	2015	2015	2010-15	2010-15	2015	
	World Total	**2,870**	**67,566**			**-23%**	**-30%**	**24**	
1	Bulker	645	26,520	22%	39%	-35%	-39%	41	China, Japan
2	Container ship	212	17,339	7%	26%	-18%	18%	82	Korea
3	Other Dry Cargo	332	3,876	12%	6%	-42%	-49%	12	China
4	Oil Tanker	130	6,384	5%	9%	-61%	-66%	49	Korea
5	LPG/LNG (Gas)	114	5,226	4%	8%	30%	42%	46	Korea
6	Chemical Tanker	208	4,588	7%	7%	-36%	1%	22	China
7	Miscellaneous	1,182	2,976	41%	4%	3%	16%	3	
8	Passenger Ship	47	656	2%	1%	4%	-48%	14	
Bulker/Containership/Cargo				**41%**	**71%**				
Tankers (oil, gas, chemical)				**16%**	**24%**				
Offshore			*2,500*		**4%**		*4%*		

Source: IHS (2016); p. 7, p. 35 (for offshore). Offshore classified under 'miscellaneous' in IHS data, however Clarkson's includes offshore as a category.

Figure 4-8. World Ship Completions, Shares by Type (GT), 2000-15



Source: IHS (2016)

A majority (63%) of the world's commercial shipping fleet, including oil tankers and bulk carriers, is under 10 years of age, 26% is between 10-19 years old, with the balance (11%) 20 years or older (IHS, 2016). The average in-service life for commercial vessels is 23 years, with few ships remaining in-service after 25 years (OECD, 2015a). World disposals peaked in 2012, with 38.4 million GT being scrapped. Bangladesh, India, China, Turkey and Pakistan are the leading countries for shipbreaking and disposal.

Global ship exports

Global exports of ships were US$117 billion in 2015.[18] The effect of the economic recession was noticed and disruptive to both trade in ships and new orders, although many shipbuilders are still completing orders made prior to the global financial crisis.[19]

Table 4-4. Top 10 Ship Exporters by Value & Year, 2007-2015

Exporter	**Exports (US$, Billions)**					**Share of World Ship Exports (%)**				
	2007	**2010**	**2012**	**2014**	**2015**	**2007**	**2010**	**2012**	**2014**	**2015**
Total	**88**	**156**	**140**	**123**	**117**					
Korea	27	47	38	38	38	30%	30%	27%	31%	33%
China	12	40	39	25	28	14%	26%	28%	20%	24%
Japan	15	26	22	13	11	17%	17%	16%	10%	10%
Poland	3	3	4	5	5	4%	2%	3%	4%	4%
Germany	3	5	3	4	4	4%	3%	2%	3%	4%
India	1	4	4	5	4	1%	3%	3%	4%	3%
Saudi Arabia	1	1	2	2	2	1%	0%	1%	2%	2%
Brazil	1	0	2	2	2	1%	0%	1%	2%	2%
Netherlands	1	1	1	2	2	2%	1%	1%	1%	2%
US	1	1	2	1	2	1%	0%	1%	1%	1%
Top 10 (in 2015)	**80**	**140**	**124**	**104**	**107**	**75%**	**81%**	**83%**	**79%**	**85%**

Source: UNComtrade (2016)

Korea is the top ship exporter whereas China is the top producer (based on GT); at least one-third of China's production is for national buyers.

Figure 4-9 shows the world's ship exports by vessel type. As with production, containerships/bulkers and tankers are two of the leading categories in exports. However, offshore ships account for a much larger share of the market based on value than by GT as these are smaller, higher value vessels (IBIS, 2016). They also account for a larger share because more are produced for foreign customers than domestic buyers.

[18] These and following export figures were compiled from UNComtrade, unless otherwise stated.

[19] The typical production time varies by the type of ship; a bulk cargo ship takes 6-9 months to build while a cruise or LNG ship takes up to 2 years or more for construction (European Commission, 2003, p. 11).

Figure 4-9. World Ship Exports, by Type & Value, (US$ billions), 2007-2015

Source: UNComtrade (2016)

Table 4-6 lists the leading exporting countries in the major traded ship categories: (1) containerships, bulkers, cargo, (2) offshore, (3) tankers, (4) passenger ships. Collectively these categories accounted for 89% of exports in 2015. Korea, China and Japan are driving global exports in containerships, bulkers, and general cargo. Korea dominates the offshore category and in tankers. Passenger ships are primary from European countries.

Table 4-5. Top World Ship Exporters by Type & Value, 2015

	Overall	Container, Bulkers, Cargo	Offshore	Tankers	Passenger
Total Exports (US$)	$117 billion	$44 billion	$36 billion	$22 billion	$5 billion
Top 5 (by	Korea (33%)	China (37%)	Korea (47%)	Korea (58%)	Germany (38%)

type)	China (24%)	Japan (21%)	China (18%)	China (18%)	Italy (23%)
	Japan (10%)	Korea (20%)	India (8%)	Japan (8%)	Finland (10%)
	Poland (4%)	Poland (6%)	Brazil (5%)	Poland (7%)	Philippines (7%)
	Germany (4%)	Germany (3%)	Netherlands (4%)	Germany (3%)	Poland (4%)
Korea	33%, 1st	20%, 3rd	47%, 1st	58%, 1st	1%, 14th
HS02		890190, 890130	8905, 890790	890120	890110

Source: UNComtrade (2016); See Appendix table for codes and world values. Other not shown (8902, 8904, 890690), but included in overall total.

Demand for large commercial shipbuilding is driven by trends in seaborne trade and vessel age (except offshore vessels and passenger vessels). Trade, measured in tons, has steadily increased since the 1990s reaching 10.5 billion tons in 2014.

Table 4-6. World Exports of Ship Subassemblies/Components, 2015

System/VC Stage	Specific to Ships	Item	Main Exporters	World Exports 2015 (US$, B)
Platform: Propulsion	Ship-Specific	Turbines for marine propulsion	Japan (42%), India (15%)	< $1
		-Spark-ignition reciprocating or rotary internal combustion piston engines -Outboard motors/Other	Japan (58%), US (16%)	$3
		Compression-ignition internal combustion piston engines (diesel or semi-diesel engines)	Korea (23%) Germany (21%)	$4
	Not Ship-Specific	Nuclear reactors, boilers, machinery and mechanical appliances/Other engines and motors/Hydraulic power/Other	Germany (16%) US (16%) UK (8%)	$3
		Parts for use with engines of heading 84.07 or 84.08 /Other/for use with spark-ignition internal combustion piston engines	Germany (19%) Japan (15%), US (12%), Mexico (10%)	$30
		Parts/applies to ships and auto for engines other than internal combustion	Germany (24%) China (7%), US (7%)	$33
Mechanical	Ship-Specific	Propeller & blades	Japan (21%), Germany (14%) China (12%)	$1
	Not S.-Specific	“Other machinery self-propelled, other”, 4D code lists ship derricks (crane)	Germany (24%) Japan (19%)	$3
Navigation & Comm-unication	Not Ship-Specific	Radar apparatus, radio navigational aid apparatus and radio remote control	China (16%) Germany (14%)	$18
		Surveying, hydrographic, oceanographic, hydrological, meteorological or geophysical instruments and appliances	US (22%) UK/Germany (17%)	$9
		Navigation-related	US (20%), France/ UK/Germany (30%)	$3
Hull/ Raw Materials	Not Ship-Specific	Steel	China (10%) Japan (9%) Korea (9%) Germany (7%)	$160
		Tubes & pipes & fitting (steel products)	China (19%) Germany/Italy (18%)	$71

Source: see Table A-4-1. Shipbuilding HS Codes.

4.1.5. Lead Firms and Governance Structure of the Shipbuilding GVC

Assembly and integration activities are organized as a tiered production system. The shipbuilder holds the contractual relationship with the ship owner. In commercial shipbuilding, the shipbuilder generally is responsible for hull fabrication, outfitting, and a range of service activities related to ship production, including procurement, sub-contracting, risk management, and scheduling, collectively known as Engineering, Procurement and Construction (EPC). The shipbuilder may also have design capabilities in-house. As an EPC, the shipbuilder typically develops a list of system and subsystem suppliers appropriate to the vessel specifications. Although the ship owner may add additional suppliers, the final procurement decision is made by the EPC to optimize cost and performance. Thus, the shipbuilder and ship owner collaborate in selecting the system and subsystem suppliers.

Depending on the capability of the shipbuilder and the complexity of the ship, major systems may be supplied either internally by the shipbuilding firm or by external firms. Some large shipbuilders are vertically integrated enough to use internally sourced propulsion systems; Hyundai Heavy Industries in Korea is a notable example. However, as the complexity of the ship increases, the more likely it is that systems are sourced externally from specialized firms. Below the shipbuilder are tier 1 companies, providing major systems for the ship. Additional tiers to this system supply subassemblies, components, and raw materials to the shipbuilder and tier 1 suppliers.

Table 4-7. Global Lead System Suppliers

System	Global Lead Firms
Propulsion/ Electric Power Generation	MAN Diesel (Germany), Wartsila (Finland) *Licensees of one or both of above companies:* HHI (Korea), Doosan (HSD) (Korea), Mitsui (Japan), Mitsubishi (Japan), Hitachi Zosen (Japan), Diesel United (Japan) *Others:* Caterpillar Marine Power Systems (US), GE (US), Rolls Royce (UK/US), TECO Westinghouse (US), ABB (Switz), Sulzer (Switz), Stadt (Norway), Schottel (Germany), Volvo Penta (Sweden)
Navigation & Electronics	Kongsberg Maritime (Norway); Siemens (Germany); ABB (Finland/Norway/Switz.); Wartsila/SAM Electronics (Netherlands); Imtech Marine (Netherlands); SperryMarine/Northrup Grumman (UK)
Communication	L-3 Communications (US); Inmarsat (UK); EADS/Astrium (France); Telenor Satellite Broadcasting (Norway); Cobham SATCOM (UK)
Cargo Handling	Cargotec (Finland); Liebherr (Switz); TTS Group (Norway); Scana Industrier (Norway)
Auxiliary Systems & Outfitting	HVAC: Bronswerk Marine (Canada); Ballast water treatment/emission control: Alpha Laval (Denmark), Wartsila Hamworthy (UK); Autronica Fire & Security (Norway); Winches: Bosch Rexroth (Germany) Electrical systems: Schneider Electric (France) Life-saving equipment: Survitec Group (UK)
Coatings/Paint	AkzoNobel (Brand: International Paint) (Netherlands), Hempel (Denmark) Chogoku Marine Paints (Japan), Jotun Paints (Norway), PPG Coatings (Belgium), Sigma Samsung Coatings (Korea), Subsea Industries (Belgium)
Other	Offshore Engineering & Construction: Saipem (Italy), Tyco Marine (UK); Technip (France); Aker Solutions (Norway)

Source: Authors; see also (EC, 2014)

At the components level, the degree of coordination and information exchange between buyer and supplier (i.e., value chain governance) depends on the level of product value and supply chain risk to the shipbuilder (EC, 2014). Components suppliers typically have multiple clients, both in terms of geography (i.e. domestic versus international) and industry (e.g. aerospace, infrastructure, mining and oil and gas).

- *General product*s, defined as off-the-shelf standardized products, are characterized by low product value and low supply chain risk. For example, pumps required for shipbuilding have general specifications, are readily available in large quantities, and are manufactured by several suppliers. The critical factors in general products are the acquisition costs and ease of ordering for the buyer, and quick response and delivery by the supplier.

- *Strategic products* -- those that provide product differentiation competitive advantages to the shipbuilder, are characterized by high product values and high supply chain risk. The critical factors for strategic products are long-term sourcing, long-delivery lead times, and long-term contractual agreements between the supplier and shipbuilder. Engines and complex integrated bridge systems are examples of strategic products in the shipbuilding sector because they have special-to-type specifications, are developed cooperatively with the shipbuilder, and few manufacturers exist to provide the systems.

- *Price critical products* are high value (i.e., relatively expensive to produce and purchase) but with low supply chain risk due to their general availability in the market. These are standard catalog products such as diesel generators and deck cranes, that are available from several suppliers. Differentiation among suppliers is based on price and consistent product quality; suppliers are managed by the shipbuilder through supplier audits and individual price negotiations.

- Finally, *bottleneck products* have relatively low value but are critical for the final product. Suppliers are differentiated by their ability to deliver on time with consistent product quality; they closely coordinate their activities with the shipyards to ensure timely delivery at a reasonable price. Examples are ship propellers and fire doors (EC, 2014).

Shipbuilding is becoming increasingly concentrated; in 2015, only 240 shipyards received an order (although 730 were active), with 47% of orders going to 20 large shipyards (annual max capacity above 500,000 CGT) and another 47% to medium shipyards. Small shipyards only accounted for 6% of orders (annual maximum capacity of less than 80,000 CGT). Typical shipyard size also varies by country, although all large shipyards are in China, Korea, and Japan (DSF, 2016). Korea's orders are dominated by large shipyards (91% of new orders in 2015) whereas medium yards dominate in Japan (large was only 20% of new orders). China is composed of a fairly even split between large and medium firms (DSF, 2016). The number of large yards has remained constant, from 20 to 24, on average attracting 46% of annual contracting over the five-year period; 20 of the large yards have existed since at least 2011 (i.e., new large yards are uncommon).

Table 4-8. Geographical Distribution of Active Shipyards, 2015

Country	2011 (Active)	2015 (Active)	2015 w/new orders
China	191	200	75
Korea	22	30	13
Japan	48	70	55
Philippines	4		
Other		430	97
World		730	240

Source: 2011, Clarksons (2013); 2015, (DSF, 2016), p. 29-33. DSF data based on CGT, an international unit of measure that facilitates a comparison of different shipyards' production regardless of the types of vessel produced.

Offshoring production is uncommon in shipbuilding. Lead firms (with a few exceptions) primarily only own shipyards in their home country. This is at least partially tied to naval shipbuilding as countries want to keep the skills/technology to produce ships close to home for national defense reasons.

Table 4-9. Top Global Shipbuilders

Orderbook Value US$*	Name	Revenue $US, B*	Emp. ('000)	Year Est.	Ownership	Segments/Types (CGT, 2016)	Linkages/ Locations/	Yards
$24.4	Hyundai Heavy Industries (HHI)	$40.9 $16.4	27	1972	Korea, Ulsan KSE: 009540		Engines; steel; shipping HSHI: Mokpo, 2002 (acq.); $3.3B	3
$19.9	Daewoo (DSME)[20]	$13.3 $12.6	13	1973	Korea, Seoul KSE: 042660	Container (32%), LNG/LPG (32%), Oil Tankers (29%) Offshore (7%)		1-2
$10.5	Samsung Heavy Industries (SHI)	$8.6 $3.9	14	1974	Korea, Seoul KSE: 010140	Container (52%), LNG (36%), Offshore (13%)	China	2
	Hyundai Mipo Dockyard (HMD)[21]	$3.3		1975	Korea, Ulsan	Chemical tankers, containerships	Vietnam	2
	Tsuneishi				Japan	Bulkers (100%)	Philippines, China	3
	Yangzijiang Shipbuilding (Holding Co.)	$2.6	.9	2005	China Singapore SE: BS6	Bulkers, containerships	China (Jiangsu New YZJ), Singapore, US	3
$9.9	Imabari Shipbuilding			1942	Japan Private	Bulkers, containerships, tankers, others		9
$15.1	China State Shipbuilding Corp. (CSSC)			1999	China, Beijing SOE		Shanghai Waigaoqiao SB (SWS)	3?
	China COSCO		150	1999	China, Beijing	Dalian Shipyard largest. CSSC		7

[20] Recently had a yard in Romania, but sold: www.reuters.com/article/us-daewoo-restructuring-idUSKBN17K0KX
[21] HMD claims to have the largest global ship repair facility.

Orderbook Value US$*	Name	Revenue $US, B*	Emp. (‘000)	Year Est.	Ownership	Segments/Types (CGT, 2016)	Linkages/ Locations/	Yards
	Shipping (COSCOCS)[22]				SOE SSE: 601989	spin-off.		
	Hanjin Heavy Industries & Construction (HHIC)	$2.8 $1.5?	2.6	1937	Korea, Busan KSE: 097230	Container, bulkers, gas	Philippines	2
	Fujian Shipbuilding				China			4+
	Oshima Shipbuilding				Japan Private	Bulkers (100%)		1

Sources: Generally based on Clarkson’s 2016 rank by CGT, GT, DWT and number of ships completed. Other sources: WMN (2016) (Orderbook value in $US billions as of March 2016; same data provided in Statista), IBIS (2016), Clarksons (2011), Worldyard Statistics (2011). For Korean companies: MarketLine Company Reports; KOSHIPA members; OneSource. Notes: Revenue column (*): first number is total revenue and second is shipbuilding-specific revenue for most recent year available. KSE designates stock exchange number.

4.1.6. Standards and Institutions

The shipbuilding industry has several classification and certifications relevant to the design, production, and post-production phases of shipbuilding. “Classification” establishes that a ship or offshore structure conforms to class rules developed by national classification societies during construction and time in-service, which are verified through periodic inspections called “surveys”. Ship class rules are standards for the structural strength, integrity, and functioning of various parts of a ship, including the hull, propulsion, steering, power and essential service-related auxiliary systems (IACS, 2016). “Certifications” establish conformity with safety, health, and environmental statutory requirements found in international conventions or national legislation (Table 4-10). Certifications in the marine industry are applicable to ships, offshore units and installations, marine equipment, training and management systems and thus are relevant to marine products and their components, services, people and systems (BV, 2017). We discuss classifications and certifications in turn below.

Table 4-10. Standard Setting Organizations and Agreements in the Shipbuilding GVC

Organization	Description	Reference
International Association of Classification Societies (**IACS**)	Umbrella organization for the major twelve national classification societies, which comprise more than 90% of in-service cargo ships. The twelve members are listed below.	www.iacs.org.uk/default.aspx
National classification societies	Classification societies set technical rules, confirm that designs and calculations meet these rules, inspect (“survey”) ships and structures during construction and commissioning, and survey vessels to	US: American Bureau of Shipping (ABS) UK: Lloyd’s Register (LR) Russia: Russian Maritime Register of Shipping Poland: Polish Register of Shipping (PRS) Korea: Korean Register of Shipping (KRS)

[22] Formed by Government of China in July 1999 from companies spun-off from CSSC, and is 100% owned by SASAC. CSIC handles shipbuilding activities in the north and west of China, while CSSC deals with those in the east and the south of the country (Wikipedia). Think is the same as China Shipbuilding Industry Corp (CSIC).

Organization	Description	Reference
	ensure that they continue to meet the rules during in-service.	Japan: ClassNK Italy: Registro Italiano Navale (RINA) India: Indian Register of Shipping (IRS) Germany/Norway: Det Norske Veritas (DNV) Germanischer Lloyd (GL) (DNV-GL) France: Bureau Veritas (BV) Croatia: Croatian Register of Shipping (CRS) China: China Classification Society (CCS)
International Maritime Organization: (**IMO**)	United Nations agency founded in 1948; establishes standards on maritime safety, health and environmental protection.	www.imo.org/en/About/Pages/Default.aspx List of IMO conventions: www.imo.org/en/About/Conventions/ListOfConventions/Pages/Default.aspx
International Convention for the Safety of Life at Sea (**SOLAS**)	(1974): IMO convention that governs safety regulations for ships.	www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-%28SOLAS%29%2c-1974.aspx
International Convention for the Prevention of Pollution from Ships (**MARPOL**)	International Convention for the Prevention of Pollution from Ships (1973, modified 1978, 1997): IMO convention that governs air and water pollution released from marine sources. **Annex VI,** limits sulphur oxide and nitrogen oxide emissions from ship exhausts and mandatory technical and operational energy efficiency measures aimed at reducing greenhouse gas emissions from ships.	www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-%28MARPOL%29.aspx

Sources: references in table.

Classification: IACS is the umbrella organization for 12 of the world's major classification societies, including those of the US, Korea, China, and Japan. More than 90% of the world's cargo carrying ships' tonnage is covered by the classification standards set by the 12 member societies of IACS (IACS, 2016). The IACS holds special status with IMO regarding the development and application of rules in the shipbuilding industry, including those related to the International Convention for the Safety of Life at Sea (SOLAS) and MARPOL (marine pollution). While classification represents the level of compliance of a ship or offshore structure to these rules, they are not a warranty of the ship's safety, seaworthiness, or that the ship is being operated in a manner consistent with its purpose. Classification societies have no control over how a vessel is manned, operated, and maintained between the periodic surveys (IACS, 2016). Classification societies set technical rules, confirm that designs and calculations comply, survey ships and structures during construction and commissioning, and inspect vessels while in-service to ensure that they continue to meet class rules. Table 4-12 details the key inspections undertaken by these classification societies.

