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List of Abbreviations

4K2K TV	4000 × 2000 Pixel Television
ADT	Acer Display Technology
AMOLED	Active Matrix Organic Light Emitting Diode
AUO	AU Optonics
CMO	Chi Mei Corporation
CRT	Cathode-Ray Tube
DOIS	Department of Investment Services
DRAM	Dynamic Random Access Memory
EMS	Electronics Manufacturing Service
EPO	European Patent Office
FDI	Foreign Direct Investment
FDP	Flat Panel Display
FIPA	Foreign Investment Promotion Act
GCF	Gross Capital Formation
GDP	Gross Domestic Product
GPN	Global Production Network
HDI	Human development Index
IC	Integrated Circuit
IDM	Integrated Device Manufacturer
IPC	International Patent Classification
ITRI	Industrial Technology Research Institute
KOSPI	Korea Composite Stock Price Index
	Korea Trade-Investment Promotion Korea Trade-Investment Promotion
KOTRA	Agency
KRX	Korea Exchange
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MNE	Multinational Enterprise
MOEA	Ministry of Economic Affairs
MOTIE	Ministry of Trade, Industry and Energy
NAND	Active Matrix Organic Light Emitting Diode
ODM	Original Design Manufacturer
OECD	Organization for Economic Co-operation and Development

OEM	Original Equipment Manufacturer
OLED	Organic Light Emitting Diode
R&D	Research and Development
SMC	Stock Market Capitalization
SME	Small and Medium-sized Enterprises
STN-LCD	Super-Twisted Nematic Liquid Crystal Display
TAIEX	Taiwan Capitalization Weighted Stock Index
TFT-LCD	Thin-film transistor Liquid Crystal Display
TN-LCD	Twisted Nematic Liquid Crystal Display
TSMC	Taiwan Semiconductor Manufacturing Company
TWSE	Taiwan Stock Exchange
UHD	Ultra-High Definition
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	United States Dollar
WIPO	World Intellectual Property Organization

1 Introduction

1.1 The Thin Film Transistor Liquid Crystal Display Industry

Ever since the first broadcast of the images, display industries have been preoccupied with improving the quality of images and videos. Over the years, this has led to improvements in image quality, a higher color intensity, as well as thinner and larger screens that are more energy efficient. Especially the introduction of Flat Panel Displays (FPD) has revolutionized the display market. Compared to the previous Cathode Ray Tube (CRT) displays, the image size of FPDs is larger, with higher brightness and contrast, and the production involves lower power consumption (Hung et al. 2012, 10). Among the many types of FPDs, the liquid crystal display (LCD) panels dominate the market. They are classified into three kinds: Twisted Nematic (TN) LCD technology, Super Twisted Nematic (STN) LCD, and Thin Film Transistor LCD (TFT-LCD). The latter type is the most advanced technology and offers the best resolution (C. Yang 2014, 7). LCD panels have a wide range of applications, including computers, TVs, instrument panels, as well as consumer digital devices such as mobile devices, game devices and watches (Hung et al. 2012, 10; C. Yang 2014, 7). Especially the rapidly growing markets for LCD televisions, small laptops and other portable devices have spurred the growth of the LCD industry (Hu 2012, 543).

The growing demand and progress in technology of LCD devices promoted the economic development of many countries. Especially nations in the East Asian Region, including Japan, South Korea, Taiwan and China¹, profited from developments of their display industries. These four nations have also been dominating the LCD-industry in the past few decades.

Japan was the first East Asian nation to enter the LCD market and commercialized large-size TFT-LCD applications, with companies such as Seiko, NEC, and Sharp (Hu 2012, 541; Yun et al. 2010, 207). During the 1990s, Japan's NEC started to produce the first large panels and Sharp pioneered in the mass production of 8.4 inch laptops using TFT-LCDs (Linden et al. 1998, 13). Over the years, other Japanese firms such as Matsushita, Mitsubishi and Toshiba joined the TFT-LCD industry (Hu 2012, 541).

During an industrial downturn at the beginning of the 1990s, Korean firms, Samsung and LG Phillips entered the TFT-LCD market (Hu 2012, 541). South Korea quickly accelerated its production with the help of knowledge spillovers from the DRAM industry (T. Y. Park, Choung, and Min 2008, 2856). The companies LG and Samsung followed a low-price strategy with mass production capacity and were heavily supported by the Korean government

¹ Throughout this thesis the Republic of Korea will be abbreviated as "South Korea" or "Korea", the Republic of China as "Taiwan" and the People's Republic of China will be referred to as "China".

(Tseng and Chiu 2006, 2–3). Since the turn of the century, Samsung and LG-Phillips became the largest and second global TFT-LCD producers in the global display industry in terms of production capacity (Hu 2014, 84).

The Taiwanese companies, Unipac and Acer Display Technologies (which later merged to AUO) as well as CMO followed the Korean example and entered the TFT-LCD market during another industrial downturn (Hu 2012, 541). Initially, Taiwanese companies faced several challenges, including insufficient talent and technology bottlenecks. However, in 1998 due to a price war between Korea and Japan, technology from Japan was transferred to Taiwan. Japanese companies agreed to sign a technology transfer to six Taiwanese firms to increase their production value. Simultaneously, Taiwanese manufacturers developed more production facilities to improve their economies of scale and made enormous progress in the following years. Eventually, the country increased its worldwide market share for TFT-LCD panels from 1 percent in 1998 to over 30 percent in 2002 (S. C. Chang 2005, 200). In 2007, Taiwan captured the highest global market share for TFT-LCD production capacity with 43 percent, thereby outpacing Korea which captured 40 percent (Zhang et al. 2008, 1). By that time, Japan had lost most of its global market share to the latecomers Taiwan and Korea.

Over the years, Japan has been lagging behind Taiwan and Korea as the latecomers aggressively increased investments to advance manufacturing technology and product design (Hu 2012, 544). Within a couple of years, Taiwan and Korea managed to capture a large share of the global LCD market from Japanese manufacturers. In 2007, Korea's Samsung and LG Display, and Taiwan's AUO and CMO became the largest panel makers in the industry, together accounting for 76 percent of the global TFT-LCD markets (Yun et al. 2010, 208). Korea and Taiwan became the two strongest players in the TFT-LCD industry, followed by Japan (Tsaur, Chen, and Chan 2017, 4389).

