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Chapter 5: GVCs, Industrial Transformation and Opportunities for Korea

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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.

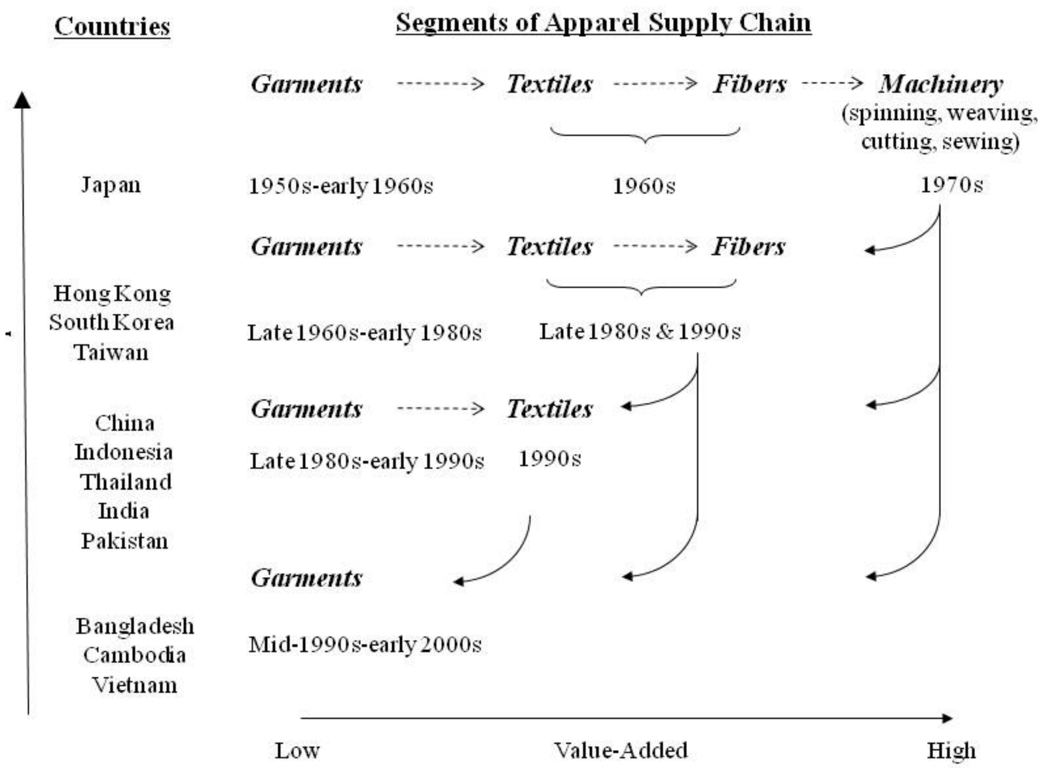
5.4. A GVC Perspective for Korea's Industrial Transformation

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



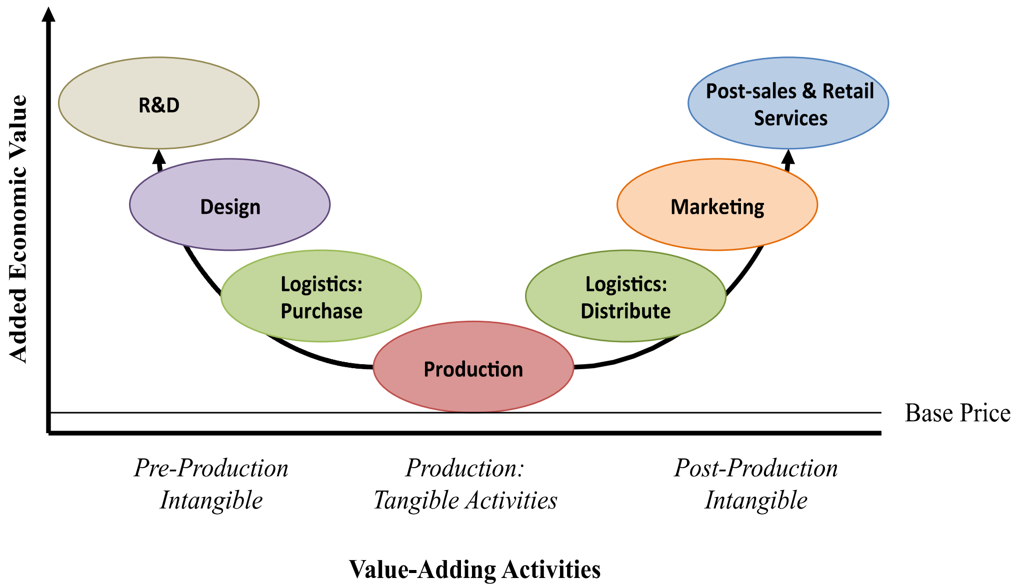
In today's globalized economy, however, this development path has become more elusive for countries that previously dominated manufacturing. As firms in many of these nations have increasingly relied on offshoring and outsourcing to boost their competitiveness, they have simultaneously moved away from 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.