Table 4-11. IACS Required Inspections ("Surveys")

Survey Name	Description	Frequency
Assignment of Class	Class is assigned to a vessel following review of the design and compliance surveys during construction.	**on completion of the new build**, **ship transfer** between IACS members **on completion of a satisfactory specific class survey** of an existing

Survey Name	Description	Frequency
		ship not classed with an IACS society, or not classed at all.
Annual survey	The ship is generally examined. The survey includes an inspection of the hull, equipment and machinery.	Annually (three months before to three months after anniversary date)
Intermediate survey	Includes examinations and checks on the ship's structure for compliance. Rule criteria become more stringent with age. According to the type and age of the ship the examinations of the hull may be supplemented by thickness measurements.	Every three years (three months before second to three months after third anniversary date)
Class renewal or "special" survey	Includes extensive examinations to verify that the structure, main and essential auxiliary machinery, systems and equipment are in satisfactory condition. Examinations of the hull are supplemented by thickness measurements to assess that the structural condition remains effective and to help identify substantial corrosion, significant deformation, fractures, damages or other structural deterioration.	Five-year intervals
Bottom or "Docking" survey	A bottom/docking survey is the examination of the outside of the ship's hull and related items. This examination may be carried out with the ship either in dry dock (dry-docking survey) or afloat (in-water survey). The conditions for acceptance of an in-water survey in lieu of dry-docking depend on the type, age and history of the ship.	Twice in five-year period. One of the two bottom surveys to be performed in the five-year period is to be concurrent with the class renewal survey.
Tailshaft survey	A tailshaft survey is the survey of screwshafts and tube shafts (hereafter referred to as tailshafts) and the stern bearing. Three different types of tailshaft surveys exist: **partial, modified, and complete**. "Complete" means that the shaft is drawn up for examination or that other equivalent means of examination are provided. Partial and modified are more limited examinations.	**Partial**: Permits the postponement of the complete survey, having a periodicity of 5 years, for 2.5 years. **Modified**: Alternate five-yearly surveys for tailshafts. **Complete:** Based on the type of shaft and its design.
Boiler survey	Steam boilers, superheaters and economizers are examined. Boilers are drained and prepared for the examination of the water-steam side and the fire side.	Boilers and thermal oil heaters must be surveyed twice in every five-year period. The periodicity of the boiler survey is normally 2.5 years.
Non-periodical survey	• To update classification documents (e.g. change of owner, ship name, change of flag); • To deal with damage or suspected damage, repair or renewal work, alterations or conversion, postponement of surveys or outstanding conditions of class; • At the time of port State control inspections.	Earliest opportunity and without delay

Source: IACS (2016)

Certifications: Certifications, on the other hand, establish compliance with international and national statutory (legal) requirements regarding the safe and sustainable operation of ships. Certifications cover ships, marine equipment, people and management processes.

Statutory certification of ships: The IMO[23] sets out uniform safety, security, pollution mitigation, and sustainability requirements to promote trade by ensuring that a ship registered in one country is accepted by the waters and ports of another (IACS, 2016). Statutory certifications cover four

[23] Established under the United Nations Convention on the Law of the Sea (UNCLOS) in 1948.

broad areas: (1) design and structural integrity; (2) pollution control during normal operation (see below); (3) accident prevention; and (4) accident mitigation, including containment and escape.[24]

Pollution control during normal operation must comply with several statutory and treaty obligations. Most notable among these are the ballast water convention (2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments) requiring the bilge to be free from fouling organisms by September 2017, and the IMO's adoption of enhanced environmental regulations, including reductions in the emission of marine air pollutants from ships. First adopted in 1997, MARPOL limits the main air pollutants contained in ships exhaust gas, including sulphur oxides (SOx) and nitrous oxides (NOx); prohibits the deliberate emission of ozone depleting substances (ODS) and; regulates shipboard incineration, and the emissions of volatile organic compounds (VOC) from tankers. These conventions also regulate emission caps and special emissions control areas (ECAs) for SOx and NOx emissions in specific geographic areas, and stepwise reductions in CO_2 emissions (IMO, 2017a) (IMO, 2017b).

Marine equipment certification: Classification societies also establish procedures to approve marine equipment suppliers. For example, since 1999, EU's Marine Equipment Directive (MED) requires certain categories of marine equipment placed on European ships to have an EU marine equipment "conformity mark." The categories of equipment include lifesaving appliances (i.e., lifeboats and lifejackets), marine pollution prevention equipment, fire protection equipment, navigation and radio communication equipment (BV, 2017). Korea's Classification Society (KRS) identifies radio equipment, fire extinguishing equipment, lifesaving equipment, voyage recorders and low location lighting (LLL) systems as among the marine equipment requiring certification to be compliant with KRS rules and national legislation (KRS, 2017a).

Management processes: Various standard management system process standards are relevant to the shipbuilding industry. Among the most common are ISO 9001, 14001, 28000, 28007, 50001 and OHSAS 18001. ISO certifications are typically valid for three years (see table below for description).

Table 4-12. Management System Certifications in Shipbuilding

Standard	Description	Source
ISO 9001	Quality management certification	https://www.iso.org/obp/ui/#iso:std:iso:9001:ed-5:v1:en
ISO 14001	Environmental management system certification	https://www.iso.org/obp/ui/#iso:std:iso:14001:ed-3:v1:en
ISO 28000	Supply chain security management certification	https://www.iso.org/obp/ui/#iso:std:iso:28000:ed-1:v1:en
ISO 28007	Guidelines for Private Maritime Security Companies (PMSC) providing privately contracted armed security personnel (PCASP) on board ships	https://www.iso.org/obp/ui/#iso:std:iso:28007:-1:ed-1:v1:en
ISO 50001	Energy efficiency management system certification	https://www.iso.org/obp/ui/#iso:std:iso:50001:ed-1:v1:en

[24] The statutory certification of the design and structural integrity may be fulfilled by the classification survey; in other words, the classification survey may be given the status of the required statutory survey if the classification society is designated as the recognized organization to perform this function (IACS, 2016)

OHSAS 18001	Occupation health and safety management system certification	http://www.osha-bs8800-ohsas-18001-health-and-safety.com/ohsas-18001.htm

National legislation on inland and nearshore commercial vessels: Many countries designate coastal and inland waterways as closed to international vessels. The limitations are variously defended as required on national security and national capability grounds. Known as "cabotage" restrictions, these laws generally require vessels operating in coastal and inland waters to be flagged by the country and manned by sailors with citizenship or permanent residence in the country. In the U.S., the Jones Act (Merchant Marine Act of 1920) requires all goods transported by water between U.S. ports to be carried on U.S.-flag ships, which must be constructed and owned by U.S citizens, and crewed by either U.S. citizens or permanent residents.[25] Other countries with cabotage laws include Argentina, Japan, India, and Malaysia (UNCTAD, 2016b).[26]

4.1.7. Human Capital and Workforce Development

Shipbuilding is highly labor intensive, with the largest shipyard employing tens of thousands of workers. Workers tend to be skilled labor, ranging from welders to marine engineers. In countries with low labor costs, labor intensity tends to be higher as operators take advantage of lower wages. There were approximately 1 million employed by the ship and boat building industry globally in 2016 (IBIS, 2016). A report by the OECD estimated global employment in 2010 to be 1.875 million (OECD, 2016).

Given the project-based nature of shipbuilding, subcontracting is common. Subcontracting occurs in two ways. The primary shipbuilder hires subcontracted laborers (instead of regular workers) for shipyard workers (i.e., welders, fitters, operators, etc.). Although they receive temporary contracts, given the time to build a ship, they are often for a year and tend to be renewed if work at the shipyard is steady. Alternatively, primary shipbuilders will outsource a portion of the assembly process to a nearby shipyard. In many cases, subcontracted firms also co-locate in the same facility as the primary shipyard and operate as if they were a part of the main company.

Like materials and equipment purchases, the relative share of labor costs varies based on ship type and country, but typically falls in the range of 15-30% (IBIS, 2016; Korean Shipbuilding Stakeholders, 2017; Philippines Shipbuilding Stakeholders, 2016). Generally, ships with a higher share of material versus equipment costs will require more labor (i.e., bulkers, containerships).

Table 4-13. Employee Profile for the Shipbuilding Assembly

Position	Share	Median Hourly Wage (US$)	Education	Job Characteristics
Production/ Assembly	71%	$22	High school and technical college	Production, Construction, and Maintenance, including Welders, Crane Operators, Steel

[25] http://www.maritimelawcenter.com/html/the_jones_act.html

[26] For example, in Japan the limitations on foreign vessels in these waters is defended as protecting the domestic shipping industry from foreign competition, preserving domestically owned shipping infrastructure for national security purposes, and ensuring safety in congested territorial waters (JFCSA, 2011). The restrictions also may guarantee work for domestic shipyards if ships built in the country are required (UNCTAD, 2016b).

Position	Share	Median Hourly Wage (US$)	Education	Job Characteristics
				Cutters, Outfitters, Painters
Engineers	11%	$34	Technical, college, and/or post-graduate education	Engineers (electrical, mechanical, marine, naval architects; design (CAD))
Administrative	13%	$25	Technical, college, and/or post-graduate education	Business and financial operations, office and administrative support, sales & marketing
Managerial	4%	$53	Post-graduate	Management occupations
Subcontractors	*46%*			Approx. share of employment; primarily from production workers

Source: wage and share data based on BLS (2015). Occupational breakdown is similar for Korea based on data from KOSHIPA (2001-2015). Subcontractor share based on Japanese data from IHS (2009-2016).

Shipyard workers are needed to perform a variety of different tasks including welding (blocks and pipes), fitting (pipe fitting/ship outfitting), painting, masonry/carpentry, electrical work, and plumbing. The types of workers needed to build a ship are like those in the construction industry, and to a lesser extent other transportation equipment such as automobiles, airplanes, or trains and skills are thus relatively transferable across industries. Given the importance of regulations and safety in shipbuilding and all transportation industries, workers must demonstrate their ability to perform to standard operating procedures for specific tasks (i.e., welding) and employers are required to maintain documents proving their capabilities. For example, welds must be certified as being completed by a certified welder and following approved welding procedure specifications (WPS).[27] The specific qualifications of certified welders are determined by the classification society, but generally, certification requires the welder to produce test welds of acceptable quality, which are then subjected to visual examination, non-destructive testing (NDT), and mechanical testing. IACS and DNV require that welders are qualified to society recognized standards[28] Welders qualified for more difficult welds are also approved for easier welds. As such, training and workforce development are important for shipyards building and repairing IACS vessels. However, specific workforce qualification requirements are changing along with the introduction of new technologies; for example, as welding becomes more automated and mechanized, welding operators of mechanized or automated processes do not need to pass approval testing as long as they maintain records exhibiting their proficiency in programming and operating the equipment (Moore, 2009).

Box 4-2. Workforce Development in Singapore's Shipbuilding Sector

In Singapore, the shipbuilding sector is hallmarked by a strong training culture with multi-stakeholder support. Major shipyards and marine companies have invested in training infrastructure and resources in-house to ensure that workers are trained and reskilled

[27] WPS is a document providing in detail the required variables for specific application to assure repeatability by properly trained welders

[28] EN 287 (standard for welding steel) has been replaced with ISO 9606 covering a variety of metals as of October 2015 and is now more similar to ASME Section IX. (www.twi-global.com/technical-knowledge/job-knowledge/a-comparison-of-bs-en-287-part-12011-with-bs-en-iso-9606-part-1-130/) ASME IX (arc welds) and AWS D1.1 (laser welds) cover different types of welds. A good description of Section IX and ANSI/DWS D1.1 is offered by www.thefabricator.com/article/shopmanagement/asme-and-aws-welding-codes-similarities-and-differences

continuously to keep up with changing requirements to execute work safely. Key industry players worked with the Association of Singapore Marine Industries (ASMI) to set competency standards, develop generic curriculum for training marine workers and supervisors as well as certify workers' skill competency.

In recent years, academic courses on marine and offshore technology have been introduced at the technical, diploma and degree levels to ensure a continuous pipeline of trained manpower to support the sector's specialized manpower needs. ASMI continues to partner with key industry players to offer scholarships to students enrolled in relevant courses at the technical institutes, polytechnics and universities. This collective offering of scholarships is aimed at attracting more talents to join the industry as well as to groom competent leaders for the future (ASMI, 2014).

4.1.8. Upgrading Trajectories in the Shipbuilding GVC

Upgrading in the shipbuilding GVC can be analyzed in two ways. The first approach is to define the level of sophistication and capability of a company, or portfolio of firms in a country, within a segment of the value chain as low, medium, or high, and to find pathways to increase the level of sophistication of the firm, or portfolio of firms in a country, within a value chain segment. The second is to look across the entire value chain of a product and identify ways to achieve product, process, functional, and inter-sectoral upgrading of the value chain by a firm or portfolio of firms in a country.

Increased Sophistication within a Value Chain Segment
In pre-production segments, upgrading requires improvements in research, design and purchasing capabilities. Within **design**, the challenge is moving from the design of relatively simple components, to the design of systems with multiple components, to the design of ships with multiple systems, and from there to the design of increasingly more sophisticated vessels. For example, upgrading in design would move from the design of bulkers – considered relatively simple commercial vessels -- to passenger vessels and icebreakers, which are some of the most sophisticated. In the **research** segment, firms with low levels of capability engage in incremental innovation, adding simple customization to existing products, such as redesigning existing ships for conversion and refitting. Firms with a medium level of sophistication in research could design a new hull with increased efficiency or sturdiness; for example, STX Canada Marine's (now Vard Marine) design of Canada's Icebreaker. Firms with high levels of research capabilities create new products. For example, Akzo Nobel/International Paints (NL) developed new, biocide-free antifouling paints with extremely slippery surfaces, thus limiting the ability of fouling organisms to grow on the hull and increasing fuel efficiency.[29] The **purchasing** capabilities of companies can also be tracked along a continuum of less to more sophisticated supply chain management practices. Companies with a high level of sophistication search for global component suppliers and evaluate them using balanced scorecards to determine ongoing suitability for inclusion in their supply chain.

[29] http://www.international-marine.com/foulrelease/foul-release-home.aspx

Within **production**, firms can be evaluated based on the type of commercial vessel they produce. Fincanteiri (IT), a well-known cruise ship designer and shipbuilder, is constructing some of the newest and most sophisticated passenger vessels around the world for Carnival and Norwegian Cruise Lines. Each ship requires sophisticated design and engineering with very high levels of customization. In contrast, China's Yangzhou Guoyu Shipbuilding Company produces relatively simple cargo vessels and bulk carriers that contain few modifications from ship to ship. These vessels are much simpler to produce, requiring little innovative production techniques or sophisticated integration. A third category of vessels, offshore vessels, can range from very simple (supply vessels) to highly complex (drill ships). Due to their broad range of sophistication, shipbuilders of a variety of capabilities can participate in this segment of the market, eventually increasing the range of products provided by increasing their capability in the market segment.

In **post-production**, companies provide a range of maintenance, repair and overhaul (MRO) services to in-service vessels to ensure that they remain compliant with regulations. Shipyards and service providers within this segment can be distinguished by the types of vessels and systems they are qualified to work on. Highly capable companies work on complex systems and vessels, while less capable companies work on less sophisticated ones. As noted in the standards and institutions section, shipyards specializing in ISS and MRO must be capable of meeting classification society requirements for the ship class, which generally requires the ability to meet new construction welding processes. Interestingly, in the final stage, shipbreaking, many of the South Asian countries with extensive experience in shipbreaking are now starting to develop their own shipbuilding industries (Johari, 2011). Thus, shipbreaking can be a pathway into shipbuilding. Table 4-14 summarizes how companies can upgrade capabilities within each segment of the shipbuilding value chain.

Table 4-14. Capability Upgrading in the Shipbuilding GVC

Stage	Value Chain Segment	Capability Level	Activity	Example
Pre-production	Research & Design	Low	Product design modification and customization	Re-designing ships for conversion and refitting
		Medium	Applied research and new product design	Developing a new hull design with advanced capability or efficiency
		High	Basic nautical research	Conducting scientific research to develop new anti-fouling coatings
	Purchasing	Low	Local search for supply chain partners	Shipbuilder identifies outfitting contractors within 20 km of plant
		Medium	Local and regional search for supply chain partners + practice of simple supply chain management practices	Shipbuilder scans for regional outfitting contractors and maintains informal quality assessments of suppliers
		High	Regional and/or global search for supply chain partners + sophisticated supply chain management practices	Shipbuilder seeks "best in class" component producers and evaluates suppliers with balanced scorecards
Production	Production	Low	Construction + assembly of simple vessels	Cargo vessels and bulk carriers
		Medium	Block construction + assembly for moderately complex vessels	Producing moderately sophisticated ships (oil tankers; RoRos)
		High	Fully integrated block construction + assembly for	Producing sophisticated passenger ships (cruise ships) or military vessels (frigates; aircraft

Stage	Value Chain Segment	Capability Level	Activity	Example
			complex vessels	carriers)
Post-production	Marketing, distribution and post-production services	Low	Domestic distribution + MRO	Domestic distribution and MRO repair network for locally owned and operated commercial vessels
		Medium	Domestic + regional distribution and MRO	Regional distribution of assembled vessels and providing MRO for regionally-owned and operated commercial + passenger vessels
		High	Domestic + regional + international distribution and MRO activities + advanced post-production services, such as consulting & training	Global export of assembled vessels; providing MRO for globally-owned and operated commercial/passenger or sophisticated military vessels; providing post-production services for commercial/passenger + military vessels

Source: Authors; adapted from Brun et al. (2012)

Value Chain Upgrading

A second path to upgrading is to distinguish between product, process, functional, and intersectoral upgrading of the value chain.

- **Entry** into the value chain is a necessary precondition to upgrading and exemplified by a firm entering the shipbuilding segment and offering a simple product or service within the shipbuilding industry. Examples could include companies producing a simple boat placed on a larger seagoing vessel, or offering welding subcontractor services. In either case, the focus of the firm is narrow to provide a product or service to a specific customer or end market in the sector.
- In **process upgrading**, a firm produces a product or service more efficiently. For example, some shipbuilders adopted robotic plasma steel plate-cutting to improve cutting quality, speed, and waste reduction. In-sourcing and outsourcing decisions are also examples of process upgrading practices.
- The purpose of **product upgrading** is to increase the value of the good or service produced by a firm. For example, a firm could produce a more durable product or provide a service requiring advanced engineering capabilities more valued in the marketplace.
- Upgrading can also be achieved by establishing additional **backward linkages** in the production-related segments of the chain. An example would be if a ship assembly facility or country establishes a local engine, steel or propeller manufacturing operation (typically via FDI).
- In **functional upgrading**, a firm enters new segments of the value chain. Examples include adding maintenance services to existing product offerings. For example, a company may start in ship repair or as a contract manufacturer, but over time takes on additional responsibilities such as input purchasing, logistics, NPD, or marketing.
- Finally, **intersectoral upgrading** occurs when a firm enters a new GVC based on the skills learned in the shipbuilding industry (i.e., entering the energy production GVC).

Figure 4-10. Types of Upgrading in the Shipbuilding Value Chain

	Value Chain Segments	Description	Example

	Value Chain Segments	Description	Example
Entry	Production, Services	• Firm offers basic shipbuilding services. • Focus of the company may be relatively narrow to focus on a specific customer, product, service or end-market.	• Company provides welding services for block construction. • Company provides design services for simple commercial ships.
Increasing productivity (Process Upgrading)	Purchasing Production Marketing Distribution	• Company focuses on increasing the productivity of value chain segments. • Reconfigures production processes, pre- and post-production activities to become more efficient. • Outsourcing and in-sourcing are considered options for increasing productivity.	• Company reconfigures production line to improve efficiency. • Company streamlines distribution network to increase speed to market • Company outsources product design to specialized firm,
Better products or services (Product Upgrading)	Production Services	• Company offers better, higher quality products and/or services. • Focus of the company is to increase unit value of products or services offered.	• Company produces more durable or better-designed products. • Company offers services requiring advanced engineering capabilities.
Expansion across value chain segments (Functional Upgrading)	R&D Design Production Services	• Firm adds services to existing product manufacturing or adds product manufacturing to services. • Focus of the company expands to an increasing number of value chain segments, products, or services. • Company may carry out pre-production processes, such as design or product development with a major customer or research partner.	• Shipbuilder offers design or MRO services

Source: Authors; modified from Brun et al. (2012); Not pictured: intersectoral upgrading.