Subsequently, during the late 2000s, China has also shown interest in the TFT-LCD industry, as it depended on imports from Japan and Korea. Accordingly, China began to establish itself in the TFT-LCD industry and the government started to raise import tariffs on TFT-LCD panels to achieve a higher self-sufficiency rate (C. Yang 2014, 5). The Chinese TFT-LCD industry has evidenced a strong development with annual growth, supported by low labor costs and an extensive market (Tsui, Tzeng, and Wen 2015, 6436). The emergence of China poses a major threat to Korea and Taiwan's dominance in the TFT-LCD industry, who enjoyed a leading position for many years. Since 2016, Chinese manufacturers have drastically increased their LCD production capacity, thereby even outpacing Taiwanese manufacturers and are approaching Korean capacity (S. H. Liu 2019). China is expected to become the market

leader in TFT-LCD manufacturing in the near future. However, China is not the only threat. The TFT-LCD industry is still expected to grow and potential new entrants will come from India, Brazil and Cambodia (C. Lee, Chang, and Wang 2020, 5–6).

Apart from the growing number of players, the TFT-LCD industry itself is extremely competitive. LCD-related products are traded in highly competitive markets and are usually developed in industries that are of strategic interest for the respective governments (S. C. Chang 2005, 199–201). The TFT-LCD industry is characterized by economies of scale, capital-intensiveness and technology-intensiveness (Z. Y. Lee and Kung 2012, 81; Tseng and Chiu 2006, 1). Also, the industry has a short product life cycle, with prices being subject to supply, demand, business cycles and international divergence. Thus, in order to remain competitive, companies need to continuously invest in research and development (R&D) and expand their production capacity. In addition companies need to establish strategic alliances or vertical integration with upstream and downstream firms to stabilize purchase costs of display materials and equipment (Z. Y. Lee and Kung 2012, 81–82).

At the turn of the 21st century, most of the world's TFT-LCD panels were supplied by Taiwan, Korea and Japan, with Taiwan and Korea constantly fighting on the lion's share of the global market. Both followed different strategies to increase production and in a short time after their entrance, they outpaced Japan and became market leaders. However, since 2010, the two nations are facing strong competition from China, which is taking over the market.

The time frame of this research is set from 2009 to 2018, which are the years following the financial crisis. During this period, the TFT-LCD market reached its peak with market demand approaching saturation (C. W. Yang and Chen 2020, 145172). This thesis chose Taiwan and Korea as case studies, as they were market leaders for the majority of time in the years between 2009 and 2018. While China has experienced a strong growth in the past five years, Taiwan and Korea have successfully placed themselves among leaders ever since the early 2000s. The two nations achieved leadership in a highly competitive industry for over a decade and are thus a valuable example for successful TFT-LCD industry players. Additionally, Taiwanese and Korean manufacturers are still market leaders in several segments, such as in the 65 inch TFT-LCD panel segment (Asakawa 2019, 149).

It will be interesting to see how and if Taiwan and Korea can maintain their competitive edge in this highly competitive industry. This paper is set out to analyze the competitiveness of the TFT-LCD industry of Taiwan and Korea countries, consequently, the research question of this paper reads the following:

How competitive are the TFT-LCD industries of Taiwan and South Korea and what are their key success factors?

The purpose of this research is to find out the differences and similarities between the two nations concerning their competitiveness in the TFT-LCD industry. In order to analyze the competitiveness of Taiwan and Korea, the remainder of this paper is divided into six sections. First, the relevance of the topic is provided in the final part of the introduction. Section two will give a critical review on the competitiveness of Taiwan's and Korea's TFT-LCD industry. This part further includes the debate on theories of competitiveness. The third section discusses the analytical framework – a derivation of Porter's diamond model – which is used to examine the competitiveness of the TFT-LCD industries. Here, Porter's diamond model, empirical studies and critiques and modifications of the model are discussed. The final part of section three will present the modified analytical framework based on the literature review and provides the data collection-method. In section four, the adjusted diamond model is then implemented for the comparison of Taiwan's and Korea's competitiveness in the TFT-LCD industry. Section five offers the analytical deductions for the thesis. The final section concludes with findings and recommendations for future research.

1.2 Relevance of the Thesis

This chapter illustrates the relevance of the thesis and the primary reasons for conducting a comparative analysis on the competitiveness of Taiwanese and South Korean TFT-LCD industries.

First, this study decided to investigate the TFT-LCD industry as currently it is the largest segment among all the display industries. It is the most promising key technology among the LCD types due to its production in various sizes and its cost benefits (S. H. Lee, Yun, and Jeon 2020, 160). Additionally, this industry was chosen as it remains the most competitive sector among FPD industry sectors (Hu 2012, 543). It is characterized by economies of scale, a capital-intensive production and high technology thresholds (Tsaur, Chen, and Chan 2017, 4378). Thus, in order to survive in this industry, players must achieve a competitive edge. This makes the TFT-LCD industry a compelling study for analyzing competitive advantage. Second, Taiwan and Korea were selected as case studies as they became market leaders in the early 2000s and are still highly competitive (Tsaur, Chen, and Chan 2017, 4389). Within only a decade after their entrance in the TFT-LCD market, they achieved significant growth in

global market shares. Shortly after entering, Taiwan and Korea undermined Japan's dominance. While Japan had a global market share of 50 percent in 2000, it decreased to merely 8 percent in 2008. On the contrary, Taiwan and Korea's combined market share rose to 90 percent in 2009 (Hu 2012, 543). Although China has moved up in ranks in the past 5 years, Taiwanese and Korean TFT-LCD companies still have an edge over China in certain segments. Taiwanese TFT-LCD companies for example are more competitive in respect of large-size TV panel manufacturing (C. W. Yang and Chen 2020, 145173). Korean and Taiwanese manufacturers also lead the 65 inch TFT-LCD panel production (Asakawa 2019, 149). In addition, only few studies discuss China's role in the TFT-LCD industry as the nation is a relatively new player, while there is plenty of literature discussing Taiwanese and Korean TFT-LCD industries. Based on their achievements, Taiwan and Korea are regarded as highly competitive players in the TFT-LCD industry.