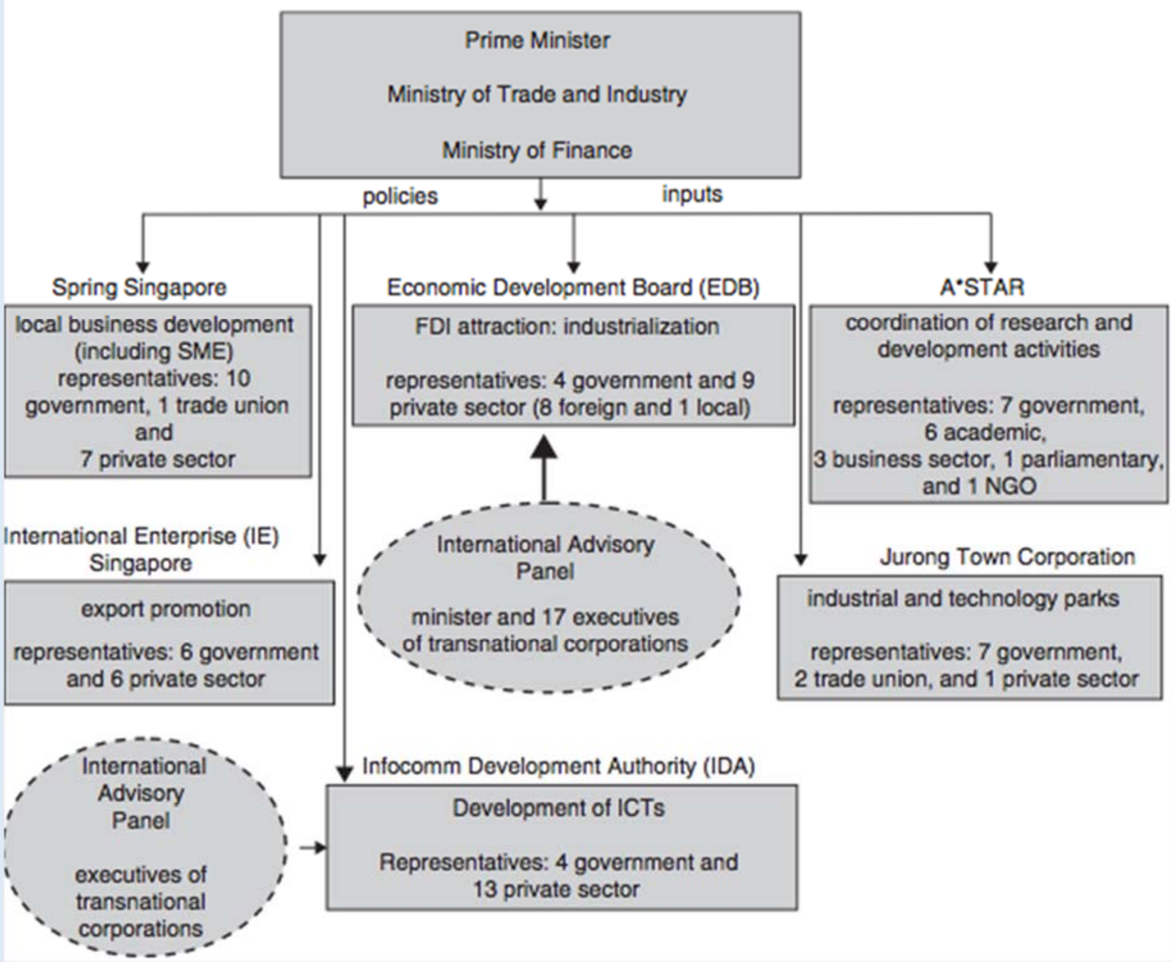
and ICT. Over the period analyzed, membership of the Council has varied considerably with the balance of power between private and public sector shifting back and forth.