While listed separately above, the various types of upgrading often occur in combination. For example, Hawboldt Industries (CAN) traditionally only produced winches for shipboard use; however, due to the interest of one of its customers, International Submarine Engineering (ISE), it now designs and builds the Launch and Recovery System (LARS) for ISE's autonomous underwater vehicle (AUV).[30] In this case, Hawboldt engaged both product upgrading (making a more sophisticated product) and functional upgrading (participating in design with manufacturing).

4.2. The Asian Regional Value Chain (RVC)

Having discussed the global shipbuilding value chain, we now turn to the Asian regional value chain within the commercial shipbuilding industry. For most regions and industries, the global

[30] http://hawboldtind.com/project/launch-recovery-system-for-autonomous-underwater-vehicle-auv/

and regional value chains differ with regards to lead firms and position within the value chains. However, in the case of commercial shipbuilding, Japan, Korea, and China are both global and regional leaders and the analysis of the global industry also covers the region. As a result, much of the analysis and discussion provided in the global section is also relevant to the analysis of the region. In order to not duplicate the narrative in the global section, we more closely examine the shifting geography of commercial shipbuilding from Japan to Korea and China, paying particular attention to the relative productivity and production costs within product segments leading to the market shifts.

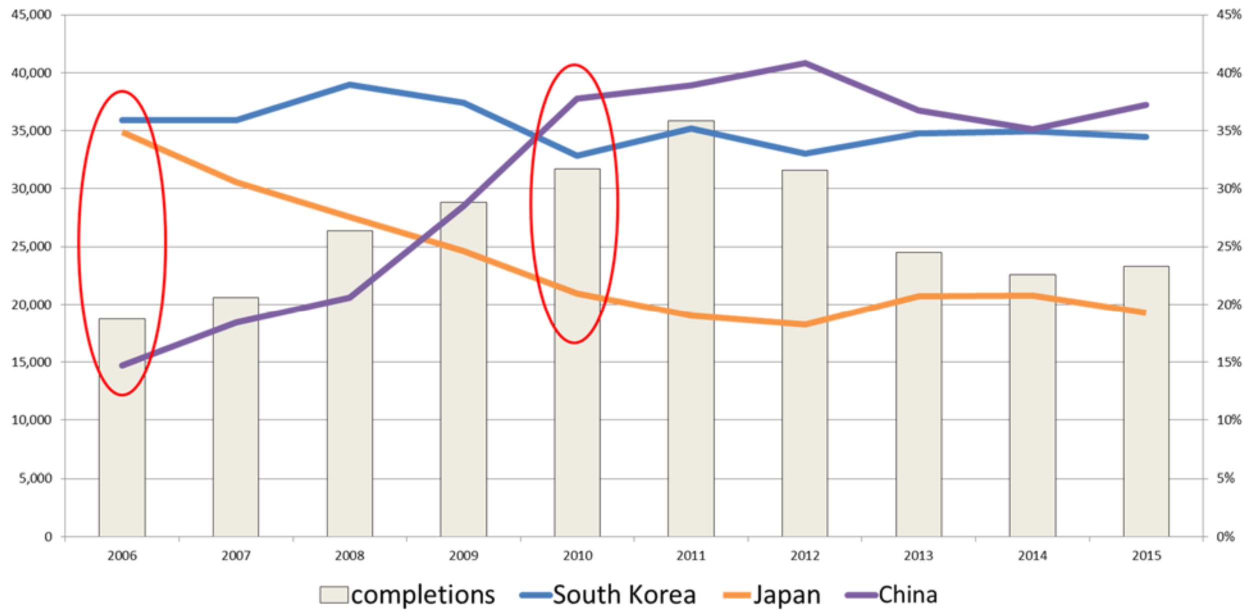
4.2.1. The Shifting Geography of the Regional Value Chain: The Rise of China

Since the advent of modern commercial shipbuilding era, the industry has been characterized by globalized sales, highly concentrated final assembly, and significant levels of state intervention. The production shifts from Western leaders to Asia, and the subsequent rise of China, occurred as high cost yards were supplanted by low cost ones, leading to intermittent periods of trade conflicts and accusations of protectionism and subsidies. During periods of crisis, in which the industry is characterized by low demand, low prices, and overcapacity, emerging shipbuilding nations have historically captured and consolidated market share as low-cost shipbuilders are better able to survive these periodic crises than higher cost builders. Korea's own industry began in a period of massive overcapacity resulting from the oil crises and aggressive price based competition during the 1970s. Likewise, China's market share growth during the 2000s is currently being consolidated during the current crisis period, and could signal another inflection point in the global shipbuilding market.

China rapidly emerged since 2000 to become the largest shipbuilding nation in the world. By 2006, it was the third largest commercial shipbuilder, producing about 15,000 thousand GT per year (circle 1 in Figure 4-11). Over the next four years, China doubled its shipbuilding activities (circle 2), surpassing both Korea and Japan to become the largest shipbuilder by volume. This remarkable growth followed the designation of shipbuilding as a strategic sector. The sector is dominated by two large state-owned shipbuilders, the China State Shipbuilding Corporation (CSSC) and the China Shipbuilding Industry Corporation (CSIC) which own approximately 26 shipyards across China, and report, as do other heavy industries in China, to the State Council through the State-owned Assets Supervision and Administration Commission (SASAC). CSSC and CSIC originated from the China State Shipbuilding Corporation in 1982, and received increased access to financing to develop and expand shipyards from a variety of sources, including state subsidies, tax exemptions, reinvested profits, and private-sector financing. Many of these supports are still in place today.[31]

[31] For an accessible history of the development of China's shipbuilding sector, please see G. Collins and M. C. Grubb (2008).

Figure 4-11. Ship Completions (in thousand GT) and Market Share, by Country 2006-2015



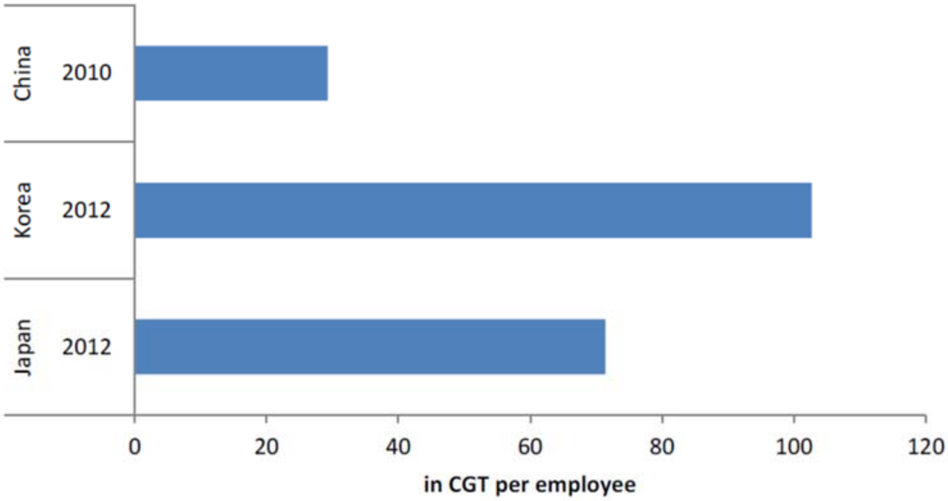
Note: Circle 1 illustrates the situation in 2006 in which China was in third place, after Japan and Korea. Circle 2 illustrates the situation in 2010 when China became the leading shipbuilding country in the world.
Source: calculated from IHS (2009-2016)

During China's tremendous growth in shipbuilding production, Korea kept pace with China as a result of its focus on higher value vessels. In contrast, Japan's output remained static and the country has lost market share. Korea continues to capture more than 30% of the total value in global shipbuilding market. From 2006-2013, Korea generally led the sector by total value captured of vessels delivered (OECD, 2015b).[32] In contrast, Japan's share in total value declined from 23% in 2007 to 14% in 2013, due largely to China's rise in the shipbuilding market. Measured on a per-vessel basis, Korea's average value per ship was US$92 million in 2013, compared to a world average value of approximately US$ 50 million. China's average per-vessel value was lowest among major shipbuilding nations (~US$45 million), while Japan averaged US$48 million. Korea was surpassed in unit values of vessels delivered only by smaller scale, specialty shipbuilders in Germany and Italy, which averaged US$175 million and US$105 million, respectively (OECD, 2015b).

China currently leads the region in building lower cost, less sophisticated ships. Although the productivity of China's shipbuilding sector is half that of Japan's and a third of Korea's (see Figure 4-12), it has significant cost advantages over Japan and Korea in building in this segment, resulting in greater profits. Calculations by Jiang et al. (2013) indicate that China has profit rates in bulk carriers and tankers around 30% greater than Korea, and between 44% (tankers) and 54% (bulkers) greater than Japan. These profit differentials become significantly greater during periods of crisis. China's profit rates relative to Korea during crises periods increase to 33% for bulkers and 39% for tankers, while for Japan they rise to 69% for tankers and 76% for bulkers. Thus, market troughs further strengthen China's shipbuilding competitiveness due to its lower shipbuilding costs in the tanker and bulker product markets.

[32] With the exception of 2012 when China narrowly received more total value than all other shipbuilding countries.

Figure 4-12. Shipbuilding Industry Productivity, China, Korea, and Japan

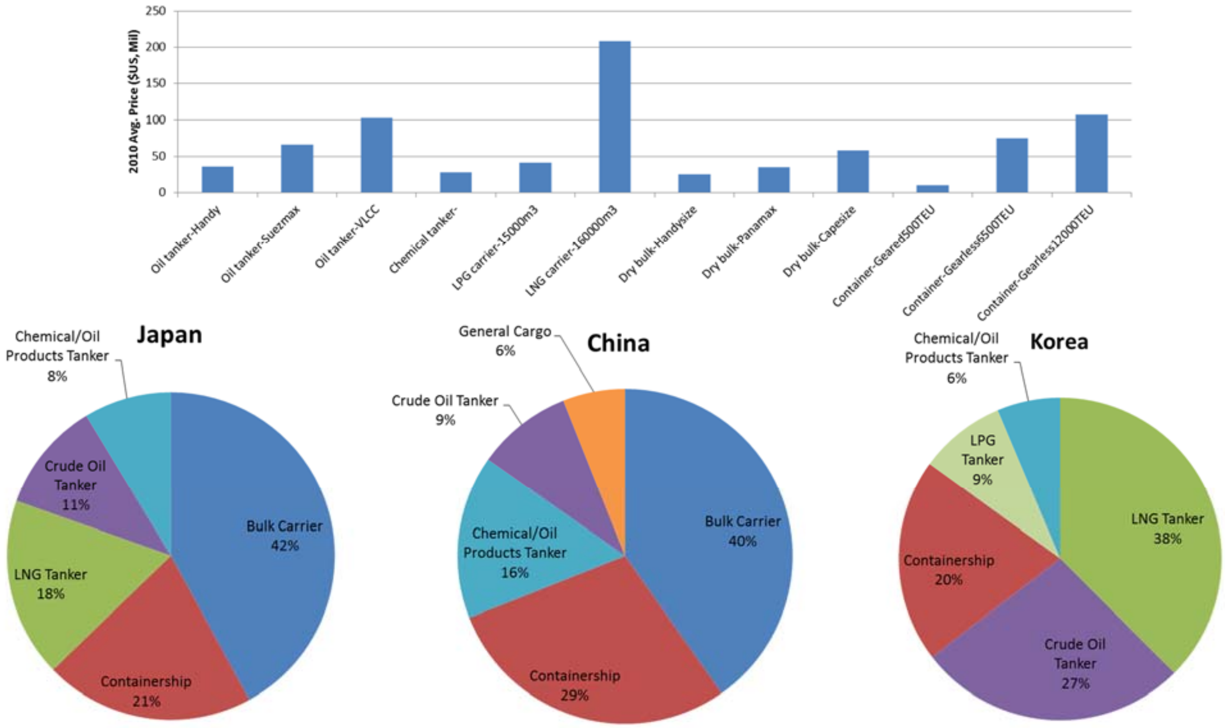


Source: OECD (2015a)

China's strategy has focused on exceling in the construction of general cargo ships and dry bulk carriers. While these are less complex vessels than those produced by Korea (see discussion on ship types in global section), they have been a traditional strength of Japan's shipbuilders. The cost differential between low costs producers in China and higher cost operations in Japan is accentuated in crises like the current period. These crises serve to make low cost producers stronger relative to higher cost producers and capture market share in product categories.

The point is underscored by the product portfolio and the value of ships produced by Japan, China, and Korea illustrated in Figure 4-13. Both China and Japan produce bulk carriers and containerships which are more commoditized, lower value ships than Korea's dominant footprint in gas carriers (LNG/LPG tankers) and crude oil tankers. Because price is a dominant competitive factor for lower value ships, China will continue to erode Japan's position in these product markets. In contrast, Korea's position in the gas carrier and tanker product markets is both a higher value category and less susceptible to price based competition due to the higher technological requirements and the "very large" nature of these ships, which China has, up to now, been unable to match. How long the dominant position of the Korean shipbuilders in these product markets will remain is uncertain, however. During our interviews with Korean shipbuilders, they noted that China has completed construction of a VLCC and has orders for both LPG and LNG tankers.

Figure 4-13. Product Portfolio and Value of Ships: Japan, China and Korea, 2010-2015



Source: Bottom calculated from IHS (2009-2016); top UNCTAD (2016b)

In the next section we more closely examine Korea's position in the shipbuilding value chain, recounting its historical development, current status, workforce profile, and examples of upgrading in the sector. In the final section, we provide our recommendations for maintaining and improving the competitiveness of the commercial shipbuilding sector in Korea.

4.3. Korea and the Shipbuilding Global Value Chain

Leading technological development in both shipbuilding and component production have allowed Korea to remain globally competitive in terms of productivity, exports, and improving the types of ships it produces. Prior to the 1970's, Korean shipbuilding was primarily concentrated in wooden ship and small fishing vessel construction; today it is a global leader in VLCCS, LNG/LPG ships, FPSOs and drillships and entering into higher cost and technologically sophisticated ice-classed and passenger vessels. It achieved this level of success by continually investing in its production facilities to make them more efficient, able to meet global demand, and be at the forefront of technology development and adoption (Sung-hyuk, 2010). Interestingly, while Brazil, Taiwan, and Korea all tried to enter the shipbuilding market during the 1970s using similar state-led development approaches and a focus on price competitiveness, only Korea was able to flourish due to its ability to maintain shipbuilding activity that was not only based on low wages but improved productivity and backward linkages (Bruno & Tenold, 2011).

Policies of the Korean government have revolved around three aspects: upgrading and maintenance of facilities, technology development, and "localization" of equipment and machineries (Mendoza, 1994). Korea created a well-developed 'cluster-type' strategy that focused on developing backward linkages to key inputs, investment in R&D and public-private research and training institutions, as well as developing horizontal linkage to similar industries in the country at the same time, notably heavy industries including automotive and construction. Today, the Korean shipyards' market share is driven by its traditional focus on producing "very large" ships combined with 1) efficient yard management, 2) access to the newest technologies through either indigenous development or licensing agreements, and 3) ability to develop and retain skilled manpower, particularly for welding work. Korean yards have robust R&D and integrated business structures that enhance the quality of the vessels built in terms of ship operating performance, fuel efficiency and technically-strong designs to meet the customized requirements of different ship owners.

The purpose of this section is to examine Korea's position in the global shipbuilding value chain by summarizing its development, current status in the industry, workforce profile and how it has upgraded throughout the years. The survey of Korea's historical development, current position, and upgrading provides a foundation for our recommendations for the future development of the sector.

4.3.1. Development

Both international and national level factors led to Korea's rapid emergence as a commercial shipbuilding powerhouse (Bruno & Tenold, 2011). Internationally, the oil crisis of the early 1970s led to a rapid decline in demand for shipbuilding, which affected high cost shipyards in Europe more than the lower-cost shipyards in Japan and Korea. Europe's main shipbuilding nations could not keep up with productivity improvements necessary to maintain their global leadership despite infusions of public funding (Bruno & Tenold, 2011). Domestically, Korea established key national policies targeting the development of heavy industries, including shipbuilding. The Third Five Year Development Plan (1972-1976) focused on heavy and chemical industrialization (HCI), which included shipbuilding, as a key objective for economic growth in Korea. HCI development was emphasized in light of the erosion of the country's competitive advantage in light manufacturing exports as labor costs increased and international competition ramped up (Bruno & Tenold, 2011). In addition, shipbuilding was prioritized in the midst of national security concerns resulting from the1969 US announcement to reduce its presence in Asian countries (the "Nixon Doctrine"), including a reduction of US troops in Korea.

The first Shipbuilding Development Plan was launched by the Korean Ministry of Trade and Industry (MTI) in 1973. The goal was to make Korea self-sufficient in vessels by 1980 and ensure that shipbuilding exports reached US$1 billion (3.2 million GT) by 1980 and US$2 billion (6.2 million GT) by 1985. The plan designated the construction of nine shipyards by 1980 and another five by 1985. To help achieve these goals, the government provided capital incentives, infrastructure, steel industry investments, trade incentives and tax holidays. The capital incentives included low nominal rates from state-owned banks, which made real interest rates for preferred sectors negative for most of the decade, as well as government guarantees for foreign loans. Complementary investments included large infrastructure programs for new facilities in both the shipbuilding and steel industry (Bruno & Tenold, 2011).

Hyundai Heavy Industries (HHI), established in 1972, was designated by the Korean government to lead shipbuilding production (Bruno & Tenold, 2011). As a *chaebol*, HHI was supported by the government to achieve a competitive level of efficiency in production, and was managed in a hierarchical, top-down, and centralized manner in close cooperation with the national government in return for the support (Hassink & Shin, 2005). By 1983, HHI had become the largest shipbuilder in the world in 1983, a position it still holds in 2017.

Shipbuilding was once-again targeted in the Fourth Five Year Development Plan (1977–81). The Development Plan emphasized the goal of producing ship components domestically and the use of government procurement to increase demand. Additional financing came from the National Investment Fund and foreign loans. Due to overcapacity and low international shipping rates during the period, the number of planned shipyards was reduced in the Development Plan from nine to two (Bruno & Tenold, 2011). Two other *chaebols*, Daewoo and Samsung, entered the shipbuilding market under the plan. In December 1978, Daewoo purchased the former Korea Shipbuilding and Engineering Corporation (KSEC) shipyards at Okp'o and completed it in January 1981. Samsung purchased the Geoje Shipyard and began shipbuilding operations in September 1979. Daewoo and Samsung also received state support in the form of preferential access to financing and lending guarantees

During this early development phase, Korean shipbuilders used technological assistance and license agreements with foreign firms to develop shipbuilding technological capacity in the country. This is seen as a critical element for upgrading the Korean shipyards (Bruno & Tenold, 2011); European shipbuilders, unable to secure new shipbuilding orders due to the shipping crises of the 1970s and early 1980s, were willing to sell technology and services to the Korean yards. HHI received dockyard designs from A&P Appledore (UK), ship designs and shipyard operation instructions from a second UK company, Scott Lithgow, and production knowledge from Kawasaki Shipbuilding (Bruno & Tenold, 2011). Samsung, Daewoo, and smaller shipbuilders in Korea signed 159 license agreements and spent US$117 million between 1962 and 1987 to develop their productive capacity (Gomes-Casseres & Lee, 1989). The agreements included access to European engineers who worked at HHI's Ulsan Shipyard for the first three years of its operation, and overseas training in shipbuilding technology and management by Appledore and Scott Lithgow.