Third, the respective national governments consider the TFT-LCD industry as an important factor for economic development. At the turn of the century, the Taiwanese national government promoted the TFT-LCD industry as its premier industry. The Ministry of Economic Affairs (MOEA) proposed a 5-year plan to achieve world leadership in the supply of TFT-LCD industry. In addition, universities and research institutes are subsidized to increase R&D of new technologies and products to spur the industry's development (S. C. Chang 2005, 209). In 2002, the Taiwanese government further presented two programs for the development of the image display industries, the Two Trillion and Twin Star Development Programme (Tsaur, Chen, and Chan 2017, 4378).

Similarly, the TFT-LCD industry is considered important for economic development in Korea. The Korean government provided strong support, especially in financing the chaebols in fund raising to activate the TFT-LCD industry (T. Y. Park, Choung, and Min 2008, 2855–57). Over the years, the Korean government supported the industry through several acts, including the “Industrial Development Act” and the “Industrial Technology Innovation Promotion Act”, and in addition gave financial support to display clusters.

Furthermore, a comparison of the TFT-LCD industry of the two East Asian nations can reveal strengths and weaknesses, as well as similarities and differences concerning their competitive advantage. This can further disclose what constitutes competitive edge in the TFT-LCD market. Based on the result of this research proposed methodologies can be formulated, which can strengthen Taiwan's and Korea's competitive advantages in the industry.

Finally, the findings from this analysis can present key success factors that led both nations to achieve market leadership. Korea and Taiwan were both latecomers in the TFT-LCD industry,

yet they managed to become successful within a decade. Analyzing both countries' strategies can be beneficial for potential entrants as they are able to learn from successful latecomer strategies in the TFT-LCD market. Potential market entrants and investors can gain a better understanding on the specific characteristics, the main players as well as the competitive environment of this industry. In addition, the analysis is also relevant for international competitors, such as Japan and China, as it allows them to adapt their strategies accordingly.

2 State of the Art

2.1 TFT-LCD Industry Research

The literature on the global TFT-LCD industry is abundant. The majority of studies focus on the three leading nations Korea, Taiwan, and Japan. Within this research area, authors are concerned with different topics. The main issues discussed are latecomer-strategies (Hung et al. 2012; Linden et al. 1998; Zhang et al. 2008), clusters (S. C. Chang 2005; Yun et al. 2010), competitiveness (S. C. Chang 2005; P. L. Chang, Chiang, and Chou 2007; Hsiao et al. 2011), knowledge spillovers from related industries (T. Y. Park, Choung, and Min 2008) and Global Production Networks (GPNs) (Y. S. Lee, Heo, and Kim 2014; C. Yang 2014).

As this study is set out to conduct an analysis of competitiveness of TFT-LCD industries of two nations, the author decided to focus on the two strongest players following the year of the financial crisis in 2008. The literature reveals that in the first few years after the financial crisis, the main players in the TFT-LCD industry were Korea, Taiwan, Japan, and China with Taiwan and Korea competing for the leading position. Taiwan and Korea were latecomers to the TFT-LCD industry but became the strongest players within a short span of time (Hung et al. 2012, 11). According to Hung et al. (2012) Taiwan overtook Korea's market share from 2004 to 2008 and became the largest TFT-LCD producer, while the years after the financial crisis Korea obtained the leadership position in TFT-LCD production (Hung et al. 2012, 11; Tsaur, Chen, and Chan 2017, 4389). Thus, there seems to be a fierce combat between the two nations to gain a leading position. Eventually, with the entrance of China in 2008, both nations are now facing a strong competitor. While in 2009 China's global market share in the display manufacturing sector was below 10 percent, in 2016 the country captured well above 20 percent and is expected to increase its global market share (C. Lee, Chang, and Wang 2020, 2).

Notably, the majority of studies are concerned with Taiwan's and Korea's success story, since the countries are known as latecomers but have successfully placed themselves in the TFT-LCD industry. The majority of studies focus on Taiwan, followed by Korea. Fewer papers analyze China as it's a new competitor, and Japan, which has lost its leading position during the 1990s. Many studies compare Taiwan's and Korea's performance in the TFT-LCD industry, such as their development strategies (Hung et al. 2012), their structure and competitive priorities (P. L. Chang, Chiang, and Chou 2007), the emergence of TFT-LCD industry clusters (Yun et al. 2010) or their technological innovation capabilities (Hu 2012) and conduct performance assessments (Hon and Chu 2011).

Hung et al. (2012) for example, analyzed the development and competitive strategies of Taiwan and South Korea. They found that South Korea's development strategy was to challenge the first mover Japan regarding new TFT-LCD technologies, while Taiwan focused on becoming a quick-follower (Hung et al. 2012, 9). Japanese companies on the other hand focused on maintaining their leadership in cutting-edge technologies and therefore gradually transferred more mature technologies to Taiwan and Korea to secure income from licensing (Hung et al. 2012, 11).

Among the studies concerned with the competitiveness of the TFT-LCD industry, Chang (2005) conducted an analysis of the competitiveness of Taiwan's TFT-LCD industry, with special focus on the merger of one of the largest TFT-LCD manufacturers. The author used Porter's diamond model as a framework to develop a greater understanding of Taiwan's competitive advantages and disadvantages in the global TFT-LCD industry. The study further provided suggestions for the future development of the Taiwanese TFT-LCD industry. Chang's study offers several insights into Taiwan's competitiveness. He stated that strong government support and Japan's technology transfer contributed to the acceleration of development of the TFT-LCD industry in Taiwan (S. C. Chang 2005, 212). However, since the study was conducted in the early 2000s, results are outdated. Furthermore, for the most part, the study focused on Taiwan's industry and included only a few comparisons between Taiwan and other TFT-LCD industries. However, Chang's paper is useful as it provides an opportunity to compare the results in the determinants from 2005 and this study to show the developments in this industry sector over the past 15 years.

Apart from Chang et al.'s study on competitiveness, other works also discussed the performance of Taiwan's TFT-LCD industry. A study from Hsiao et al.'s (2011) applied the system approach to investigate the development structure of the Taiwanese large area TFT-LCD industry system. It attempts to explain how the country became the strongest TFT-LCD player within a span of 30 years. The authors suggested that factors such as the accumulation of talents, the availability of capital, supportive government policies, as well as the supply of technologies from Japanese manufacturers played a significant part in the development of Taiwan's TFT-LCD industry. In addition, the authors pointed out that future co-competition between Korea, Japan, Taiwan and China will become a significant issue for the development of the TFT-LCD industry (Hsiao et al. 2011, 130).