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

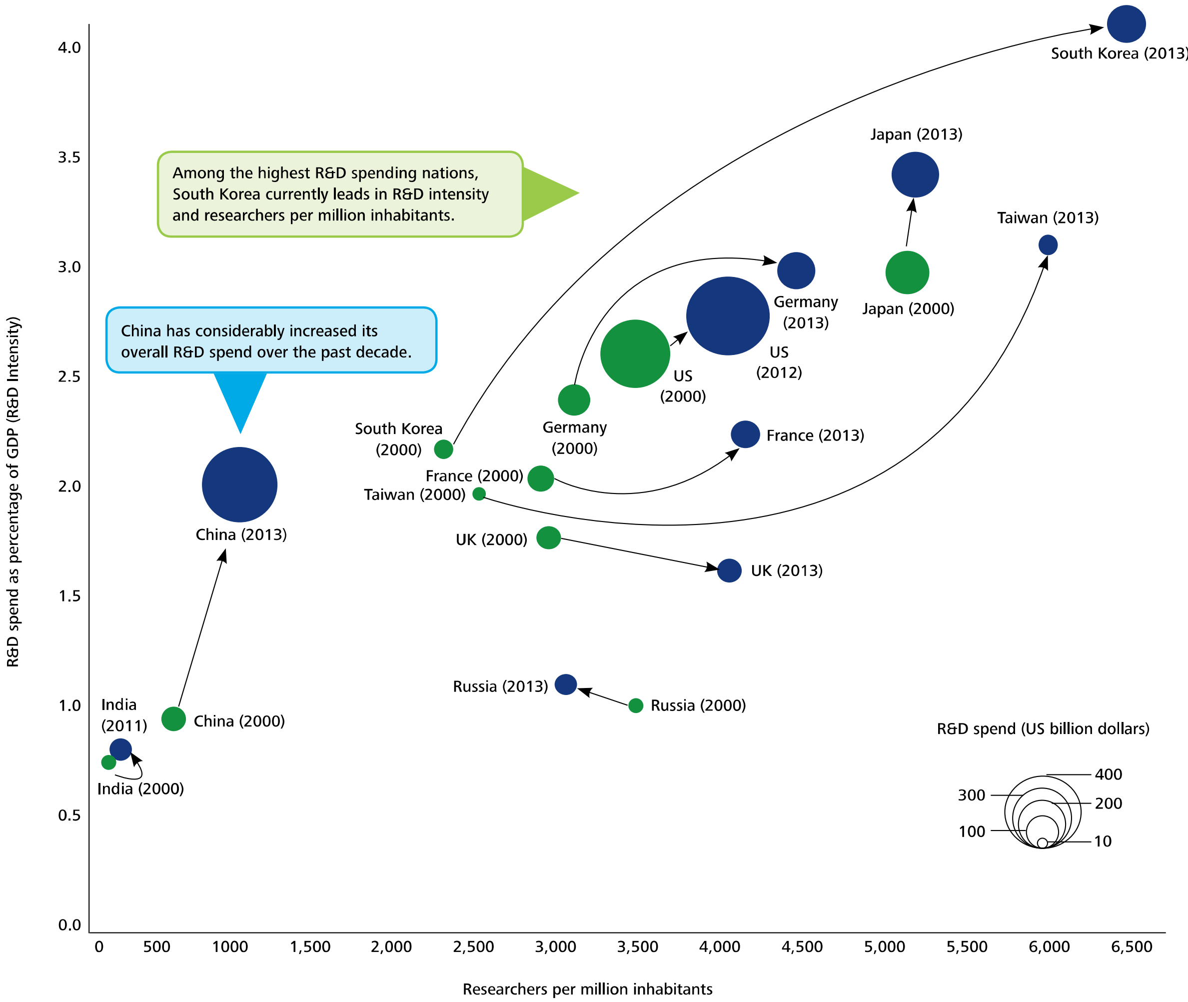
The upgrading trajectories suggested above to help Korea achieve its industrial transformation goals require a well-structured innovation system (IS) with a focus on incentivizing cutting-edge research, developing the right types of human capital, and promoting mechanisms for the adoption and diffusion 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

[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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