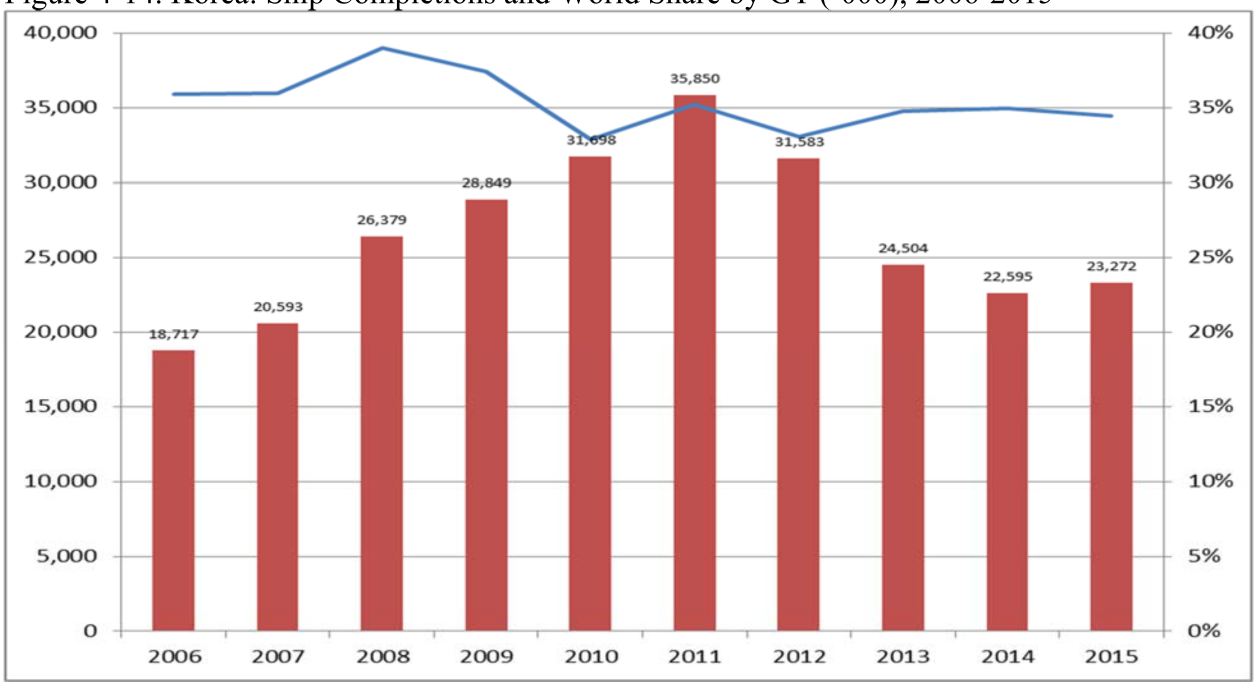
Similarly, while most shipbuilding components were imported during the 1970s and early 1980s, by the end of the 1990s, between 70-80% of components were supplied domestically (Bruno & Tenold, 2011). To achieve this level of domestic production, shipbuilders either developed in-house capabilities or used Korean component manufacturers. HHI developed, with technical assistance, licensing, and overseas training, the ability to make engines and other ship components (Amsden, 1989). Samsung used its electronics division to develop and purchase electronic component systems for its shipbuilding unit. The government also put its R&D resources behind the industry, developing components in partnership with shipbuilders and suppliers. Hyundai Mipo developed a research center in Ulsan; Samsung established a research center in Daejon, and governmental research institutes began to actively develop increased capabilities in ship component systems. The Korean Institute of Machinery and Materials (Daejon and Changwon), Pusan University's Advanced Ship Engineering Research Center, and the Korea Electronics and Telecommunications Research Institute (ETRI) have been important in developing ship systems, with ETRI leading the development of electronic devices for shipbuilding, including semiconductors, telecommunications and information technology (Shin & Hassink, 2011).

From this early stage, Korea created a shipbuilding industry that has been a cornerstone of its development and source of foreign exchange. Its cluster development approach coordinated financing, production, workforce development, and research and development to increase the Korean content of commercial vessels. In the next section we discuss the current status of the Korean shipbuilding industry before turning to it workforce and upgrading trajectories.

4.3.2. Current Status

Korea is one of the world's three major shipbuilders, competing with Japan and China for a combined 92% of 2015 global ship production (IHS, 2016). Korea consistently completes around 35% of total world ship completions (Figure 4-14). Total completions almost doubled from 2006-2011, from 18.7 million GT to 35.9 million GT when the global financial crisis affected the shipbuilding industry.

Figure 4-14. Korea: Ship Completions and World Share by GT ('000), 2006-2015



Source: IHS (2009-2016)

An important reason for Korea's continued strength in capturing value in the global shipbuilding industry is the portfolio of ships produced. Korea is particularly strong in the construction of gas carriers[33] (81% of global completions), containerships (58% of global completions), and oil tankers (53% of global completions) (Table 4-15).

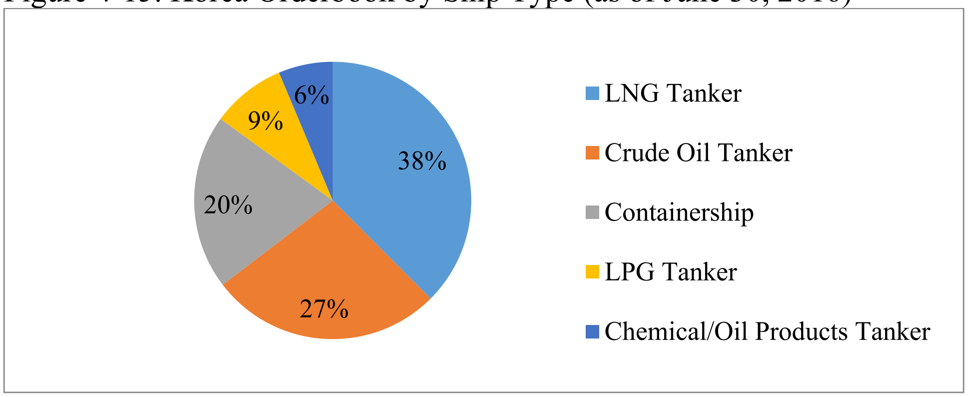
Table 4-15. Korea Ship Completions by Vessel Type, Share of World, 2015

	Korean Global Market Share
Gas carriers	81.1%
Containerships	57.8%
Oil Tankers	53.3%
Offshore	43.9%
Chemical tankers	28.7%
General cargo ships	20.4%
Bulk carriers	5.9%
Ferries and Passenger	0.6%

Source: (UNCTAD, 2016a)

From 2003 to 2013, Korea increased its share in global LNG tankers completions from 60% to 90%, LPG tankers from 27% to 62%, containerships from 42% to 68%, and oil product tankers from 21% to 50%, while minimally participating in the bulk carrier market dominated by Japan and China (OECD, 2015b). Orderbook statistics through June 2016 indicate that Korea continues to specialize in LNG tankers (32% of orderbook), crude oil tankers (23% of orderbook), and containerships (17% of orderbook), while Japan and China's orderbooks are dominated by bulk carriers and containerships (IHS, 2016).[34]

Figure 4-15. Korea Orderbook by Ship Type (as of June 30, 2016)

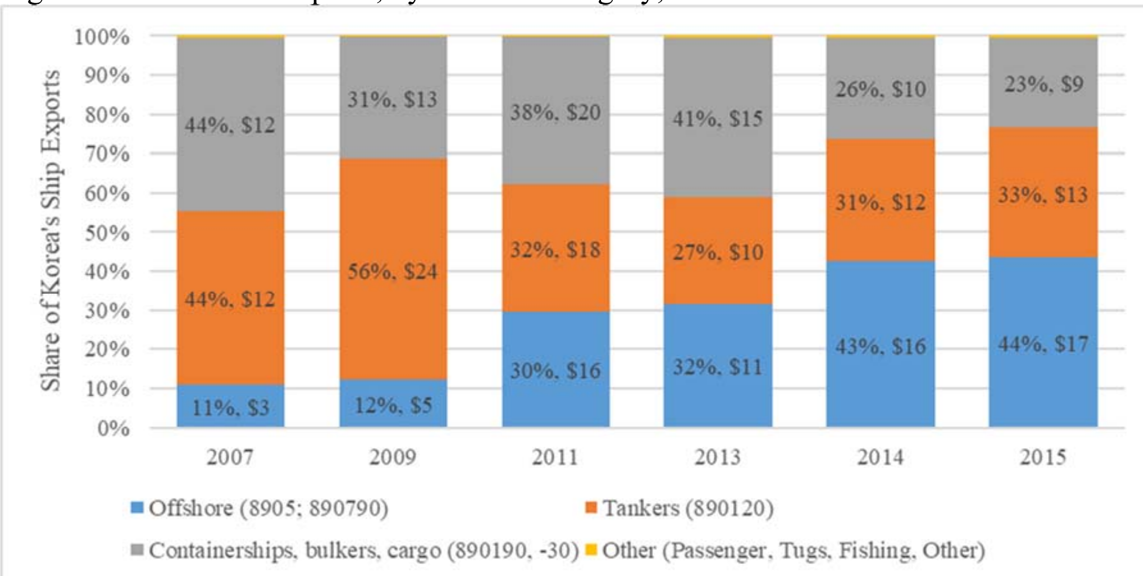


Source: IHS (2016)

Korea is primarily an exporter of offshore vessels and tankers (based on value) as well as containerships (Figure 4-15). In 2015, Korea's US$38 billion in exports accounted for 30% of world ship exports. In the same year, ships accounted for 7.3% of Korea's total exports.

[33] Especially LNG tankers. Korea regularly accounts for 90% of LNG tankers completed annually (OECD, 2015b)
[34] Top three orderbook items are Japan: 33% Bulk, 16% container, 14% LNG Tanker; China: 29% Bulk, 21% Container, 11% Chemical & Oil product tankers.

Figure 4-16. Korea's Exports, by Product Category, 2007-2015



Source: UNComtrade (2016); bars include values in billions and shares.

Firm Profile

The lead firms in Korea's shipbuilding industry are globally competitive shipbuilding conglomerates. The conglomerates own shipyards and possess networks of marine equipment manufacturers, which also include globally competitive heavy industry manufacturers. In 2012, there were 1,275 shipbuilding establishments in Korea, with output valued at US$59 billion (4% of Korea's output in 2012) (Table 4-16).

Table 4-16. Key Indicators of Shipbuilding in Korea

Variable	**Year (2000-2014)**															**% Change**	**Share of Mfg.**	
	00	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**00-12**	**00**	**12**
Output (US$, Billions)	14	15	17	19	22	29	39	51	60	59	64	71	59	71	74	317%	3%	4%
Employees ('000)	77	87	86	86	90	92	104	118	128	130	132	137	131	154	154	70%	3%	5%
Establishments	761	893	900	830	808	800	1,020	1,028	1,104	1,114	--	1,286	1,275			68%	1%	1%

Source: UNIDO (1963-2014, 1985-2013, 2005-2013); Represents ISIC 351/301 (Building and repairing of ships and boat) except 2013-14 (35/30, other transport equipment). 2000-2006 based on INDSTAT4, Rev3, 2007-12 on INDSTAT4, Rev4.

Most of the shipbuilding production and output is concentrated in three shipyards. The three largest shipyards in Korea include:[35]

Hyundai Heavy Industries (HHI): HHI is the global leader in shipbuilding, routinely capturing around 10% of global orders. Although HHI can produce a variety of ship types, it mainly produces tankers, bulk carriers, and container vessels. HHI also has a specialized business

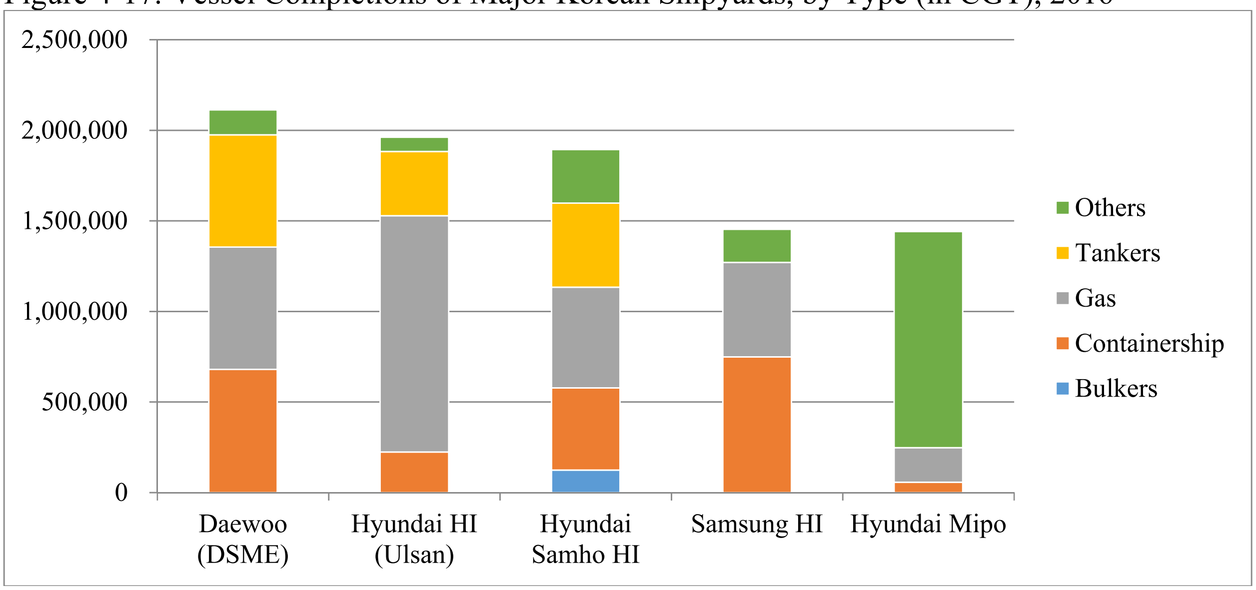
[35] Adapted from (ECORYS, 2009)

service unit for the oil extraction and production ("offshore") market. Production primarily occurs in Ulsan, with secondary yards in Samho and Gunsan, Korea. It maintains a repair yard (Vinashin) in Vietnam. HHI is largely a vertically integrated firm, with components produced internally. Engines are jointly produced by a joint venture with Wärtsilä.

Daewoo Shipbuilding & Marine Engineering (DSME): Daewoo is routinely one of the world's largest shipbuilders, capturing around 6% of total world orders. Its largest shipyard is situated in Okpo, Korea and is focused on LNG and specialized carriers. It used to own yards in China (DSME Shandong), which opened in 2005, and a facility in Europe ((Daewoo Mangalia Heavy Industries (DMHI), focused on both bulk and container carriers as well as ship repair, but which were recently sold. DSME is a vertically integrated firm, supplying most of its shipbuilding inputs internally.

Samsung Heavy Industries (SHI): SHI is one of the top three shipbuilders in the world. The company produces mostly tankers and container ships, but is also increasing production of LNG and offshore vessels. Its shipyard is in Geoje, Korea.

Figure 4-17. Vessel Completions of Major Korean Shipyards, by Type (in CGT), 2016



Note: "Others" primarily refers to the offshore market

Source: Clarkson's Shipyard Monitor, 2016

4.3.3. Workforce Profile

Employment in the industry has increased by 70% since 2000 (Table 4-16). According to the Korea Offshore & Shipbuilding Association (KOSHIPA), there were 181,239 workers in the industry in late 2015. Assuming the manufacturing profile has remained similar to 2012, this is approximately 5% of Korea's manufacturing employment (UNIDO, 2005-2013)(Table 4-17).

Table 4-17. Workforce Profile of the Shipbuilding and Offshore Industry in Korea, 2015

Position	Share	Workers
Subcontractors	70%	126,716

Technical & Skilled Workers	17%	30,060
Engineers	11%	19,401
Managerial/Administrative	3%	5,062
Total		**181,239**

Source: KOSHIPA (2001-2015)

4.3.1. Evidence of Upgrading

The traditional focus in the Korean shipbuilding industry has been on process and product upgrading, that is, improving the efficiency of the manufacturing and assembly processes and improving products. **Process upgrading** remains relevant today. Korean shipbuilders are developing and implementing shipyard improvements that optimize work flow and processes ("Smart Shipyards"), and adopting associated technologies such as welding robots to help workers assemble ever-larger ship sections more efficiently, and unmanned flatbeds and forklifts to move materials from one area of the shipyard to another. Although still progressing, the adoption of Industry 4.0 technologies in shipyards could improve shipyard efficiency by 30% (Y.Heo, 2017). To remain competitive in the face of china's low cost yards, Korea's shipbuilders are looking to optimize their use of technology to increase productivity.

Product upgrading continues to be relevant and actively pursued in three distinct senses. First, the quality of the ships continues to improve, and continues to be well-regarded in the marketplace. Korean ships are considered better built and easier to maintain than Chinese ships. Second, products are being improved through the introduction of ICT to improve ship operation and navigation efficiency, which may reduce the number of personnel needed on commercial vessels, offering significant value and cost savings to shipowners and positioning the Korean industry for continued growth. The development and adoption of "Smart Ship" technologies continue to add value to the brand and reputation of Korean shipbuilders even though full implementation of driverless ships is still in the future. Third, Korean shipbuilders continue to dominate product categories that are particularly high value, such as gas carriers and FPSOs, that are financially profitable and highly sophisticated. FSRUs used for South Asian energy production are also an important offshore product category for Korean shipbuilders.[36] Deepwater offshore oil platforms, while not pursued by all three major shipbuilders at present due to different perceptions of product market risk, are an additional area for product upgrading identified in government documents.[37]

In addition, Korean shipbuilders are developing the technical capability to enter new product markets. For example, Korean shipbuilders have active plans to modify roll-on/roll-off passenger ferries (RoPax) for the growing Chinese cruise market segment, and are active, though not dominate, in ice-classed commercial vessels led by Norway. Workforce development strategies that address shipbuilders' needs as they pursue these upgrading initiatives will be particularly important in light of Industry 4.0 trends KISTEP (2017).

[36] See for example, www.lngworldnews.com/excelerate-lines-up-seven-fsrus-at-dsme/ and www.lngworldnews.com/industry-majors-join-forces-on-pakistan-fsru-project/

[37] See KMTI "Future Growth Engine Comprehensive Action Plan 2016"

Korean shipbuilders have also engaged in **backward linkages** and **functional upgrading**. Shipbuilders are aggressively working on increasing backward linkages to enhance the domestic content of commercial ships in different product categories. Notably, in component system product categories where the domestic content is low, as, for example, cryogenic pressurized systems needed for LNG ships and LNG propulsion, Korean shipbuilders are actively conducting the R&D, material testing and partnering with technology developers to either develop domestic systems or increase the domestic content and fabrication of licensed technology. Government support through business-government consortia like Union for LNG that includes shipbuilders and component manufacturers have been effective historically in developing competitive domestic component systems for Korean shipbuilders. Forward linkages are also being added. The after-service market is an area of focus for HHI as it expands service offerings both domestically (Busan) and abroad (Shandon, China; Singapore/Malaysia, Houston, and Dubai).

In addition, Korean shipbuilders are assisting the development of shipbuilding capacity abroad; HHI is transferring technology to Saudi Arabia to establish an offshore shipbuilding industry in the country (Reuters, 2017).

Intersectoral upgrading is an active area for Korean shipbuilders. Active cross-industry expansion into allied heavy industries is occurring, particularly in energy production. In addition to the increasing presence of Korean shipbuilders in the offshore market, especially for FPSO and FSRUs, some of Korea's conglomerates are active in expanding technology from shipbuilding sector to onshore electric power generation and construction.

4.4. Shipbuilding Recommendations

The advent of Industry 4.0 leads to additional considerations for upgrading that have not been part of the traditional focus on better processes or products as the source for competitive advantage in the shipbuilding industry. The introduction of Industry 4.0 technologies leads to four additional considerations, which we touch on here briefly:

- Product-as-service business model
- Ship finance
- Software and systems
- Monetizing data.

As discussed in the first chapter, Industry 4.0 technologies are introducing new business models in which capital equipment is seen as a service. Due to the rapidly changing technology and service requirements of Industry 4.0 capital equipment, pay-by-use and subscription services could become an attractive option for both shipowners and shipbuilders, turning capital expenditures into operational expenditures. In the shipbuilding industry, the implication of this trend is that a variety of new business models could emerge. In the traditional business model, the shipbuilder builds a ship to customer specifications and sells the ship outright to the shipowner with an industry-standard one-year warranty for product performance. In the product-as-service business model, the focus is not on selling a product to a customer, but rather selling a capability, in this example water-borne transportation services, to a customer on a subscription or per-use basis. The shipbuilder extends their responsibility and risk for product performance beyond one year in return for access to the revenue stream related to the maintenance and service of the ship and the data generated from shipborne systems. The maintenance and service revenue stream is not inconsequential; a third of the purchase price of the ship is used to keep the ship maintained and operating in good condition, assuming no major upgrades like ballast water management systems to keep the vessel compliant with regulations. By incorporating the maintenance costs into the subscription or pay by use price, the shipbuilder can capture downstream value currently abandoned.

Hybrid business models exist between the extremes of traditional product sales and the product-as-service or product-sharing model. Product sales can be bundled with warranties, service contracts or performance-based contracts in which the manufacturer maintains the responsibility and risk for product performance. In return, the manufacturer retains a close relationship with its customer and can monetize the data being generated from the ship to a variety of customers.