Another paper from Tseng and Chiu (2006) conducted a performance evaluation for TFT-LCD panel companies in Taiwan to establish the most important attributes for business performance in the TFT-LCD industry. Their findings revealed that business performance is

mainly concerned with competition dimension, financial performance and innovation capacity. The paper also argued that government rewards and business investments were important for Taiwan to become successful in the TFT-LCD industry (Tseng and Chiu 2006, 7).

Studies analyzing Korea's performance in the TFT-LCD industry viewed state support as one of the main factors for Korea's success (Y. S. Lee, Heo, and Kim 2014; Linden et al. 1998). However, Park et al. (2008) noted that apart from government policy, industrial organization, firm strategy, and knowledge spillovers from related industries should also be considered as key factors for Korea's success in the TFT-LCD industry. His results suggest that spillovers in capital control, technology, production, and quality management amongst others, can diversify products (T. Y. Park, Choung, and Min 2008, 2855).

Another paper from Lee et al. (2020) regarded Korea's catch-up strategy in technological development as one of the critical elements for the nation's success in the TFT-LCD industry. The paper conducted an analysis on the knowledge flows in the Korean TFT-LCD industry based on patent data. Results from the study revealed that Korea plays a central role in technological knowledge. During the initial stage, it has actively developed patents that concern core and standard TFT-LCD technology and has thus established a dominant position in the global market (S. H. Lee, Yun, and Jeon 2020, 179).

In summary, researchers identified a multitude of key success factors in the TFT-LCD industry development based on different methods of analysis. The key factors for Taiwan's success are strong governmental support, technology transfer from Japan, R&D talent accumulation, and investments. Similarly, Korea's success is based on governmental support, but also knowledge spillovers from other industries such as DRAM has helped spur Korea's competitive edge. Another factor for Korea's success is the accumulation of important TFT-LCD related patents.

Notably, many scholars identified governmental support as critical to the success of a nation's TFT-LCD industry. Both countries owe much of their achievements to their national governments, which strongly influenced progress and development in TFT-LCD industry through policies and other support measures.

After reviewing studies on specific factors of competitiveness in the TFT-LCD industry, the following section discusses the various strands of theories on competitiveness.

2.2 Competitiveness

The author decided to investigate factors for competitiveness in the TFT-LCD industry in Taiwan and Korea. In order to find a suitable framework for the analysis, this section will firstly discuss theories and definitions on competitiveness, including traditional theories on competitiveness, such as price and cost competitiveness, current ideas such as real competitiveness, and competitive advantage to gain a better understanding of competitiveness.

Traditional theories on competitiveness began with Adam Smith and David Ricardo. Their theories are the first to discuss price and cost competitiveness. Smith's theory of absolute advantage in his work "Wealth of Nations" (1776) claims that nations export products that give them an absolute cost advantage in comparison to other economies (Penttinen 1994, 4). Based on Smith's theory, David Ricardo created the principle of comparative advantage. In his book "On the Principles of Political Economy and Taxation" (1817), he argues that a state can gain from trade by exporting products and services of which it has the most comparative advantage in productivity. In addition, the state will import those products and services it has the least comparative advantage compared to others. In this theory, a state benefits from trade with others even though it cannot generate goods at lower cost than other trading nations. According to Ricardo's theory it suffices if a country can produce goods at a lower cost than other goods (Penttinen 1994, 4).

The theories of Smith and Ricardo were followed by Eli Heckscher and Bertil Ohlin, who further developed ideas on competitiveness (Lindert 1991, 9:18–41). The two Swedish researchers designed their theories on comparative advantage at the beginning of the 20th century. According to them, a country exports the commodities that are produced with large quantities of the country's relatively abundant factor. They view a factor as abundant, when a country has a higher ratio of the factor than any other country (Jones 1956, 1).

What traditional theories of competitiveness have in common is that they explain differences in competitiveness between countries with differences in costs of resources or final goods. However, recent studies show that the development of costs and prices cannot explain the differences in competitiveness among countries and industries. Competitiveness according to traditional theorists is based on prices and domestic factors of production. Yet, nowadays competition is international, and factors can derive from anywhere. Thus, other factors must be included (Penttinen 1994, 4).

Another approach to competitiveness was offered by Joseph Schumpeter, an Austrian scholar, who introduced the theory of entrepreneurship and innovation. He believes that a company's ability to innovate is a key factor for competitive advantage. According to him, differences in

innovative capacity and entrepreneurship lead to differences in competitive advantage of an economic agent (Siudek and Zawojka 2014, 95).

In the current international environment, the importance of price and costs as factors for competition have steadily decreased. Meanwhile technological development and innovation gained importance. Scholars of “real competitiveness” view a firm’s ability to innovate as the primary source of competitive success (Penttinen 1994, 5). Being successful means that a firm must be sensitive to market and technological developments. Furthermore, a company should be able to respond creatively to opportunities and threats and should enforce their ideas and products in a rapid and efficient way. The rising cost of R&D, the closing gap on technology innovation between nations and firms, and short product life cycles have decreased the significance of price competitiveness in the current international market (Barlett and Ghoshal 1998, 115).

The term competitiveness has been widely discussed in the academic literature, especially during the 1980s and 1990s. This generated differing views on the meaning of competitiveness and its value for policies. Amongst them, two key opposing definitions need to be highlighted. The first definition from Krugman (1994) defines competitiveness based on cost- or market share (Ketels 2016, 7). He regards competitiveness as a location’s unit cost level which drives a company’s ability to successfully compete in the global market. Krugman is concerned about the location’s “external balance” (i.e. the ability to sell its products and services, defend its international market share and generate inflows). Locations achieve competitiveness if their macroeconomic aggregates are balanced. However, this definition has been heavily criticized by academics, especially as it was initially created to analyze firm rivalry. Critics argue that locations, unlike firms, cannot go out of business and can benefit in their prosperity if other locations thrive. Hence, this concept is regarded as faulty as it can be used to motivate policies that lower costs and raise exports, thereby creating zero-sum competition among locations and lower prosperity (Ketels 2016, 7).