The shift from thinking of equipment as a capital cost to an operations costs is a major change in the way capital equipment (including heavy industrial and manufacturing equipment) producers and their customers relate to one another. It is rapidly changing the automotive industry and could have similar effects in the shipbuilding industry. The new business models have consequences for ship finance, but new approaches – such as those developed by Japan's Joint Ownership Shipbuilding Scheme and China's ICBC Leasing Scheme are good models to evaluate.[38]

More generally, as sensors and communication capabilities are embedded in products, they can be used to create system platforms of similar products, optimize their individual or combined use, or be sold to develop new information products to new customers. For example, data on fuel efficiency of a ship under different operating conditions could be valuable to a number of potential customers, including other shipbuilders and shipping companies. Data on how, when, and where the product is used could be valuable to shipbuilders to better segment customers, customize features and provide specialized service plans or discounts for additional products. The increasing value of data further supports the shift to a product-as-service business model as this offers the opportunity to collect longitudinal data on the ships operations.

Operating systems are becoming essential platforms in a variety of products, leading to the entrance of new suppliers that have core capabilities in software and electronic systems integration. As commercial vessels become more sophisticated, will Korean shipbuilders outsource the development of these operating systems, or develop them internally? If outsourced, operating system developers could begin to commoditize the ships as functioning and performance is less dependent on mechanical systems and more dependent on the interoperability of internal systems and coordination with external communication and control systems. If internalized, it will require enhanced capability and concomitant resource dedication to ensure that operating systems are interoperable and secure. Potential lessons could be learned from the automotive industry about how best to develop software systems that meet the performance and operating requirements.

[38] For the ICBC Leasing Scheme, please see a number of conferences held on the topic by Marine Money, including a recent presentation: https://www.marinemoney.com/sites/marinemoney.com/files/1525%20Interview.mp3).

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Appendix

Table A-4-1. Shipbuilding HS Codes by Value Chain Stage

Shipbuilding Final Products, HS02 Codes & World Export Statistics, 2015

Category	HS02 Codes	World Exports (US$, B)
Total		**$117**
Containerships, bulkers, cargo		**$44**
Other goods carriers (e.g., containerships)	890190	$44
Refrigerated vessels (reefers)	890130	$0.1
Tankers	890120	$22
Offshore		**$36**
Floating structures: rafts, tanks, coffer-dams, landing-stages, buoys, beacons	890790	$1
Construction: dredgers	890510	$1
Drilling/production platforms	890520	$11
Light-vessels, fire-floats, floating cranes; other vessels of which navigability is subsidiary to their main function; floating docks	890590	$22
Passenger ships	890110	$5
Other		**$10**
Tugs and pusher craft	8904	$5
Fishing	8902	$2
Other vessels (life boats)	890690	$4

Shipbuilding Subassemblies, Components & Raw Materials, HS02 Codes

System/VC Stage	Ship-Specific	Item	HS02 Codes
Platform: Propulsion	Yes	Turbines for marine propulsion	840610*
		Marine propulsion engines: -Spark-ignition reciprocating or rotary internal combustion piston engines -Outboard motors/Other	840721 840729
		Compression-ignition internal combustion piston engines (diesel or semi-diesel engines)/Marine propulsion engines	840810
	No	Nuclear reactors, boilers, machinery and mechanical appliances/Other engines and motors/Hydraulic power/Other Hydro-jet engines for marine propulsion code ended in .40	841229
		Parts for use with engines of heading 84.07 or 84.08 /Other/for use with spark-ignition internal combustion piston engines	840991
		Parts/applies to ships and auto for engines other than internal combustion	840999
Mechanical	Yes	Propeller & blades (Note: 848710 in HS07-12)	848510
	No	Other machinery self-propelled, other; 4D lists ship derrick (crane)	842649*
Navigation & Communication	No	Radar, radio navigational aid apparatus and radio remote control	8526
		Surveying, hydrographic, oceanographic, hydrological, meteorological or geophysical instruments and appliances	9015
		Navigation-related	901480* 901490*
Hull/ Raw Materials	No	Steel (iron & non-alloy steel)	7206-7217
		Tubes & pipes & fitting	7303-7307

Source: Authors; see Gereffi et al. (2012) for an earlier version; (*) code was not included in it, but added here.

Table A-4-2. Delivery of Newbuilds by Vessel Type and Country of Build, 2015

Type	**Gross Tons (millions)**						**Country's Share of World (%)**					**Vessel Type Share of Country's GT (%)**					
	China	**Japan**	**Korea**	**Phil**	**ROW**	**Total**	**China**	**Japan**	**Korea**	**Phil.**	**ROW**	**China**	**Japan**	**Korea**	**Phil.**	**ROW**	**Total**
Total	**23.1**	**13.4**	**22.0**	**1.9**	**3.8**	**64.1**	**36**	**21**	**34**	**3**	**6**						
Bulk carriers	13.3	10.8	1.6	0.9	0.2	26.8	50	40	6	3	1	58	81	7	47	6	42
Containerships	5.0	0.2	9.3	1.0	0.6	16.1	31	1	58	6	4	22	1	42	53	17	25
General cargo	0.7	0.2	0.3	0.0	0.4	1.6	43	12	20	0	24	3	1	1	0	10	3
Oil tankers	2.9	0.9	4.8	0.0	0.4	9.0	32	10	53	0	5	12	7	22	0	11	14
Other ships (if looking at UNCTAD vessel groupings data, all below are under "other")																	
Gas carriers	0.1	0.7	3.4	0.0	0.0	4.2	3	16	81	0	0	1	5	16	0	0	7
Chemical tankers	0.2	0.2	0.2	0.0	0.1	0.6	23	30	29	0	18	1	1	1	0	3	1
Offshore	0.9	0.0	1.5	0.0	1.0	3.4	25	1	44	0	29	4	0	7	0	26	5
Ferries and Passenger	0.1	0.0	0.0	0.0	0.8	0.9	11	3	1	0	85	0	0	0	0	21	1
Other	0.0	0.4	0.8	0.0	0.2	1.5	3	27	57	0	13	0	3	4	0	5	2
Containership, bulkers, cargo	19.0	11.2	11.2	1.9	1.3	44.5	43	25	25	4	3	82	83	51	100	33	69
Tankers	3.1	1.8	8.4	0.0	0.6	13.8	23	13	61	0	4	14	13	38	0	15	22

Source: UNCTAD (2016b); UNCTAD secretariat calculations, based on data from Clarkson. Note: covers propelled seagoing merchant vessels of 100GT+.

Table A-4-3. Supporting Shipbuilding-Specific Stakeholders in Korea by Focus Area

Name	**Abbreviation**	**Focus**	**Location (City)**
Korea Marine Equipment Association	KOMEA	Industry Association	Seoul
Korea Marine Equipment Global Service Center	KOMEC	Industry Association	Busan
Korea Offshore & Shipbuilding Association	KOSHIPA	Industry Association	Seoul
Korea Research Institute of Ships & Ocean Engineering	KRISCO	Research	Daejeon
Korea Shipbuilding Industry Cooperative	KOSIC		Seoul
Korean Register of Shipping	KRS	Classification Society	Busan
The Society of Naval Architects of Korea	SNAK	Professional Society	Seoul
Korea Marine Equipment Research Institute	KOMERI	Research	Busan
The Korea Shipowners' Association		Industry Association	Seoul

Chapter 5. GVCs, Industrial Transformation and Opportunities for Korea[1]

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5. GVCs, Industrial Transformation and Opportunities for Korea

5.1. Introduction

Having built its economy on a strong manufacturing base, Korea is now at a crossroads and must redefine its growth drivers for the future. Its strong commitment to process and product improvement have seen steady gains in productivity and output in the past. However, its manufacturing sector is coming under growing pressure on two fronts. In labor-intensive operations, Korea increasingly competes with lower cost countries which are building up their capabilities, particularly China and others from Asia, while, in capital- and knowledge-intensive stages of the chain, Korea is up against the world's most advanced industrialized countries – the US, EU and Japan, which are all rapidly innovating, defining brand new industries, and ramping up new production technologies that will shape the future of manufacturing itself.

Traditional development paradigms would suggest that, to survive these challenges, Korea aim to move out of manufacturing and into services. With an underperforming services sector, this provides a somewhat pessimistic outlook for Korea's future. It also presents policymakers with an overwhelming task as the "services" sector is broadly defined and covers a very wide range of activities, including everything from construction to finance and insurance and tourism, drawing on a wide range of skills and other capabilities and requiring a considerable transformation of the economy. The global value chain (GVC) paradigm, however, suggests that the country leverage its existing strengths in manufacturing to lead its upgrading into services, while at the same time, consolidating its leadership as a production technologies specialist. Korea has established a formidable leadership in its manufacturing chains to date based on strengths in science and technology, manufacturing and an emphasis on applied research and development (R&D). By identifying future sources of value in these manufacturing GVCs, Korea can pursue a much more targeted approach to drive the development of a stronger services sector while focusing on the highest value manufacturing segments.

This study analyzed Korea's participation in two of its leading manufacturing sectors, electronics and shipbuilding, in the context of several trends shaping GVCs– including those induced by new Industry 4.0 technologies - to identify insights into the country's potential for growth. This analysis indicates that Korea has achieved its success to date through high degrees of product and process upgrading, together with upgrading into new product development and design activities. Unlike other industrialized countries, this has been done by indigenous firms with strong local production networks, and a particularly heavy focus on manufacturing in-house and also in-country, uniquely positioning Korea for the future. Industrial transformation could thus be achieved by focusing on innovation in production technologies, upgrading into high value services activities, and intersectoral upgrading by combining its strengths in various existing industries.

With the correct policy combination, Korea can reorient its strengths towards these future goals. In particular, the country needs to make strong improvements to enhance its knowledge and innovation environment. Having shifted its economic development approach to innovation in the early 2000s (Song, 2016), the country is well recognized as a leader in R&D, particularly in high tech industries, spending more than any other country as a share of GDP. However, this system needs to be redirected towards the country's future goals, rather than its current ones. In particular, its innovation system needs to be oriented towards more basic research, human capital investments need to go beyond STEM, and opportunities need to be created for entrepreneurs to develop new solutions – especially in the areas of knowledge-intensive post-production services.

This chapter is structured as follows: First, we briefly recap the recent changes in GVCs in general and their impact on GVC evolution. This is followed by a discussion of the key findings from the GVC studies. Based on the lessons derived from the country's participation in these value chains, we highlight three key directions for GVC-oriented strategy to drive Korea's industrial transformation. We then discuss significant areas for GVC-oriented policy and how Korea is currently performing. Finally we conclude with a discussion of the importance of seizing this opportunity, and the high risks of Korea's failure to act on it.

5.2. Recent Changes in GVCs

Shifts in global demand, changes in national and international trade and investment policy, and technological advances, have begun to change the opportunities for different countries to use GVCs to advance their economic development agendas. The most important of these to affect global manufacturing sectors include value chain rationalization, a reorientation towards Asian markets, automation and an increase in the role and value of services (*servicification*). The latter two are based on changes being ushered in by the set of cutting-edge technologies broadly referred to as "Industry 4.0"[2], automation/additive manufacturing affects tangible production operations, while servicification covers a new series of intangible operations in chains. Together, these dynamics affect the distribution of value along the chain, and can alter its governance structure and geographic composition. These trends are detailed in Table 5-1.

Table 5-1. Current Trends in Manufacturing GVCs and Implications for Participation

Trend	Description	Key Implications for GVC Participation
Rationalization	Consolidation of supply chains in scale, cost-driven businesses around a few, large technologically capable suppliers.	Smaller firms are increasingly shut out of major volume GVCs and must seek out new niche markets to remain competitive.
Reorientation towards Asia	Shift in both demand and supply in GVCs towards Asia as industrial base grows and incomes rise.	Asian end markets become increasingly important for innovative firms. Firms must develop capabilities to serve these profitable consumer and industrial markets.
Automation	Incorporation of new disruptive technologies into supply chains to improve efficiencies, particularly driven by additive manufacturing techniques (i.e., 3D printing) and robotics.	Production operations are increasingly capital-intensive rather than labor-intensive, with an important emphasis being placed on productivity and efficiency in supply chains.
Servicification	Increased role of services in manufacturing sectors, includes the emergence of important post-production services based on increasing availability of data from sensors and semiconductors embedded in manufactured products and widespread Internet access.	Changing business models, as manufacturers become service providers. Analysis of new data provides insights into a host of topics from consumer behavior to fuel efficiency and performance amongst others. Ownership of this data can lead to knowledge-intensive services offerings (new GVC stage).

Source: Authors.

[2] See Chapter 1 for a further description of these technologies and trends in Table 5-1.

In particular, for manufacturing powers such as Korea, these changes have important implications. In manufacturing sectors, value chain leadership and proximity to the growing Asian market combined with expertise in automation and other new disruptive production technologies will be key to future competitiveness. Capital substitution for labor in routine manufacturing tasks is expected to be high in the future. This is promising for advanced industrialized countries where capital intensity tends to be high in the face of population declines and high labor costs (Bughin et al., 2017). Korea's strong technological capabilities, combined with rising labor costs and a shrinking workforce (see Chapter 2) suggests that the country is well positioned to incorporate a growing share of automation technologies into its production operations. It will face stiff competition in the region from China (see Box 5-5) and other East Asian economies, such as Singapore (see Box 5-2), which are also pushing hard to develop indigenous capabilities in these new advanced technologies (National Research Council, 2012).

At the same time, the rising importance of services in manufacturing chains will require traditional manufacturers to seek out new solutions to remain competitive. Beginning in capital-intensive sectors – from aerospace and mining to medical devices, new consumption models are emerging. The new models mean that, rather than purchasing equipment, clients will likely pay a fixed subscription or variable "per-use" fee to equipment manufacturers to use and maintain the equipment. Industrial machinery and equipment producers need to redefine themselves as capability and service providers to their customers and develop financial mechanisms to support this. Service provision relies on an entirely different set of skills from those that make countries and firms great manufacturers, and thus education systems need to include more focus on services provision (Gereffi et al., 2011; WEF, 2016a). Manufacturing tends to depend more heavily on technical skills, while services requires a mix of technical skills and "soft skills" such as problem solving, conflict resolution and communication.

To understand Korea's potential to take advantage of these opportunities, we examine the country's experience in two distinct GVCs: electronics and shipbuilding. These industries represent two different types of GVCs: Electronics for the consumer market is characterized by rapidly changing technologies with profits driven by scale, brand and speed of product innovation. The size of the market, particularly in Asia, will be a major driver of growth in the future. Shipbuilding, on the other hand, is very capital-intensive, products have a long life-cycle (approximately 23 years for most ships), and production is highly concentrated in three countries. The following section highlights key lessons regarding Korea's role in these two industries from which broader lessons for the country's GVC oriented industrial transformation can be derived.

5.3. Lessons from Korea's Participation in Electronics & Shipbuilding GVCs

Korea currently holds a dominant leadership position in both the electronics and shipbuilding GVCs, with strong lead firms and impressive production capabilities. As such, GVC analysis of these two industries can provide important insights regarding potential paths for Korea's upgrading in the future. Table 5-2 summarizes the main findings from the two GVC studies. This is followed by a discussion of major lessons in these industries which have implications for Korea's participation in manufacturing GVCs in general. Each of these industries was analyzed individually and in-depth, understanding both the evolution of the global industry, how these major trends are playing out in practice and how Korea's role has evolved. This analysis is available in Chapters 3 and 4.

Table 5-2. Korea in Key Global Value Chains: Electronics and Shipbuilding

Variable	Electronics	Shipbuilding
Exports (2015)	Total: $120 billion 3C Final: $22 billion 3C Subassemblies: $30 billion Components: $64 billion Other: $4 billion	Total: $38 billion Container, Bulkers, Cargo: $9 billion Offshore: $17 billion Tankers: $13 billion Passenger: $50 million
Share of Korea's Exports (2015)	23% ($120/$527 billion)	7.3%
Share of Global Export Value (2015)	8th 3C final products (2%) 3rd 3C subassemblies (9%) 5th electronic components (8%) 10th industrial electronics (2%) 7th medical electronics (2%)	1st Overall Final Ships (33%) 3rd Container, Bulkers, Cargo (20%) 1st Offshore vessels (47%) 1st Tankers (58%) 14th Passenger (1%)
Share of Global Completions (GT)	--	2nd Overall Final Ships (34%)
Principal End Markets	For components (based on exports): China/Hong Kong Vietnam	For components: China; Japan For completed ships: Greece, Denmark, Saudi Arabia
Employment	278,314 (components, 2012) 117,911 (final 3C, 2012)	58,263 (components, 2016) 203,282 (final, 2016)
Important Firms in Korea	Samsung, LG, SK Hynix	Hyundai Heavy Industries (HHI), Samsung Heavy Industries (SHI), Daewoo Shipbuilding & Marine Engineering (DSME)
Lead Firms Position in Global Market (2015)	Consumer electronics: #1, 3 (Samsung, LG) Computers: #3 (Samsung) Cell Phones: #1, 5 (Samsung, LG) Displays: #1, 2 (LG Display, Samsung Display) Semiconductors: #2, 5 (Samsung, SK Hynix)	Three of the top five shipbuilders HHI DSME SHI
Key Expertise/Products	Manufacturing: Displays, ICs (memory) Branding/NPD: cell phones and consumer electronics	Offshore vessels Gas carriers Large containerships Oil tankers
Main Stages of GVC Participation	Components/subassemblies manufacturing (for export) Lead firms (final 3C products)	Lead firms; Components; Integration
Current Competitiveness Strategy	Volume, cost-driven consumer market in electronics	Higher-value, niche markets in shipbuilding
Recommended Upgrading Approach	Upgrading to production equipment Upgrading into ICT services	Upgrading to production equipment Upgrading into after-sales services
Trends with the Most Impact	Servicification Automation Regionalization/shift to Asia	Automation Servicification

Source: Authors

Korea's participation in these two GVCs is characterized by strongly linked local production networks, with limited use of foreign outsourcing and/or external suppliers. In both the electronics and shipbuilding sectors, lead firms are still also manufacturers and tend to rely on an array of quasi-independent subsidiaries supplemented by small- and medium-sized domestic suppliers, to undertake different stages of the GVC. In electronics, this contrasts significantly to the approaches pursued by the country's competitors, such as the US, where lead firms have outsourced the majority of production and manufacturing activities, choosing to focus on their core strengths of product development, marketing and sales. Where Korean firms have become masters of in-house production, their competitors have rather focused on developing significant coordination capabilities to control the chain. For example, Apple has somewhat notoriously outsourced all of its production operations to Foxconn and others, leveraging the manufacturing strengths of their global technology partners. These partners have grown significantly over time, upgrading their capabilities and leveraging economies of scope and scale to become more innovative. Thus, as new technologies are incorporated into these industries, Korean lead firms are in a unique position as they own the production processes and are not at risk of upgrading threats from their large global suppliers.[3]

However, this business model brings with it other risks for Korea. As a result of lead firms using quasi-hierarchical and captive governance approaches (Gereffi et al., 2005), suppliers in the country are typically small, have relatively weak export capabilities and face high risks due to lack of market and buyer diversification. This captive relationship also limits their potential to learn, upgrade and innovate independently (Pietrobelli & Rabellotti, 2011). Korea's GVC participation is thus dependent on the continued success of a small number of lead firms.

Korean firms have remained leaders in these two sectors by excelling in areas of process upgrading. While product strategy has differed, with electronics firms focused on cost-driven consumer market, while shipbuilders have pursued higher-value, niche markets, investments in process upgrading in both GVCs has been a fundamental driver of competitiveness. This includes the constant incorporation of new technologies into the production process, such as utilizing automated welding in shipyards. This tendency is reflective of Korea's productivity growth in manufacturing in general. Multifactor productivity has grown faster in Korea over the past decade than other OECD countries (OECD, 2017a). These upgrading strategies have been essential to continue to position the country as a manufacturer versus the rising low cost locations around the world. Peers, such as Japan in the shipbuilding sector, have comparatively lost market share to China.

Functional upgrading into high value activities within these chains has been predominantly in the pre-production stages of R&D. Electronics firms in particular have extended their participation through the front-end of the value chain. Indeed, firms in the sector are amongst global leaders in product development; over the past decade, Samsung alone has won some 350 prestigious awards for innovation at the International Consumer Electronics Show in Las Vegas (Samsung, 2017); it spends more on R&D than any other technology firm. Korea has also focused its electronics R&D on securing technological dominance in key component products most critical in consumer electronics and mobile phones (displays and semiconductors).

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[3] This type of threat is illustrated by the emergence of Lenovo. The company was primarily a supplier to IBM before it decided to launch its own consumer products.

Likewise, in shipbuilding, although R&D spending is lower and the country continues to rely on importing and licensing foreign technologies, there has been a focus on conducting R&D to develop and manufacture new domestic components for the industry. Korea spends more on R&D as a percentage of its GDP than any other country, with a very high level of private sector participation (OECD, 2016; WDI, 2017).