The second definition regards competitiveness as a location’s productivity level that increases the standard of living (Ketels 2016, 8). Amongst others, Michael Porter (1990) has become a supporter of this definition. The debate is motivated by a concern about a location’s ability to generate value, based on its production factors. Studies following this definition look at cross-country differences in prosperity and long-term growth rates. Furthermore, this definition is associated with a set of policies in domains including skill upgrading, infrastructure investment and research and innovation amongst others, and focuses on what policies should be applied to achieve productivity growth. Contrary to Krugman’s (1994) concept of competi-

tiveness, this definition has met less criticism as academic literature is clear that productivity is a key driver of prosperity differences across locations (Ketels 2016, 8). This study decided to implement the productivity-based view of competitiveness, as it has seen much more support among scholars.

Krugman and Porter not only defined the current debate on the meaning of competitiveness, but also offered important and widely used theories of competitiveness. Paul Krugman's study on comparative advantage theory (1996) has become one of the most influential theories discussing the mechanism of trade among countries (J. Y. Lee and Karpova 2018, 199). According to his study, trade depends on the end price of products which are determined by a country's relative labor productivity (Krugman 1994; 1996; Krugman and Obstfeld 2000). Krugman not only contributed to the debate of competitiveness by emphasizing the relevance of productivity to a nation's competitive advantages in international trade and improving the standard of living of a population, but also took into account the debate on competitiveness between nations (Siudek and Zawojka 2014, 96).

Krugman's main arguments include that 1.) from a Ricardian view, all countries possess a comparative advantage; 2.) states cannot go bankrupt while firms can; 3) international competitiveness of domestic firms may negatively affect the international competitiveness of other domestic firms; 4.) nations do not compete economically while companies do, since they can be involved in zero-sum games; 5.) global trade between countries is a positive sum game in which differing economic development rhythms of nations promote the development of global markets. Furthermore, economic partners of faster developing countries benefit from the availability of better and/or cheaper products and better trading conditions (Voinescu and Moisoiu 2015, 516).

However, Krugman's idea on competitiveness has often been challenged. Pestowitz for example contradicts Krugman's view on the zero-sum game of trading countries. He states that two similarly developed countries which produce comparable products can find themselves competing for jobs and incomes instead of taking advantage of their comparative advantages (Prestowitz 2008, 38–41).

The second concept which gained much attention in competitiveness literature is Michael Porter's diamond model (1990). Michael Porter is a well-known critique of previous economic theories. In the 1980s and 1990s he argued that main stream economic theories, such as the theory of comparative advantage and international trade, solely focused on factor endowments (M. E. Porter 1990b, 12). Although Porter was heavily criticized for his one-sided view about traditional economics, his concept of competitive advantage gained much popularity (J. Y.

Lee and Karpova 2018, 190). He developed several concepts, including the “Five Forces” (1979), the “Value Chain” (1985) and the “Diamond Model” (1990) which all try to explain real competitiveness.

His diamond model was firstly published in the book “The Competitive Advantage of Nations” (1990). The theory presents a theoretical framework for analyzing competitive advantage, which provides a more holistic perspective on competitiveness than Smith’s and Ricardo’s classic theories on trade (M. E. Porter 1990b, xiii).

The diamond model is a framework that includes four endogenous determinants, which explain why certain industries are globally competitive. The four determinants are: factor conditions, demand conditions, firm strategy, structure and rivalry, and related and supporting industries. Factor conditions include the availability of human, capital and natural resources amongst others. Demand conditions refers to the home demand that affects a certain industry. Firm strategy, structure and rivalry concerns the characteristics of firms in the home market, while related and supporting industry represents the upstream, downstream and related industries that facilitate the innovation of a particular industry. Apart from four endogenous factors, Porter also adds two exogenous factors: chance events and the role of government. Change events describe events such as war and natural disasters that can disrupt an industry (M. E. Porter 1990b, 74–157).

According to Porter, traditional theories focus on the macro-level using a wide perspective. These theories start the analysis from the level of an entire nation or industry, are long term studies and neglect underlying variables. On the contrary, his model starts the analysis on the micro-level in order to explain macro events. He also states that the natural unit of analysis should be the industry, since examining firms provide a viewpoint that is too narrow and nations a viewpoint that is too broad (M. E. Porter 1990b, 9).

Porter’s diamond model is under the influence of previous studies. His concept of clusters is said to be inspired by Schumpeterian dynamics (Penttinen 1994, 9). Other determinants of the diamond model can be found in preceding research traditions, such as factor conditions, which are found in comparative advantage, firm strategy, structure and rivalry, which originate in industrial economics, and demand conditions that were discussed by Linder (1961) and Vernon (1966) (Penttinen 1994, 9).

2.3 Porter’s Diamond Model

The diamond framework (Porter, 1990) has been widely used over the years and lends itself well to the study of industry competitiveness. Scholars see several strengths in his framework.

Dunning views the concept as “a paradigm within which the determinants of national competitiveness may be identified, and the way in which they interrelate with each other; and second to offer some hypotheses on the reasons why the significance of these parameters may vary between countries and sectors” (Dunning 1991, 10). Even Porter’s critics, such as Rugman support his focus on strategies of firms rather than nations and believe that his framework is useful as it “brings together the firm-specific linkages between the four determinants and the two outside forces” (Rugman 1991, 61–62). Porter’s diamond model is also regarded as a useful framework for analyzing an industry’s competitive advantage while considering nation-level factors (C. N. Lee and Chan-Olmsted 2004, 10). It is a broad-based, integrative tool that addresses which factors are critical for improving competitiveness in a given situation (Ketels 2006, 119).

The model is also well suited to analyze competitiveness in the TFT-LCD industry. As discussed in the previous section, his model has been implemented by Chang (2005) for the analysis of the Taiwanese TFT-LCD industry and is thus deemed as applicable for this study. There are, however, several scholars that point out the shortcomings in Porter’s diamond. Alan M. Rugman suggests that “rather than using the Porter formula to study issues of international competitiveness in a mechanical fashion, scholars must consider it only as a starting point and be careful to modify it for their research in international business.” (Rugman 1993, 6). Porter’s diamond model has generated a vivid discussion on competitiveness and how to measure it. Many scholars argue that the diamond model needs adjustments in order to become a more reliable framework. Following this suggestion, the author decided to develop a framework, based Porter’s diamond model that includes some adjustments proposed by his critics. The next section thus concentrates on writings that criticize the model and provide modifications. The selected works contain the main arguments against Porter’s ideas.

2.4 Critique and Modification of the Diamond Model

2.4.1 Dunning and Multinational Activity

Over the years, several suggestions for the modification of the diamond model have been put forwards. This section reviews different modifications of Porter’s diamond model, with focus on the following researchers: Dunning (1991, 1993), Rugman and D’Cruz (1993), Moon, Rugman and Verbeke (1995, 1998), Narula (1991, 1993) and Cartwright (1991).

According to Dunning, Porter’s framework is flawed as it underestimates the importance of globalization of production and markets for competitive advantage. According to the author, the diamond model neglects activities of modern multinational enterprises (MNEs) (Dunning

1993, 7). Dunning suggests that the capabilities of multinational enterprises can be influenced by configurations of diamonds of foreign nations in which they produce. This in turn can impinge upon the competitiveness of capabilities and resources of the home nation. Thus, the competition of MNEs does not solely depend on the characteristics of their home country (Dunning 1993, 9–10). Therefore, Dunning suggests adding another exogenous determinant to the model: multinational activity (Dunning 1993, 14).

Dunning states that MNEs receive resources from other nation's diamonds, such as technology, capital or management skills. Furthermore, MNEs have access to other markets, economic systems, infrastructure and ways of competition of other diamond systems. Hence, he argues that Porter's national diamond should be substituted with a global or a supranational diamond or should include other nations that have close relations with the firm's own home nation (Dunning 1993, 10–12).

In addition, Dunning argues for the addition of multinational activity by identifying six features of the global economy of the 1990s. First, more and more value generating assets assume the shape of created assets, such as human capital rather than natural assets. Second, created assets tend to be intangible and ownership specific and can be appointed in any location, domestic or foreign in which the ownerships deems appropriate. Third, the importance of MNEs is increasing since companies use created assets they own in foreign markets or create new assets in other countries through R&D or acquire assets in foreign markets through acquisitions. Fourth, MNEs are more pluralistic in terms of motives for global engagement, in terms of geographical direction of engagement and in terms of the type of engagement. Fifth, governments realized that they need to include strategies of other governments into their own. Lastly, following the changes seen in assets that become more mobile, and government policies, firm strategies and societies that become more similar, the international division of labor also needs to adapt (Dunning 1993, 8–11).

However, Dunning's implementation of multinational activity has also come under critique. Rugman and D'Cruz question whether multinational activity should be added to the diamond model into the four determinants or as a third exogenous variable of Porter's diamond model (Rugman and D'Cruz 1993, 26).

2.4.2 Rugman and D'Cruz and the Double Diamond Model

Rugman and D'Cruz developed an adjustment of Porter's diamond model, which they refer to as the "double diamond model" (1993). In contrast to Porter's diamond model, their modification can also be applied to small, open trading economies, which are not parts of the triad

(U.S., Japan and European-based multinationals). Based on previous research that was conducted on Canada (1991), they found that the nation's competitiveness cannot be explained by Porter's diamond framework. Thus, they created a different approach to evaluate the nature of Canada's foreign-owned companies and institutional arrangements. As their case study indicates, the Canadian diamond is intertwined with the U.S. diamond, thereby creating a so called "double diamond" (Rugman and D'Cruz 1993, 18). Accordingly, the analysis of a country's competitive advantage requires to set their home country diamond against an affiliated triad diamond (Rugman and D'Cruz 1993, 19).

Their work highlights several flaws of Porter's framework. Firstly, small, open trading economies show weaknesses in their national diamonds, especially concerning its home demand. Thus, they must forge links with overseas markets, particularly larger neighboring countries, in order to increase advantages. The authors propose two options for firms to accomplish this: first, by foreign direct investment (FDI), and second, by launching foreign subsidiaries. Another flaw in Porter's model is the relationship between FDI and the generation of competitive advantage. His theory provides only a narrow definition of FDI as he regards outward FDI as valuable for competitive advantage, whereas inward FDI is described as detrimental. Furthermore, Porter views foreign subsidiaries in a nation's home market as an unfavorable condition for competitiveness (Rugman and D'Cruz 1993, 24). Yet, Rugman and D'Cruz believe that foreign-owned as well as domestic companies can improve conditions for the home market (Rugman and D'Cruz 1993, 28). Another drawback detected by Rugman and D'Cruz is the role of natural resources in achieving competitive advantage. Porter argues that the dependence on basic factor advantages, such as unskilled labor or unsophisticated technology is not maintainable. Rugman and D'Cruz on the contrary believe that this is not the case, as Canadian companies transformed their country's comparative advantage in natural resource into more advanced and sustainable competitive advantage (Rugman and D'Cruz 1993, 25).

The main issue detected in Porter's diamond model concerns small and open trading nations. Rugman and D'Cruz view that international competitiveness of such nations depends on a triad nation. Small countries usually interdependent with one or more their (larger) neighboring states, as they provide markets for firms to gain international competitiveness through foreign subsidies or FDI. In this case, competitive advantage is not solely affected by the nature of the home diamond but also the international diamond (Rugman and D'Cruz 1993, 19). Thus, the authors developed the double diamond framework, set a nation's home diamond against a relevant international diamond. They suggest that the international diamond should

be based on a relevant triad nations; in the case of Canada, the North American diamond is the most important market (Rugman and D'Cruz 1993, 18–19).