With the exception of strong product development and technical design, Korea's participation in the two GVCs analyzed is primarily in production operations; there is limited participation in services segments of the value chain. The country has yet to leverage its expertise and presence in a wide-range of manufacturing sectors to upgrade into high value services operations. Shipbuilders have yet to move into new financing and/or after-sales operations such as preventative maintenance and performance planning in the post-production stages that would give them considerably more leverage throughout the chain. This is consistent with the slow growth and relatively weak performance of the services sector as a whole within the country (OECD, 2016). In the capital equipment sectors, the rise of Industry 4.0 technologies and services means that increasingly, these post-production services account for over 50% of lead firm revenue (see Box 5-1); Korean firms are missing out.

Korea is playing a key role, in intermediates and final products, in these two GVCs as they increasingly become regional Asian value chains. Trade, production and consumer market data fully support the trend of the reorientation towards Asia.[4] 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. Asia went from 55% to 80% of world exports in electronics intermediates between 2000 and 2015, and 44% to 66% in final products. 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. While China is by far the leading actor in this sector, Korea plays important roles in components and subassembly categories. In shipbuilding the trend has been a more gradual shift over the last 30 years, however Asia's current dominance is even more pronounced (96% of output from Asia in 2015, up from 85% in 2003). In terms of vessels completed, China (37%), Korea (34%), and Japan (19%) accounted for 91% of the world's approximately 68 million GT of ships completed in 2015. Korea alone controls one third of the global shipbuilding output.

[4] See Chapter 3 (Electronics) and Chapter 4 (Shipbuilding) for further detailed statistics.

Box 5-1. Services in the Mining Equipment Sector: Komatsu-Joy Global

In the extractive industries, the development of smart, connected equipment has begun to fundamentally change the way miners and their equipment suppliers interact. Large mining equipment, manufactured by firms such as Komatsu and Caterpillar, is now embedded with IT-enabled sensors and software that provides increasingly accurate details on mine productivity and equipment performance. Analysis of this growing body of data can provide equipment owners with preventative maintenance schedules to avoid unnecessary down time, remote monitoring, and benchmarking against the productivity of other mines around the world in which their equipment is operating. This has driven innovation in the business models of capital equipment for the mining sector.

While mining-equipment manufacturers have traditionally provided extensive maintenance, repair, and overhaul services for their equipment (Life Cycle Management Services), this wealth of information, coupled with miners' recent reluctance to purchase new equipment, has resulted in mining equipment makers moving increasingly into service provision and rental of equipment rather than outright sales. By 2014-2015, services revenues for the leading equipment suppliers accounted for 40-60% of their revenues and services employees surpassed 50% of all employees for the first time. Firms are providing a much wider range of services, not only with respect to equipment maintenance, but also consulting services regarding how to maximize mine productivity, improve equipment combinations and reduce capital investment costs. In the very near future, these companies will also be able to operate the equipment for mining companies from centralized locations around the world.

Recently purchased by Japanese giant Komatsu, Joy Global, a specialist in the manufacturer of long-wall systems, continuous miners, shovels, loaders, and conveyers, has been a pioneer in this area. While the company continues to sell its equipment, it requires customers that want Smart Services to upgrade to smart, connected machines and share their machine data with Joy. These data services can allow Joy analysts to identify bottlenecks in the mine, reduce waste and increase capacity utilization in processing plants. In one case, they increased production by 65%, resulting in more than US$100 million in additional revenue for the mine. By 2014, the company had six Smart Services Centers operating in a number of key mining countries, including South Africa and Australia. The Smart Services offering has been a stepping stone to new business model offerings, such as performance-based service contracts that include guaranteed uptime. Thus, Joy shares risks and rewards with customers through payments based on equipment performance and output of the mine.

Source: Bamber, Fernandez-Stark, et al. (2016); Porter et al. (2014).

Compared to its leading regional competitors in these sectors Japan and China, Korea continues to lead China in upgrading into the highest stage segments, however, this lead is narrowing. Japan, on the other hand, plays a smaller role in manufacturing in these sectors today, focusing more on production technologies. Having previously undertaken considerable upgrading in these industries, the importance of these sectors to Japan has declined in the past decade and a half. This is reflected in the low and declining contributions of these sectors to its economy compared to Korea and China. In electronics, Korea maintains strong leadership in its specific niches and is an innovator, however, China is rapidly accelerating and upgrading in electronics GVC across the board, in a large number of end markets (both geographically and product categories). Korea has focused its production activities on the high value segments and components, while China has focused more on establishing capabilities along the whole supply chain. In shipbuilding, Korea continues to upgrade into higher value product segments, which is helping it maintain its leadership over China. China has primarily focused on driving volume in lower value products, but is gaining capabilities in larger containership vessels and tankers.

Table 5-3. Comparative GVC Upgrading: Japan, Korea, and China

	Japan	Korea	China
Population (2016)	127 million	51.25 million	1.379 billion
GDP (US$, 2016)	4.939 trillion	1.411 trillion	11.2 trillion
Total Merchandise Exports (US$, 2015)	625 billion	525 billion	2,282 billion
Services Share of GDP (2015)	70%	59%	50%
	Electronics		
Upgrading Type	**Japan**	**Korea**	**China**
Product	◐	● (3Cs)	○
End Market Diversification (geographic)	○	○	●
End Market (categories)	◐	○	●
Supply Chain Backward Linkages	◐	◐	●
Functional (OBM/Lead Firm)	●	●	◐
Move into production equipment	●	◐	◐
Total Electronics Exports (US$, 2015)	76 billion	120 billion	636 billion
Electronics Share of Total Exports (2015)	12%	23%	28%
Electronics Export Value Change (2000-15)	-42%	95%	1209%
	Shipbuilding		
Upgrading Type	**Japan**	**Korea**	**China**
Product	◐	●	◐
Process	●	●	◐
Supply Chain Backward Linkages	●	●	○
Functional	●	●	◐
Functional Upgrading into Services	◐	○	◐
Move into production equipment	●	○	○
Intersectoral	◐	◐	○
Total Ship Exports (US$, 2015)	11 billion	38 billion	28 billion
Ship Share of Total Exports (2015)	2%	7%	1%

High	Mid	Low
●	◐	○

Note: 3Cs stand for consumer electronics computers, and cell phones.
Source: Authors.

Finally, compared to other late industrializers, Korea's continuing success in these GVCs is now based on indigenous firm ownership rather than foreign direct investment (FDI). Where other countries continue to develop their strengths in manufacturing by attracting foreign firms, over the past few decades, Korea has focused on building its own global firms. Today, these domestic firms access foreign technologies through capital equipment purchases or licensing agreements (National Research Council, 2012, p. 42). For example, this is seen as a critical element for upgrading Korean shipyards (Bruno & Tenold, 2011); Korean firms licensed technologies from a range of British shipbuilders, including dockyard and ship designs, and had foreign engineers working at local shipyards, for much of the early years of their development. While this has required significant investments for capabilities development in the past, today, it means that local manufacturers are not constrained to functionally upgrade in GVCs. In many countries, the functions of multinational enterprises (MNE) subsidiaries have been limited to production and sustained engineering with little prospects of upgrading into the highest stages of the value chain, such as R&D and branding. MNEs consider those core activities and maintain them close to headquarters.

Table 5-4 summarizes the key advantages and constraints regarding Korea's current model of GVC engagement for future upgrading.

Table 5-4. Advantages and Challenges of Korea's Current GVC Engagement

Advantages	Disadvantages
• Indigenous lead firms not trapped in MNE network structures • Vertically integrated: Strong in-house manufacturing and ownership of production technologies • Experience in adopting foreign technologies • Strong industry-government linkages for workforce development and applied R&D • Ability to develop new technologies in high tech sectors enabled country to create top global brands (but in a narrow range of products)	• Manufacturing focus misses opportunities for new business models and financing opportunities • Captive suppliers find it difficult to diversify • Vertically integrated: high risk of innovative R&D, poor development of services providers • Reliant on government support, and willingness of public to support industry • Concentration on limited number of industries; limits transfer of skills and capabilities across sectors • Relatively isolated supply chains; limits potential of learning from international best practice

Source: Authors.

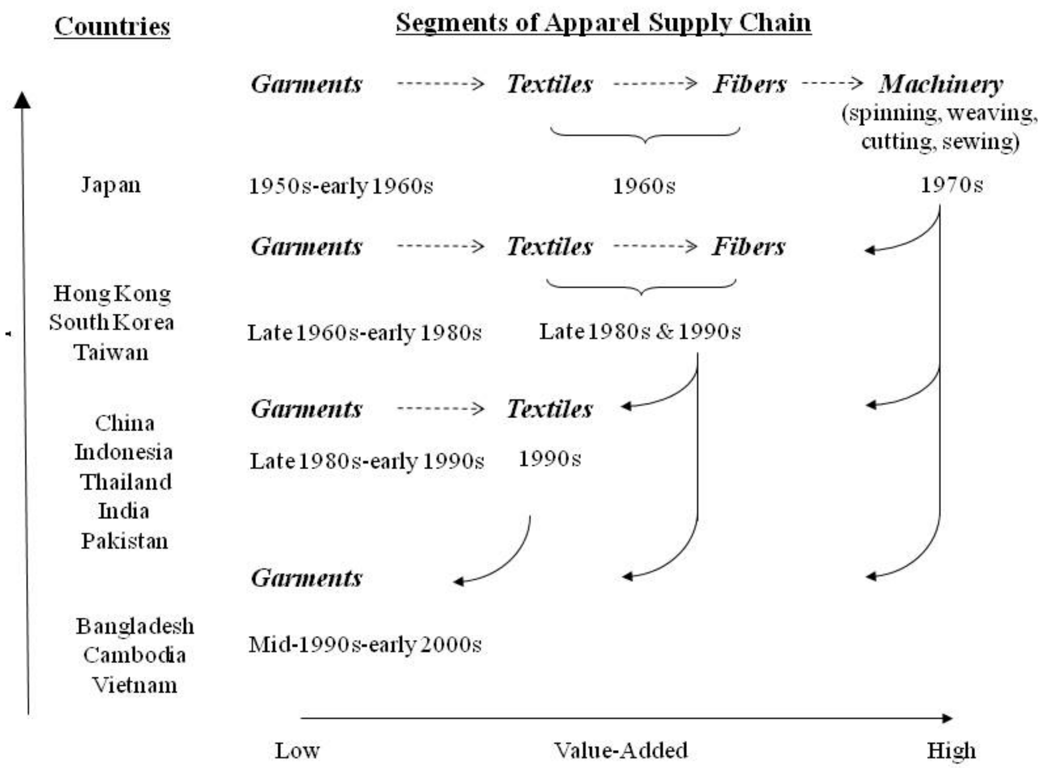
5.4. A GVC Perspective for Korea's Industrial Transformation

Korea is in a unique position as an industrialized manufacturing powerhouse driven by strong indigenous lead firms with in-house manufacturing capabilities and well-known global brands. This position affords the country the opportunity to pursue multiple GVC upgrading trajectories as it redefines its economic development goals. GVC analysis highlights the following three trajectories that can be used to drive industrial transformation.

1) **Innovation in Production Technologies and Equipment**

As production relocates, the future control of manufacturing operations will be in designing, developing and owning production technologies and equipment. Upgrading into the design and/or fabrication of production equipment in any industry requires a deep understanding of how products are put together. In the past, this was a traditional, path dependent upgrading trajectory for manufacturing centers. During the second half of the 20^{th} century, Japanese firms leveraged early knowledge in apparel and textiles to become the leading players in sewing machines and synthetic fiber manufacturing, while European firms have dominated textile (fabric and yarn) production technologies (see Figure 5-1). In electronics, Japanese firms used their expertise in optical technologies to develop the key pieces of production equipment for display and semiconductor manufacturing. European firms have used their manufacturing history to continue to develop and innovate products for non-consumer markets, including medical electronics, aerospace, and industrial (automation) equipment. Similarly, Scandinavian firms successfully transformed their shrinking resource-based sectors (e.g. forestry, mining and oil and gas) into a thriving capital equipment business (Blomstrom & Kokko, 2002). European firms are now looking to develop more of these production technologies using autonomous robots. For example, Kuka, a European robotics manufacturer recently acquired by a Chinese firm, supplies interconnected autonomous robots that work together and adjust their actions to fit the next unfinished product inline. ABB is also launching a two-armed robot designed to assemble products, including consumer electronics, with humans.

Figure 5-1.Upgrading into Equipment Production in the Apparel Global Value Chain



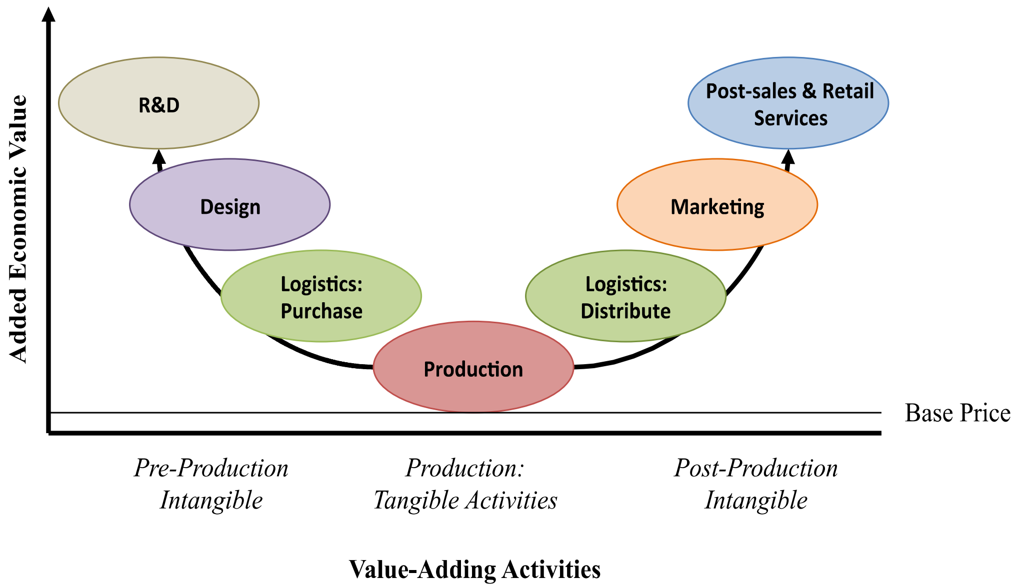
In today's globalized economy, however, this development path has become more elusive for countries that previously dominated manufacturing. As firms in many of these nations have increasingly relied on offshoring and outsourcing to boost their competitiveness, they have simultaneously moved away from actual manufacturing activities. Referred to by some as "hollowing out" of manufacturing (Goos & Manning, 2007; Goos et al., 2009, 2014; National Research Council, 2012), this limits the lead firm's knowledge of how products are fabricated. In some industries, including electronics, it has been more than a decade since large-scale offshoring of manufacturing began, and technologies have evolved rapidly in that time. Even original offshoring destinations for electronics, such as Taiwan, have felt this effect. In order to remain competitive Taiwanese ODM and OBM manufacturers opened up operations in low cost locations in China and Southeast Asia (National Research Council, 2012, p. 42).

As brand manufacturers, Korean lead firms are thus uniquely positioned in their core industries to dominate innovation and development production technologies; unlike their peers, they have maintained these value chain activities in-house, constantly upgrading their production processes and technologies as new innovations in production have emerged. In addition to know-how, Korean firms have a fertile testing ground for applying new techniques. This puts the country in an advantageous position to move into the provision of these technologies in the future. This will be particularly important as new disruptive, Industry 4.0 technologies become available and more production is ‘reshored’ to traditional manufacturing hubs. Owning and developing production technologies also ties into servicification opportunities as developers of capital equipment in some industries are shifting to a model of leasing or renting equipment rather than selling it.

2) **Functionally Upgrade into High Value Manufacturing-Related Services**

Value chains are comprised of sequences of tangible and intangible value-adding activities, from conception and production to end use. The highest value segments in manufacturing GVCs are typically in service segments, rather than production activities. These services are in pre-production and post-production operations, including new product development, design, marketing, and retail. The rise of ‘Big Data’ means that after-sales data driven knowledge services are now emerging and fast becoming the most valued segments. In addition to these specific value chain segments, throughout these chains, there are a variety of manufacturing-related services undertaken at each stage, including production and sustaining engineering and procurement activities (Low & Pasadilla, 2016). These activities can be contained within a single firm or divided among different firms. In the context of globalization, these have generally been carried out by inter-firm networks on a global scale (Gereffi & Fernandez-Stark, 2016); in Korea, however, these activities – when pursued– have been mostly undertaken within manufacturing firms. For example in shipbuilding, many European shipbuilders outsource production planning and engineering activities to specialized services firms, while in Korea, these continue to be undertaken by the shipyards themselves.

Figure 5-2. Distribution of Value in Manufacturing GVCs



Source: Authors, adapted from Shih (1996)

Servicification, therefore, offers three potential upgrading approaches into service operations for Korea: (a) Upgrading in manufacturing-related services, (b) Upgrading into newly emerging (data-driven) post-production segments of the GVCs and, (c) Upgrading into IT services. Each of these opportunities are discussed in turn below.

(a) Upgrading into Manufacturing-Related Services

Korea is a leader in the implementation of high productivity manufacturing processes. This is primarily done in-house. There is an opportunity to leverage this expertise and sell this process knowledge as a service to other manufacturers around the world. Increasingly, manufacturers in a wide range of industries are turning to specialized services providers to complete different functions in their chains. Electronic manufacturing services (EMS) firms are some of the most prominent examples, but this externalization extends to a host of other activities including raw materials procurement, production planning, logistics and inventory maintenance (Low & Pasadilla, 2016). Successfully upgrading into these services requires significant capabilities both with respect to client relationship management and a conducive environment to services firms and exports.

(b) Upgrading into After-Sales Services (data collection and analytics)

While there are immediate, profitable, opportunities in retail and marketing upgrading, the long term potential for post-production services based on Internet of Things (IoT) and Big Data is even more promising. As these trends continue to expand and sensors are embedded in a growing range of products from cell phones, computers, and cars to household appliances, and even ships, Korea will be in a strong position to upgrade into important *after-sales*, *knowledge-intensive* *services*. Each of these areas is an opportunity to gather a wealth of information; using data analytics, Korean firms could thus tap into knowledge from consumer behavior to improving operational efficiency, including fuel optimization and waste reduction. This data can be used to improve internal operations or monetized and sold as a business model.

Access to this data is a key element for entry into these knowledge services. In the mobile phone and computer markets, the opportunity to capitalize on this data is tied to application development and software; part of the larger information and communication technology (ICT) global value chain which includes IT *services* and software in addition to hardware manufacturing. When users install mobile apps, they are required to agree to service conditions that enable the application to collect various types of information such as personal information, location, and how you use the application. This information can then be used or sold by the application developer to third-party users. In shipbuilding, Korean firms could gain access to information on the preventative maintenance needs by embedding systems to collect data on ship performance, fuel consumption, and component wear and tear, amongst others for ships operating in a wide array of geographic and climatic conditions. Not only could this information help the shipbuilders to design and build better ships, but the analytical details regarding performance could also be sold to shipowners. This information would save shipowners both time and money, and clients are prepared to pay for these value-added services. Moving into after-sales services may require establishing new business models to ensure ownership, or at least access, to data (Baur & Wee, 2015; Tien, 2013).

(c) Upgrading into IT Services (software, digital content)

As outlined in Chapter 3, the IoT phenomenon means all products are increasingly becoming electronics and these electronics can now be connected to one another. What makes these connections possible (and what ultimately enables big data to be collected) is the software embedded in the electronic components of these things. Korea is in a strategic position to move into this service-oriented domain given its strong position in the manufacturing segments of electronics hardware GVC with three large 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. For example, of the top 100 digital MNEs, by sales or operating revenues (2015): 67% (two-thirds) of the digital MNEs are US firms; 23% are European, four are Japanese, two Chinese and one each from Korea, Canada, Mexico and South Africa (WIR, 2017). And of the top IT software and service companies, only one is from Korea. To move into new technology and service-oriented activities may require a strong focus on network-building between global and domestic firms. In other countries, key IoT developments have resulted from strong ties between IT service-related companies and existing lead firms in each industry.