2.4.3 Moon et al. and the Generalized Double Diamond Approach

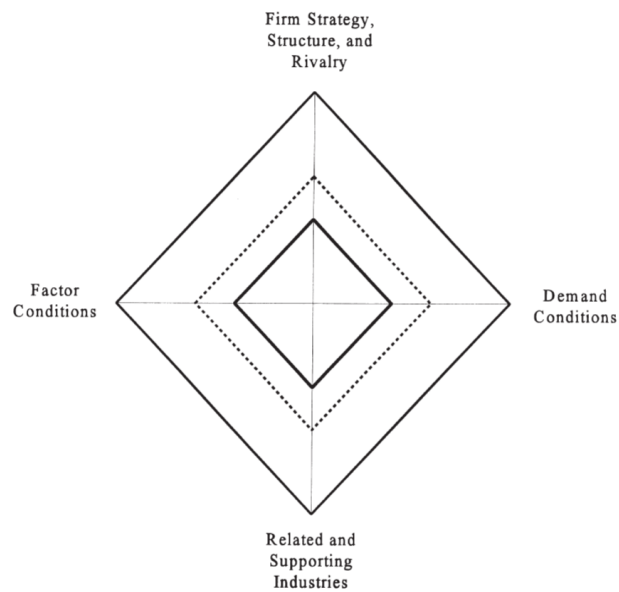
Moon, Rugman and Verbeke (1998) modified Rugman and D'Cruz's double diamond into a more generalized framework for examining smaller economies, an extended version that takes other factors into account. The new theory was named the "generalized double diamond model". The authors view Porter's diamond model as too focused on "home-base" determinants, thereby overlooking multinational activities (Moon, Rugman, and Verbeke 1998, 136).

They further state that Rugman and D'Cruz's double diamond (1993) is not suitable for all types of economies. Their new, more generalized version is considered to be better adaptable for analyzing small economies (Moon, Rugman, and Verbeke 1998, 136). Furthermore, the authors argue that Dunning's multinational activities (1991, 1993) should represent more than just an exogenous variable. Hence, they extended the framework into a generalized model, which formally incorporates multinational activity (Moon, Rugman, and Verbeke 1998, 137).

The adaption of Moon et al. (1998) has two methodological distinctions from Porter's diamond model. First, they argue that foreign as well as domestically owned companies can contribute to a nation's competitive advantage. Thus, inbound FDI is viewed as beneficial for an industry's competitiveness. The second argument states that globalization pressures businesses to outsource activities to foreign countries with more favorable conditions in order to sustain competitive advantage. In Porter's work on competitive advantage (1990) he argues that the most effective global strategy is to conduct as many activities as possible in one country to serve as a home base (Moon, Rugman, and Verbeke 1998, 139).

Figure 1 illustrates Moon et al.'s (1998) generalized double diamond model. It depicts a "global diamond" on the outside, an "international diamond" in between, and a "domestic diamond" on the inside. The global diamond has a fixed size for a foreseeable time. The size of the domestic diamond can vary as it depends on the size of the country and its level of competitiveness. The international diamond symbolizes a country's competitiveness. Unlike the original model from Porter, this framework sees competitiveness not only determined by domestic, but also by international variables. The differences between the domestic and international diamond is created by multinational activity, which includes inbound and outbound FDI (Moon, Rugman, and Verbeke 1998, 138).

Figure 1: The generalized double diamond model



Source: (Moon, Rugman, and Verbeke 1998, 138).

Moon et al. conduct a case study on South Korea and Singapore, utilizing both, Porter's diamond model and the generalized double diamond model. The study reveals that the generalized model is more suitable to explain the countries' economic progress and competitive position in global business. Their work further demonstrates the significance of multinational activities to the international competitiveness of both countries (Moon, Rugman, and Verbeke 1998, 135). Dunning (1993), Rugman and D'Cruz (1993) and Moon et al. (1998) all agree that Porter's theory disregards the significance of overseas firms' contribution to a nation's competitive advantage. They also agree that in order to maintain competitive advantage, firms need to base their success in favorable national and foreign diamonds (Moon, Rugman, and Verbeke 1995, 99). In addition, Moon et al. view the role of the government as an important determinant of national advantage. They argue that government differs from chance and should become the fifth endogenous factor instead of an exogenous factor, as proposed by Porter (Moon, Rugman, and Verbeke 1998, 148).

2.4.4 Other Modifications

Apart from the above-mentioned critics and modifications of Porter's diamond model, there are several others. For example, Narula (1991, 1993) suggests a modification that concerns the incorporation of technology as a determinant. He believes that Porter's focus on the relationship between FDI, innovation and development is too vague. In Narula's view the three

aspects have a common variable: technology. In contrast to Porter's concept, he proposes a framework that emphasizes accumulated technology on the nation level (Narula 1993, 90).

Also, similar to Rugman and D'Cruz, Cartwright (1991) applies the diamond model to the New Zealand market and reveals that the double diamond can better explain underlying structures. He believes that the diamond model is insufficient as it neglects factors that clarify international competitiveness. Hence, the author develops a multiple linked diamond, which is a more generalized version of Rugman and D'Cruz's model. It covers opportunities to multiple offshore environments where the advantage is generated, defended and seized through supportive organizational forms. The concept depicts two modifications from Porter's original model. First, it has interval scales to different parts of the diamond model to make it more quantitative. Second, Cartwright includes five off-shore variables (capture off-shore factor creation; linkage to related and supporting industries in the off-shore environment; access to demanding customers in the off-shore environment; access to rivalry in the off-shore environment; and the extend of international goals and structures of the industry). His study includes a comparison of Porter's diamond model and his extended model and reveals that his framework is more accurate in predicting competitiveness of certain industries (Penttinen 1994, 64–64).

As can be seen from the literature review on competitiveness, Porter's model has created much discussion amongst scholars. Needless to say, many arguments have been put forward that criticize several shortcomings of the framework, such as the negligence of multinational activity. Nevertheless, authors also point out that Porter's perspective is useful for the study of competitive advantage. Therefore, in order to analyze the competitiveness of the Taiwanese and Korean TFT-LCD industry, this study decided to not only include Porter's original model but also incorporate modifications suggested by his critics.

The diamond model has not only faced much criticism over the years, literature has also generated a great amount of studies that apply Porter's theory. The following section provides a few examples to gain a better understanding of how the model can be applied.

2.5 Application of the Diamond Model

Since the introduction of Porter's diamond model, it has found avid employment in academic research. The diamond model was firstly used in Porter's book "The competitive advantage of nations" (1990), where he applied the theory to ten countries (U.S., Germany, Denmark, South Korea, Britain, Italy, Sweden, Switzerland, Japan and Singapore).

Ever since, the diamond model has been applied to a multitude of case studies, ranging from Europe to America, to East Asia and Africa. Within Europe, the model was tested in several empirical studies, including Austria's "winter sport" cluster (Bellak and Weiss 1993), UK's higher education institutions (Curran 2000), three selected sectors in Ireland (Clancy et al. 2001), and Norway's maritime sector (Benito et al. 2003) amongst many others.