3) Intersectoral Upgrading into New Knowledge-Driven Industries

Over the past two decades, as traditional manufacturing has been moving abroad to lower cost locations, advanced industrialized countries such as France, Japan, the UK and the US have been steadily advancing the knowledge and technological frontiers with the development of a host of new sectors, including software applications and advanced computing (National Research Council, 2012). These industries emerge with the advent of new production methods, markets, and new forms of industrial organization, combined with cutting-edge basic research findings (Schumpeter, 1994 [1942]). Nanotechnology, biotechnology, and clean energy storage, have all emerged from these hubs by drawing on existing knowledge in the fields of medicine, biology, electronics and chemistry amongst others. While in the GVC literature, intersectoral upgrading is most often viewed from the developing country perspective – moving, for example, from bicycles to automotive and then to aerospace sectors as capabilities develop (Bamber, Frederick, et al., 2016), when seen from a developed country point of view, where firms are operating near the knowledge and technological frontier, this can be considered using existing skills to develop new industries.

The emergence of these new sectors can have their roots in interdisciplinary interactions and convergence from two separate, but perhaps related fields, such as automotive electronics, the application of existing technologies to new sectors, such as mobile banking, or through the development of brand new knowledge based on basic research, such as has given rise to nanotechnology. This requires much more active collaboration across the country's large, innovative business groups.

5.5. Policies for Future Success in Manufacturing GVCs

In order to achieve the ambitious upgrading targets for the future, Korea must undertake a number of policy initiatives to create an environment conducive to entrepreneurship, services development and innovation. In particular, it must prioritize change in three key areas:

1. Institutionalization
2. Environment for Entrepreneurship in Services
3. Innovation System and Human Capital Development

5.5.1. Industry Stakeholder Coordination and Collaboration

GVCs are embedded within local economic social and institutional dynamics. Achieving upgrading requires a strong will and association of the value chain actors (Gereffi & Fernandez-Stark, 2016). Participation in today's complex global value chains – whether as a lead firm host, or further down the chain - demands industry stakeholder coordination and collaboration to ensure that interests are aligned, skills gaps are met, constraints are overcome and regulation is supportive for development. Organized action to assess, formulate and implement specific initiatives is essential for industry upgrading.

As Korea is looking to move into the next level of development, the country needs to adjust its internal organization to embark on these changes. The country's previous strongly hierarchical industrial policy approach allowed Korea to technologically "catch up" with other industrialized countries.[5] Under this model, the government established the parameters for most aspects of production, from what sectors specific companies should focus on to research and sector

[5] The government directed and guided major economic agents for the implementation of Five-Year Economic Plans, which were formulated by the government with the joint-work of government bureaucrats and civilian experts. The horizontal interactions among major economic players were not developed and the authoritative government treated the private sector on the basis of the 'divide and rule' method (Hong, 2011).

development strategies (Kim, 2015). Over the past decade, however, Korea has been transitioning from this bureaucratic approach to a new modern industrial policy model that is more inclusive of a broader range of actors, although these are most local (Hong, 2010, 2011). However, this new model has not always been successful and has encountered duplication of efforts (Devlin & Moguillansky, 2011; Hong, 2011); often, the major problem is that strategies and programs are formulated but not implemented. In addition, the balance of power of the varying industrial development institutions has been uneven, biasing policy orientation. Government and *chaebols* are the most influential, followed by academia, with labor and SMEs having little say (Hong, 2010). The strong historical ties between the government and chaebols mean that policies, in effect, are often oriented in their favor, making it difficult for policymakers to actively support the interests of other actors.

The most recent industrial policy plan is the *Comprehensive Action Plan for Future New Growth & Industrial Engine* (see Chapter 2 for further details of the plan*).* This was developed as two separate plans by the Ministry of Science, ICT & Future Planning (MSIP) and Ministry of Trade, Industry & Energy (MOTIE), which were later merged.[6] MSIP and MOTIE decided to facilitate cooperation programs and strengthen policy coordination between the two ministries. It calls for comprehensive support for international joint research and establishment of infrastructure, along with technology development, to create an industrial ecosystem that enables shared growth of industries, academia and research institutes. In the formulation of this plan, however, Korea already appears to have repeated duplication errors of the past and it remains to be seen whether these ministries can successfully coordinate the efforts of the different actors they are encouraging to engage.

The institutional landscape for innovation policy development in Korea reflects the difficulties the country has had with respect to establishing an effective institutional setting for a more "bottom-up" approach to industrial policy. The NIS structure has undergone multiple revisions since the end of the hierarchical top-down approach in 1993. These include major changes in 2004, 2011, 2013 and 2017. In 1993, the National Science and Technology Council, with representatives from ministries and experts was established as the highest authority in terms of R&D policy. This was chaired by the President. However, during this period, it was afforded the same power as the National Assembly and the Ministry of Planning and Budget. This ultimately created challenges regarding policy formulation and implementation. In 2004, the strategy was changed, elevating the Minister of Science and Technology to that of Deputy Prime Minister. This was supported by the Office of Science and Technology, charged with allocation of R&D budgets, and the Ministry of Planning and Budgets charged with compiling R&D budgets. Expert committees also weighed in on key issues. Subsequently, in 2011, the Council was established as a permanent organization with its own secretariat reporting directly to the President and with an expanded array of responsibilities regarding the countries budget. In 2013, this was once again changed, with the President appointing the chairs and the Council became part of the Ministry of Science, ICT and Planning (which was created in 2013, and brought together the former Ministry of Science and Technology and the Ministry of Knowledge Economy). In July 2017, this Ministry was dissolved and replaced by the Ministry of Science

[6] Namely the '15 Rolling Plan' of the 'Action Plan for Future Growth Engines' by MSIP with the participation of about 200 experts and the 'Development for Industrial Engines Project' by MOTIE.

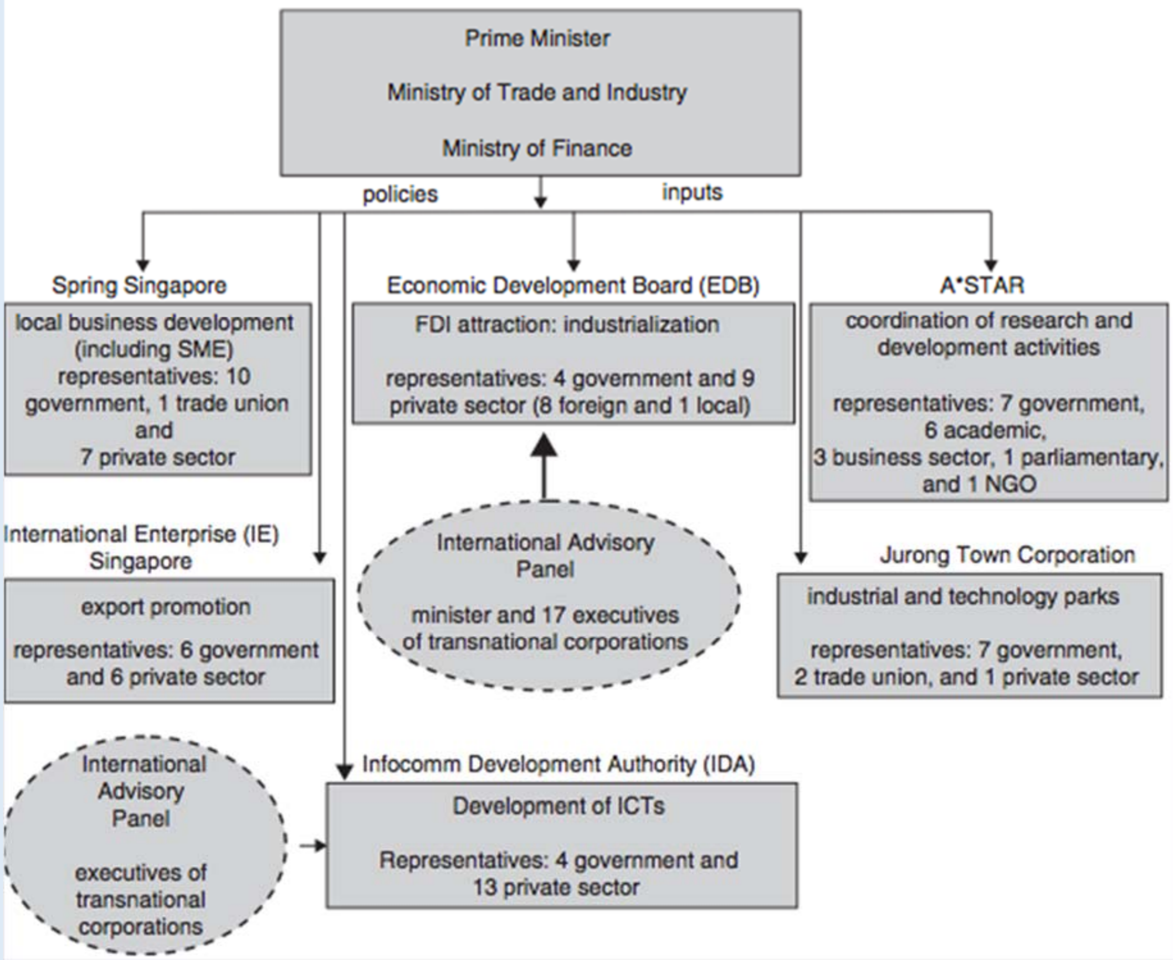
and ICT. Over the period analyzed, membership of the Council has varied considerably with the balance of power between private and public sector shifting back and forth.

Upgrading to operate at the knowledge and technological frontier in a wider range of industries requires a well-oiled machine. This requires an array of established firms, and smaller innovative ones, skilled labor, a legal framework that protects intellectual property, well-functioning infrastructure and investment and trade policies, and financing, amongst others. Inadequacies in any area can undermine potential growth. This is just as important in the area of the state, where policy approach must be coherent (Yeung, 2014). Ensuring these needs are met requires a suitable institutional development, which effectively includes all actors from SMEs and R&D centers to universities and labor organizations from across all major economic sectors. At the same time, linkages to the world's leading research organizations are critical to help absorb and contribute to the latest global discoveries (see Box 5-2 and Box 5-4 on Singapore and Taiwan's approaches).

Box 5-2. Singapore: Multi-stakeholder Engagement for GVC Strategy Development

Singapore offers an example of an institutional approach to industrial policy that allows the country to develop and adapt its industrial development strategy as its economy advances. In particular, Singapore has achieved a high degree of coordination among all value chain actors including academia, trade unions, foreign and domestic firms and SMEs from its relevant sectors. At the same time, they include an International Advisory Panel to ensure their strategies are moving them closer to the global knowledge frontier while building social and intellectual networks to help the country identify opportunities. One of the most important characteristics of Singapore's institutional system is its understanding of the dynamism of the global economy, and its flexibility and proactivity to not only adapt but also reinvent itself. This is manifested by the country's insistence on incorporating foreign actors – including firms, academics and industry experts - into the development of its global integration approach. On the same front, the country has laid out a sound model to coordinate innovation institutions that addresses all the process, from project design to implementation. Compared to Korea and Taiwan, where the state role was dominant in early industrialization, Singapore has had a much longer period of higher levels of collaboration in industrial policy formulation. The domination of foreign investment in Singapore's industrialization also reduced the state's autonomy in industrial planning and policy implementation. There thus has been greater coherence to its recent industrial policy approach than in its regional peers where factional rivalries between ministries have taken much longer to resolve (Yeung, 2014). Figure 5-3 illustrates the country's organization model.

Figure 5-3. Institutional Set Up to Support Global Integration Strategy



Source: Devlin and Moguillansky (2011)

5.5.2. Services and Entrepreneurship

In the context of Industry 4.0, even manufacturing sectors, innovative and disruptive technologies are generally being introduced by services firms that start small. These one-time 'Start-Ups' include a long list of now-household names from Amazon to Google to Uber, which today have begun to challenge traditional lead firms for control over global value chains. Nurturing these potential future giants requires a new take on traditional SME policies. Small firms encounter many constraints as they seek to grow, from access to finance and information to forging market linkages and finding customers. In GVCs today, the trend towards rationalization of supply chains around larger, more capable suppliers, makes it even more difficult for these firms to develop. While this trend has mainly been for manufacturing partners, due to the scale required to serve global clients, this has implications for services firms as well.

The most innovative countries today recognize the value of these firms to their economic development, and have been actively putting in place policies to create a conducive environment for their emergence and growth. In doing so, governments play a facilitating role in establishing creative hubs that can be hotbeds for the emergence of new ideas, while supported by policies that make core procedures for setting up and running a business easy, from permitting processes to import-exports. These policies include fostering innovation hubs, such as Station F in France or Singapore's National Additive Manufacturing Innovation Cluster (see Box 5-4), facilitating linkages between academia and lead firms, supporting access to risk capital by encouraging venture capital and private equity. Given that services firms are primarily driven by human capital, supported by computing power, the investment costs for these policies are much lower than those required to foster new manufacturing firms.

While Korea has performed very well in manufacturing GVCs, with several global lead firms emerging in the two industries analyzed, it still lags behind its OECD peers in the development of its services sector, and its unique history of focusing on large firms has left a gap for smaller, start-up firms. Services accounted for 59.2% of Korean GDP, well below the OECD average, 74.2% (WDI, 2017). In 2016, while Korea had 15 companies listed in the Fortune 500, none of these were primarily services operators.[7] Just four of its top 30 companies are in services compared to 12 out of 30 in the US (Dobbs & Villinger, 2017). 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. This indicates that Korean firms are failing to excel in services innovation in the same way their manufacturing operations have. Furthermore, services as intermediates in the manufacturing process, are just 10%, compared to 19% in the US and 22% in Germany (OECD, 2016, p. 79). These statistics are, in part, a result of the high degrees of vertical integration with services being performed in-house, but also illustrate the country's comparative difficulties in developing a strong services sector. Furthermore, where services firms are operating, their productivity is just half that of manufacturing.

This performance is the outcome of pursuing a specific strategy; Korea's industrial policy environment has long emphasized manufacturing over services, and prioritized large firms over small. This compounds the challenges for creating the new knowledge-based services firms for the future. SME policy has been more focused on addressing the issue of unemployment rather than driving a strong tech start-up ecosystem, and efforts focused on developing SMEs have been with an eye to their absorption by existing conglomerates rather than accelerating their growth to become new global operators. While progress has been made in improving the country's services investment and trade policies, [8] with the liberalization of core business, engineering and professional services (OECD/STRI KOREA, 2017),[9] the local regulatory environment for services remains significantly more stringent than that for manufacturing. In 2013, there were four times as many regulations for services as there were for manufacturing (OECD, 2016). While the government has put in motion efforts to reform the regulatory environment for services, this has not yet had an impact on the sector. Thus, despite the opportunities being offered by Big Data and IoT and the world's fastest broadband (OECD,

[7] Companies in the Fortune 500 (or similar lists based on revenue or profit generation) tend to be innovation leaders and key patent holders, or hold dominate positions in buyer-driven industries such as apparel.
[8] In 2013, it ranked second-last amongst its OECD peers for openness to trade and investment (OECD, 2016, p. 94).
[9] Certain challenges remain, however, with key GVC related services, including legal and courier services, continuing to be characterized by restrictions.

2017b, p. 25),[10] the poor local business environment, combines with a local, risk averse culture, to make it very difficult to encourage or attract entrepreneurs.

Box 5-3. Station F and French Tech

France has bet big on creating a conducive environment to support innovative entrepreneurs. In June 2017, the French President Emmanuel Macron led the inauguration of Station F, the world's largest Start-up incubator, aiming to support 1,000 new companies. This new hub is considered the future for French tech. The focus is encouraging entrepreneurs and creating an environment for innovation with the support of leading companies, universities and venture capital funds.

The largest start-up campus in the world, the Parisian center has more than 3,000 desks, 26 international startup programs and, will even add a 600 person co-living space in 2018. Entrepreneurs can use the space for as little as US$221 a month and even get the first year free. Established companies, including Facebook, Microsoft and Zendesk, also have offices within the building to facilitate networking and collaboration with young startups.

While the project was started with an initial €250 million private sector investment, this is part of a much broader French Tech initiative being pursued by the government. Macron recently announced a US$11.3 billion fund for innovation and has openly encouraged global entrepreneurs to make Paris their headquarters. The focus is to convert France into Europe's technological capital, with a strong change in the country's entrepreneurship culture.

Sources: (Dillet, 2017); France 24 (2017)

5.5.3. Innovation Systems and Human Capital

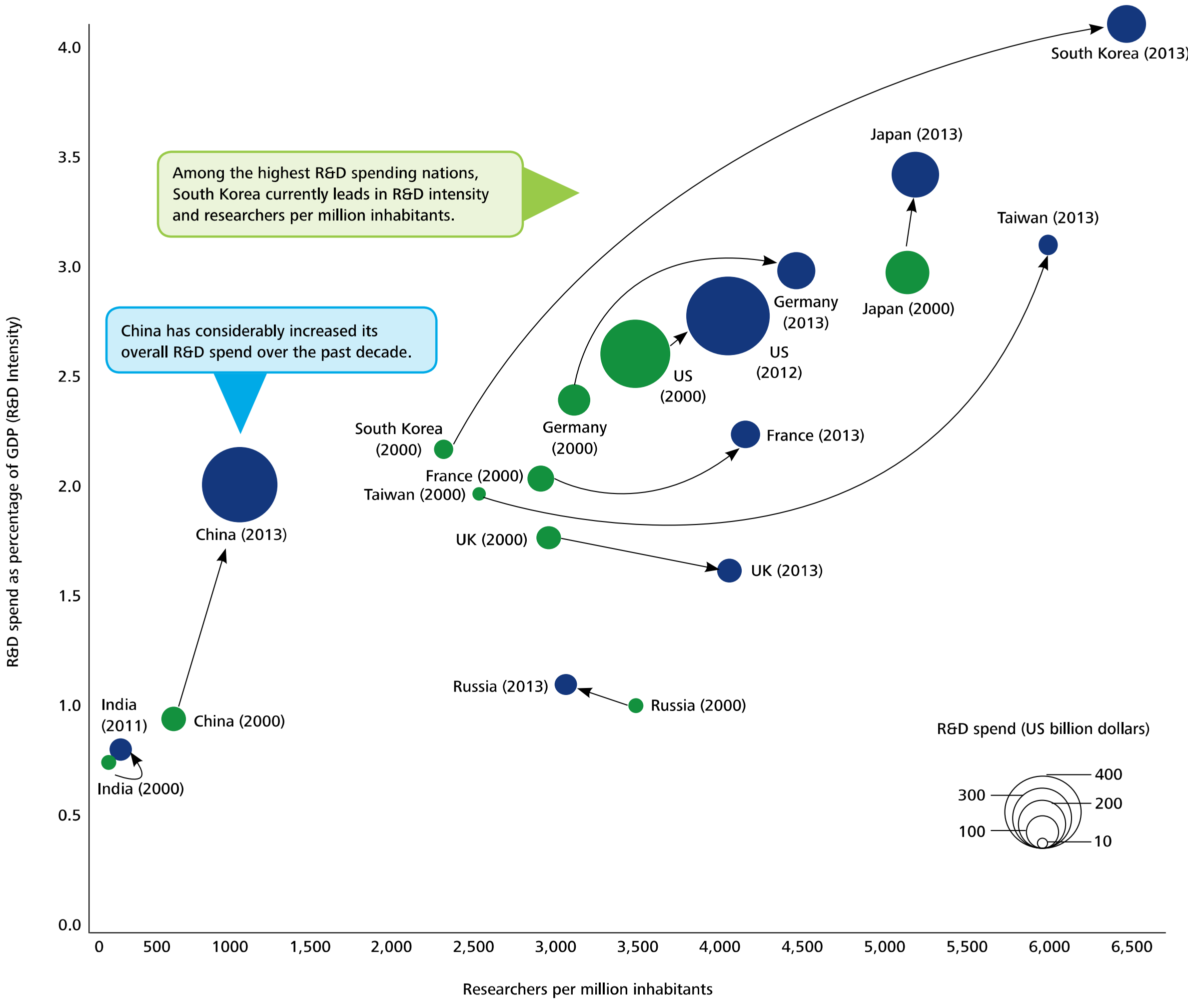
The upgrading trajectories suggested above to help Korea achieve its industrial transformation goals require a well-structured innovation system (IS) with a focus on incentivizing cutting-edge research, developing the right types of human capital, and promoting mechanisms for the adoption and diffusion of new knowledge and technological capabilities to business. This requires a high degree of collaboration across research institutions, private sector, and education, well-defined standards and efficient processes of quality assurance and testing (Pietrobelli & Rabellotti, 2011). While these systems provide the "soft infrastructure" so to speak, they must be oriented correctly towards a country's goals.

Many countries continue to struggle to even establish these systems, due to a lack of resources and capabilities; yet, overall, Korea has excelled in this. The country spends more on R&D as a share of its GDP and has a higher number of researchers per million inhabitants than all other countries (WDI, 2017). The government is making commitments to spend even more on R&D than it is currently, to push this to 6.2% of GDP (OECD, 2016). It has already successfully engaged private firms to commit to the bulk of R&D spending; the government contributes just 23% of total R&D funding.

[10] This has been driven, in part, thanks to increased liberalization to investment in the sector over the past two decades, which saw foreign ownership, merger and acquisition, and Korean national requirements eased (Nordstrom, 2017).

However, there are concerns about this system's potential to support future growth. Resources have been highly concentrated on a limited number of industries, the efficacy of some public research institutions is questionable and there is little interaction and research carried out by universities (OECD, 2016). About three-quarters of business-sector R&D is carried out in high and medium-high technology manufacturing industries; out of these three-quarters, 80% was concentrated in two sectors, ICT and automobile, one of the highest rates for OECD countries (Mittelstädt & Cerri, 2008). Korean firms in these industries have well-established private R&D operations; Samsung has three times as many patents as the next global technology players. Universities, on the other hand, contribute just 0.7% of R&D funding. This approach of heavily biasing on commercial R&D can rule out the huge potential value of serendipitous innovation and potentially disruptive technologies. A key challenge for the country, therefore, to achieve its upgrading ambitions will be to re-orient its public R&D systems away from applied R&D in a small number of sectors, and towards more basic research with a strong focus on universities that can help to place the country on the knowledge frontier.

Figure 5-4. R&D Spending and Number of Researchers, Top 10 Countries, 2000 & 2013



Note 1: Size of bubbles indicates relative R&D spend.
Note 2: For US, 2012 R&D spend and R&D as percentage of GDP was the latest available data; For India, only 2011 data was available for all three metrics.

Source: Deloitte (2016); R&D Spending based on % of GDP and Researchers are per million inhabitants.

Box 5-4. Taiwan Shifts Innovation Focus to Fast Innovation

There is a growing consensus in Taiwan that an exclusive focus on hardware manufacturing is no longer sufficient to guarantee sustainable growth. Taiwan's new innovation strategies now seek to build on its capacity for low-cost and fast manufacturing by complementing its contract manufacturing and component production excellence with knowledge-intensive support services and a capacity to provide "integrated solutions." In addition, Taiwan has a long-term objective to strengthen its software capabilities, especially for the design of complex system software and for cloud-computing applications. To implement this strategy, Taiwan's innovation policies seek to strengthen further the linkages and interactions among industry, academia, and public and private R&D organizations.

A defining characteristic of Taiwan's innovation policy is its openness to foreign strategic advice and knowledge sharing, distinguishing it from Japan, Korea, and China with their much more closed systems of innovation policy. In addition to providing aggressive tax incentives, Taiwan's innovation policy seeks to strengthen the lead role of the private sector by generating new public-private partnerships and by coordinating their interactions. In particular, government initiatives, such as Taiwan's Technology

Development Programs, Hsinchu Science Park, and Industrial Technology Research Institute (ITRI). ITRI has in the past played a significant role in Taiwan's semiconductor industries; it is now also working towards providing services based Industry 4.0 solutions. ITRI's recent Cloud Computing Center for Mobile Application (CCCMA) seeks to promote Internet-based, on-demand computing (cloud computing) as a catalyst for strengthening Taiwan's software capabilities, building on Taiwan's strengths in lower-cost hardware, such as memory, chipsets, server, and storage network equipment.

U.S.-Taiwan-China Linkages
Since its inception, Taiwan's IT industry has greatly benefited from its deep integration with America's innovation system, especially Silicon Valley. As a byproduct, the United States and Taiwan have developed a strong mutual dependence on each other's IT and semiconductor industries. U.S. IT companies remain the most important buyers of Taiwanese ODM and OEM services, and Taiwan's silicon foundries are a critical supplier of process technology as well as manufacturing and design services to U.S. fabless design companies. In addition, Taiwan exploits a first-tier supplier advantage due to the establishment of leading U.S. R&D centers in Taiwan and to the acceleration of its "upgrading through innovation" strategy.

If Taiwan is to survive intensifying technology-based global competition, it must move beyond its traditional "global factory" innovation model, which will require quick access to radical innovations, especially in generic technologies. While Taiwan has significant policy initiatives in each of the above areas, the risk of failure remains high, implying that an exclusive focus on technology leadership strategies is unlikely to support a broad-based upgrading through innovation strategy. These risks explain why Taiwan's new innovation strategy emphasizes low-cost and fast innovation through domestic and global innovation networks.

Source: excerpted from *National Research Council. (2012). The New Global Ecosystem in Advanced Computing: Implications for US Competitiveness and National Security. National Academies Press.*

In terms of human capital, similar shifts in thinking are required as Korea seeks to reposition itself in the chain. Generally speaking, experience and skill level of the workforce in GVCs differs depending on the stage of the value chain (Gereffi, Fernandez-Stark, & Psilos, 2011); these requirements are dynamic and must respond to changing technologies.[11] Production segments are typically dominated by semi-skilled and unskilled workers, while the highest segments of the value chain tend to be knowledge intensive, requiring specialized skills to perform complex activities and usually the core labor force must possess tertiary education degrees (Gereffi et al., 2011).

Korea's participation in manufacturing GVCs to date has been focused on the pre-production and production stages; these have required high numbers of engineers, science and technology graduates and skilled technicians. The development of production technologies for the future as more and more Industry 4.0 technologies are incorporated will continue to build on this base requiring increasingly skilled technicians and engineers interfacing with automated processing (WEF, 2016a, 2016b). As automation increases, more basic tasks will be undertaken by robots; one estimate suggests that as much as 52% of the current workforce positions in Korea could be

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[11] The World Economic Forum expects job categories requiring complex problem solving, social and systems skills are less likely to be automated than positions that involve routine or physical tasks (Davis, 2016). Similarly, McKinsey estimates that 81% of time spent on predictable physical tasks can be automated given currently demonstrated technology, but only 9% of time spent on management activities is automatable (Bughin et al., 2017).

automated in the future (compared to 56% in Japan, 51% in China and 46% in the US) (see Table 5-5). The skills and know-how of the existing manufacturing workforce must therefore be continuously upgraded to support optimized use of these new technologies, while at the same time enhancing the training of those in new product development to innovate with developing and applying these new technologies to the production process. Skills in software development, systems engineering, and repair and maintenance of automated and robotic systems will likely become more important (WEF, 2016a, 2016b).

Table 5-5. Automation Potential, by Number of Employees (Millions) and Country

Rank	Country	Automation potential (%)	Total Employees	Automation potential (employees)
7	Japan	56%	63.9	35.6
16	Korea	52%	24.0	12.5
2	India	52%	454.2	235.1
1	China	51%	772.5	395.3
3	US	46%	132.3	60.6

Source: (Bughin et al., 2017); Note: employment figures are in millions.

Korea is known for its well-established education system as well as a high level of education attainment. It has excelled in orienting a significant share of its workforce towards STEM majors (45% in 2015); one quarter of all graduates come from engineering – and this has been on the rise in recent years. This positions the country well to embark on this upgrading trajectory into production technologies. This focus, nonetheless, is only on university education and does not extend through to the life-long training initiatives that will be required to benefit from automation and other emerging digital technologies. Currently, less than 1% of the country's total education budget is spent on such programs (compared to 8% and 30% in Japan and the US respectively (Dobbs & Villinger, 2017).

Furthermore, the strong emphasis on STEM has resulted in weak development of non-STEM training that is required to help drive the country's upgrading into services sectors. These sectors typically draw on more than technical knowledge. These jobs require a combination of 'hard and soft' skills. In particular, interpersonal and language skills are necessary to negotiate the challenging terrain of client and consumer relationship management from a wide range of cultural backgrounds; these are fundamental to drive success in services (Gereffi et al., 2011). Until now, graduates with humanities and social sciences majors have difficulty finding a job. This current mismatch between student qualifications and skill demand in the market could be partly reduced by reorienting these workers towards services jobs within the manufacturing sector. These non-STEM degree lines, however, must be updated in the context of today's increasingly global, and technologically sophisticated. English and Mandarin should be prioritized for future service provision, while overseas employment and education should be encouraged.

Furthermore, to support intersectoral upgrading potential, greater flexibility in employment is required to help labor flow between sectors. In the US, for example, people change jobs four times before the age of 32 and 12 times in a lifetime (BLS, 2017). In doing so, skills developed in one sector can be applied in new contexts. However, employment protection policies must be aligned to these goals. Korea ranks poorly in global ranking of flexibility; the World Economic

Forum (WEF) Global Competitiveness Report ranked Korea 113/138 economies for flexibility in hiring and firing of employees (WEF, 2017). This has given rise to a high percentage of non-regular employees (twice the OECD average at 22% in 2014) (OECD, 2016), and contributes to vulnerability. Relaxing these regulations could help increase mobility of highly talented employees between firms and sectors, diffusing innovative ideas and facilitating the commercialization of others.

Box 5-5. Massachusetts Life Sciences Supercluster

Established in 2008, the Massachusetts Life Sciences Supercluster initiative leverages the synergies between multiple different sectors related to the central social challenge of improving healthcare quality. The central goal was to drive development by taking basic research and transitioning it into commercial products and services. Building on the region's established medical device manufacturing sector, it supports the biotechnology, nanotechnology, bio-diagnostics and pharmaceutical industries. With US$1 billion in state support to drive industry growth over ten years, the Massachusetts Life Sciences Center, a quasi-public-private organization, is dedicated to fostering a strong innovation system with a focus on the development of strong human capital for the sector.

Central to the cluster's success is its existing comparative advantage in life sciences R&D emanating from the laboratories of its leading universities and medical institutions. These include Harvard University and the Massachusetts Institute of Technology. Key to engaging these universities actively was a 1980's Bahy-Dole Act giving universities ownership of intellectual property developed under federally funded research. In addition, there are efforts to boost local university efforts through building collaborative relationships with foreign universities pushing the life cycle knowledge boundaries, including in Ireland, Finland and Spain. This is also extended to firms seeking to work with foreign innovators, such as under the Massachusetts-Israel Innovation Partnership (MIIP).

Building on this researcher base, the initiative brought together a wide range of actors, including the public sector, industry, academics and financial institutions to ensure the flow of knowledge, information and finance to meet the industry's goals of creating this one of the most successful in the world. These stakeholders all interact on a regular basis to assist each other in the promotion of their activities. This is actively incentivized; US$4.8 million was made available in the early years to fund research collaboration between eight industry and academic partners. Where companies might compete in products, they make up for in collaborative contributions to basic research. For example, the Massachusetts Neuroscience Consortium was formed bringing together multiple lead life sciences firms to sponsor preclinical neuroscience research under way at academic and research institutions. The results will then be shared with all of the sponsors.

The cluster is also heavily focused on creating new opportunities for both highly qualified research talent and semi-skilled workers with technical degrees. By 2012, just four years in, tax incentives linked to job creation led to 2,500 high tech jobs, with the cluster growing at twice the rate of any other life sciences cluster in the US. Funds are available to help universities attract top research talent. Furthermore, it focuses on retaining talent from its world-class universities by funding internship programs at start-ups; in the first three years, 650 interns were placed at approximately 225 SMEs. An annual regional business school plan competition receives US$120,000 to focus on developing commercialization skills for the cluster.

Human capital initiatives are not limited to university and college training, but extend to life long and vocations training as well. Key to this is ensuring that training organizations have access to the necessary technologies and equipment to adequately prepare students for the fast-pace and innovative work-setting.

In 2011 alone, US$3.4 million in awards was made to 32 institutions for grants of up to US$250,000 for equipment for training with industry match requirements.

In addition, with translational R&D funds to help to connect near-by industries such as pharmaceuticals to the cluster, MLSC attracted billion-dollar plants from 9/10 of the world's leading pharma companies, further multiplying employment gains. These large companies further benefit from their proximity to smaller start-up companies developing breakthrough innovations, allowing them to remain competitive; carefully monitoring the discoveries underway in these research laboratories and at small start-up outfits funded through the projects helps these big firms to produce more cutting edge products than they can afford to alone.

Source: Bluestone and Clayton-Matthews (2012)

5.6. Innovation Systems in East Asia

How can Korea compete more effectively in the East Asian and global contexts? In this section, we compare Korea's current approach with other leaders in the East Asia region, placing particular emphasis on the role of China (see Box 5-6), which is fast becoming the regional leader in innovation policy in addition to its existing leadership role in production.

Table 5-6. Select East Asian Upgrading Approaches for Industry 4.0

Country	Major Institutional Characteristics	Current Policy Approach	Examples of Recent "Industry 4.0" Policy/ Program
China	Platform/Supply Chain Integrator	Developing indigenous (private) lead firms	Made in China
Korea	Integration of more domestic actors; low foreign input	Strengthening indigenous lead firm innovation in select sectors	Comprehensive Action Plan for Future New Growth & Industrial Engine
Singapore	Global integration (Foreign input plays key role)	Leading services hub in region; regional HQs	National Additive Manufacturing Innovation Cluster
Taiwan	Global integration (Foreign input plays key role)	Developing software capabilities & design services in IT	Industrial Technology Research Institute (ITRI)'s Cloud Computing Center for Mobile Application (CCCMA)

Source: Authors

China and Korea have both used national plans. While many of these policies have been quite similar, there have been subtle differences that put China in a strategic position moving forward. While both countries placed an early emphasis on developing heavy industries, both used light industries to increase exports, both placed an emphasis on electronics, however in the 2000s China made a significant push to grow in services – from logistics, to branding to information industry.

Singapore has recently adopted this approach specifically to address Industry 4.0 potential. The National Additive Manufacturing Innovation Cluster (NAMIC) located in Singapore started in March 2016 with the goal to position the country as the world leader in advanced manufacturing (NAMIC, 2017). To reach that objective, Singapore understands the changing nature of manufacturing in today's world and it is focusing in areas of digital transformation, predictive analytics and automation. Additive manufacturing is looking to innovate the way that manufacturing industries are operating and to develop progressive solutions into new areas. Some of the main strategies of the cluster that will be reviewed on a yearly basis are identifying promising areas of additive manufacturing, nurturing startups and partnering with key local companies for collaboration. NAMIC is partnering with a series of actors ranging from local companies to foreign research institutes. This has engaged 500 companies and initiated more than 120 projects. The main sectors are biomedical, additive manufacturing and design and construction.

Box 5-6. China in GVCs and Industrial Policy Approaches for Upgrading Manufacturing

Over the past three decades, China has steadily entered and upgraded through a large number of manufacturing GVCs. China has successfully been able to set policies to drive upgrading from assembly to own brand manufacturing. Partnerships between foreign and Chinese firms facilitated a continuous flow of information, finance and technology into the Chinese economy. One of the key's to China's success has been insightful industrial policies that have enabled the country to strategically use their manufacturing sectors to move into services. Specific policies have changed over time to achieve different upgrading objectives, but four factors have notably contributed to China's upgrading: (1) economy-wide policies and infrastructure investments, (2) strategic and adaptive industry-specific government policies, (3) investment and strategic relationships with foreign firms, and (4) promotion, adoption and effective use of information technology.

In the 2000s, China focused on **delinking manufacturing and services.** Policies focused on unpacking the value chain by separating manufacturing and service functions (logistics and branding policies promoted across industrial sectors). In the 11th FYP (2006), emphasis was placed on brand development.[12] During this time China also focused on gaining domestic expertise in logistics and supply chain integration, a role previously played by Taiwanese and Hong Kong firms. An advantage for China has been the functional division of labor between manufacturing, logistics and marketing/distribution functions. China effectively used agents and intermediaries to promote manufacturers; it realized the skills required to sell a product (i.e., finding buyers and maintain customer relationships) are not the same skills needed to operate a machine or run a production facility. Selling requires business and marketing skills; effectively and efficiently running a factory takes someone with industry experience.

In the 2010s, ICT promotion and IT infrastructure investment have been targets in the 12th FYP (2011), and then a lot in the 13th (2016), whereas Korea focused on the green economy, convergence industries and the creative economy. China views adoption and effective use of ICT (as well as previous experience) to functionally upgrade and enter the international market. The division of labor in the internet era has shown unique characteristics which relies on technology and data.

In 2015, the launch of 'Made in China 2025', a master plan for China's transition towards digital manufacturing, and 'Internet Plus' a masterplan to develop the high-capacity data infrastructure needed for digital manufacturing and support IoT, clearly indicate that innovation-driven development is China's number one economic policy. This indicates that its leadership believed the potential for upgrading from participation in Western-led production networks had been exhausted. This plan builds on the prior plans that focused on developing independent Chinese brands (lead firms/OBMs) and services approach and focuses on how to capitalize on automation and servicification to reposition Chinese firms and industries

[12] At least two-thirds of 3C electronics sold in China in 2015 were from domestic brands. From a global perspective, Chinese firms/brands accounted for at least 27% of mobile phone units sold in 2015, up from around 3% in 2007. They also accounted for 21% of TVs in 2015, up from 11% in 2007 (Frederick, 2017).

as the leaders in mid- and high- technology industries that have emerged over the past few decades including solar systems, wind turbines, LED, household appliances, and telecommunications and advanced information technologies.

The 13th FYP seeks to use innovation to accelerate efforts to move manufacturing up the value chain, reestablish China as a global center of innovation and technology, and ensure long-term productivity. It calls for expanded Internet usage; increase fixed broadband household and mobile broadband subscriber penetration ratios, which aligns with the broader push to leverage interconnectivity and data from the Internet to optimize manufacturing, finance, healthcare, and government.

Sources: (CTB, 2016; Frederick, 2017)

Three areas of importance in China's plans that differ from Korea include continued introduction of new industries (including service industries) with specific targets for each, continued focus on *strategically* engaging with foreign entities (inward investment, outward investment, exports, and R&D), and business and consumer adoption of IT products and services. Whereas Korea has focused on creating a few global lead firms in select industries (electronics, automotive), China engaged in GVCs by effectively and efficiently coordinating supply chains across multiple industries for foreign lead firms, often via Hong Kong or Taiwanese investors. This supply chain integrator model was an early manufacturing-based version of the platform technology providers referenced in the first chapter. While notable platform providers in 'Industry 4.0' today are often B2C or C2C service providers, the concept of building a company around 'convening different groups' originated in manufacturing by intermediaries that brought together firms from different segments of the value chain (B2B). Given that China's companies across industries are already accustomed to working within a platform model and have been for decades, this makes the transition to developing and adopting new business models easier.

Korea's limited interaction with the international community and lack of dividing participation in value chains into manufacturing and service-related tasks presents challenges for moving into new sectors. GVC studies highlight that learning typically occurs through spillovers and learning from foreign investment or selling to and interacting with powerful and innovative lead firms.

5.7. Conclusion

The earlier sections outline the tremendous opportunities that Korea has available to it as technologies change and manufacturing GVCs evolve. If Korea is able to adjust its policy landscape and leverage these opportunities, the country can position itself on the technological and knowledge frontier alongside other advanced industrialized countries. However, if it fails to do so, the current global trends suggest that it will begin to lose its leadership as a manufacturing base and potentially see its growth stagnate.

The threat to Korea's future in manufacturing is two-fold: both from low cost countries and advanced industrialized ones. First, in more labor-intensive manufacturing operations, Korea increasingly competes with lower cost countries, particularly China and others from Asia. Korea currently holds a technological advantage over them; however, as their capabilities steadily increase, Korea will find it increasingly difficult to compete as its labor costs rise. In the process, it could risk following Japan’s path of seeing its role in production decline. This is particularly concerning given the contribution of manufacturing to GDP.

Second, in capital- and knowledge-intensive stages of the chain, Korea competes directly with the world’s most advanced industrialized countries, including the US, EU and Japan. The advent of Industry 4.0, with increased *automation* and *servicification,* is altering the value distribution along the chain and providing brand new opportunities to generate value and become chain leaders. While Korea has been slow to engage in these new areas, its competitors are already advancing in both new technologies and services operations.

Korea is well positioned to build on its past strengths and become a global economic leader, but this window of opportunity will be short-lived as all countries seek to develop these capabilities. China’s Made in China 2025 policy clearly illustrates the country’s intentions to join the ranks of global innovators; Singapore is also rapidly reinventing itself, both in terms of digital manufacturing, but also as a major innovative services hub. Korea must therefore adopt a new innovation-oriented approach to its development, or it will be left behind in this new wave of growth.

This will require tapping into both the existing strengths of the country’s leading firms, but perhaps more importantly, unlocking the potential for entrepreneurship. In doing so, the government cannot achieve this alone, but must become a facilitator, creating an environment that encourages multi-stakeholder engagement, embracing entrepreneurship and help to shift its business culture away from risk aversion to embrace the creative disruption that can position countries on the frontiers of knowledge and technology creation.

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