Outside of Europe, the East Asian Region further offers plenty opportunities for the application of the diamond model. Jin and Moon (2006) applied the framework to study the competitiveness of South Korea's apparel industry. China's wind power industry development and photovoltaic power industry were also examined with the help of the model (Zhao, Hu, and Zuo 2009; Zhao, Zhang, and Zuo 2011). Furthermore, the competitiveness of biotechnology in Japan was investigated with the help of Porter's model (Kong 2001).

Porter's diamond model also gained popularity for the comparative research of competitiveness. There are a multitude of studies using his framework, including Clarkson et al., who analyzes industrial cluster formation in East Germany and Poland (Clarkson, Fink, and Kraus 2007), or Lee and Chan-Olmsted's study that compares the differences in South Korea's and the United States' broadband internet development (C. N. Lee and Chan-Olmsted 2004) and also Özer et al.'s work on Turkey's and Spain's tourism industries (Özer et al. 2012), amongst others.

Several studies also extended Porter's diamond model. Rugman and D'Cruz (1993) modified the Porter's model into the "double diamond framework" to examine the international competitiveness of Canada. A few years later, Moon Rugman and Verbeke (1995) further extended the double diamond into the generalized double diamond model in order to effectively study the domestic and international diamond. Their framework was also used by other authors such as Liu and Hsu for the comparison of Taiwan's and South Korea's overall economies (D. Y. Liu and Hsu 2009).

Other authors compared Porter's diamond model and the other variations of the framework and applied it on case studies to evaluate which model is better suited for the analysis of competitive advantage. For example, Cho et al. (2009) introduced the dual double diamond as an approach to test country specific advantages and compared it to Porter's diamond model and the generalized double diamond model. The authors derive the conclusion that Porter's diamond model is less accurate than the other modifications, as it focuses on the physical factors in the domestic context, thereby neglecting the international context and human factors (Cho, Moon, and Kim 2009, 87). Another study from Moon et al. compares the diamond model and the generalized double diamond model and supports the idea that multinational activities need

to be incorporated into Porter's framework to become more accurate (Moon, Rugman, and Verbeke 1998).

As can be seen by this review, the diamond model has been utilized by many scholars for analyzing competitive advantage of a multitude of industries, among different countries, for comparative research and has further been modified and extended in various ways. The next chapter presents the research design and method for this thesis, which is based on Porter's diamond model and his critics' modifications.

3 Research Design

3.1 Porter's Diamond Model

In order to examine the competitiveness, the paper decided to apply Michael Porter's diamond model (1990b), which is a framework that analyzes the competitive advantage of nations or industries. The following sections discuss the factors contained in Porter's framework to gain a deeper understanding of what constitutes competitive advantage. As a final step, the diamond model is adjusted for the present case study. The final framework is then implemented to analyze the competitiveness of the TFT-LCD industry in Taiwan and Korea.

As has been stated before, this work attempts to evaluate the competitiveness of nations and industries and tries to explain why a nation can become the home base for successful global competitors in a particular industry (M. E. Porter 1990b, 1). Porter's diamond model is deemed useful as it endeavors to understand and disclose the underlying conditions of a national environment that create and sustain competitive advantage for certain industry.

Porter suggests that the influence of a firm's home nation is important for determining its ability or inability to create and sustain international competitive advantage, especially for the level of productivity growth. He believes that theories from classical economists such as Adam Smith and David Ricardo have become inadequate to explain the current nature of international competition. These theories are unable to clarify why firms of certain nations compete successfully in a particular industry, or why a nation's firms can sustain their competitive edge over a long time (M. E. Porter 1990b, 2).

According to Porter's, theories that see national competitiveness as a macroeconomic phenomenon, which is driven by exchange rates, interest rates, government deficits, cheap labor, natural resources, management practices or government policies are conflicting as they only focus on a single factor to justify the competitive position of nation's industries (M. E. Porter 1990b, 3). Thus, he proposes a broader and more complex set of determinants (M. E. Porter 1990b, 5).

In contrast to traditional theories, Porter understands that the principal economic goal of a nation is to provide a high standard of living for its citizens. This depends on the productivity of a nation's resources, such as labor and capital that are employed. For Porter, "Productivity is the value of the output produced by a unit of labor and capital" (M. E. Porter 1990b, 6). It is the prime determinant for a nation's standard. The rising standard of living depends on a nation's capacity to achieve a high level of productivity and increase it over time. This requires that a constant upgrade of the economy takes place (e.g. raising product quality, improving

product technology etc.) (M. E. Porter 1990b, 6). Additionally, he states that the analysis of competitiveness should not be focusing on the economy as a whole but on specific industries or industry segments. This enhances the research as it concentrates on industry-specific determinants instead of broad and general data. Why and how meaningful valuable skills are generated can only be fully understood at the level of the particular industry (M. E. Porter 1990b, 7). Yet, Porter adds that the role of the home nation is still strong, even though globalization of industries and internationalization of companies would make it appear that the nation has lost its importance. He argues that competitive advantage is a highly localized process, as economic structures, values, cultures, and institutions etc. generate competitive advantage. Thus, the home nation plays an increasingly significant part, since it is the source of skills and technology that support competitive advantage (M. E. Porter 1990a, 19).

In order to analyze competitive advantage of nations, Porter argues that a theory must firstly address why firms in particular nations choose better strategies than other competitors. Secondly, the theory should reflect why a nation is a home base for successful global competitors of a given industry (M. E. Porter 1990b, 19). The theory should further analyze a broader spectrum of determinants beyond costs, treating quality and differentiated products. In addition, it should encompass the dynamics and evolution of competition, while also taking into account improvements and innovations in methods and technology (M. E. Porter 1990b, 20).

Hence, Porter developed the diamond model that is set out to analyze the competitive advantage of nations which addresses the above-mentioned issues. The diamond model is based on four attributes that shape national competitive advantage and determine the environment in which local firms compete by promoting or impeding competitive advantage. The four determinants are: (1) factor conditions, (2) demand conditions, (3) related and supporting industries, and (4) firm strategy, structure and rivalry (M. E. Porter 1990b, 71).

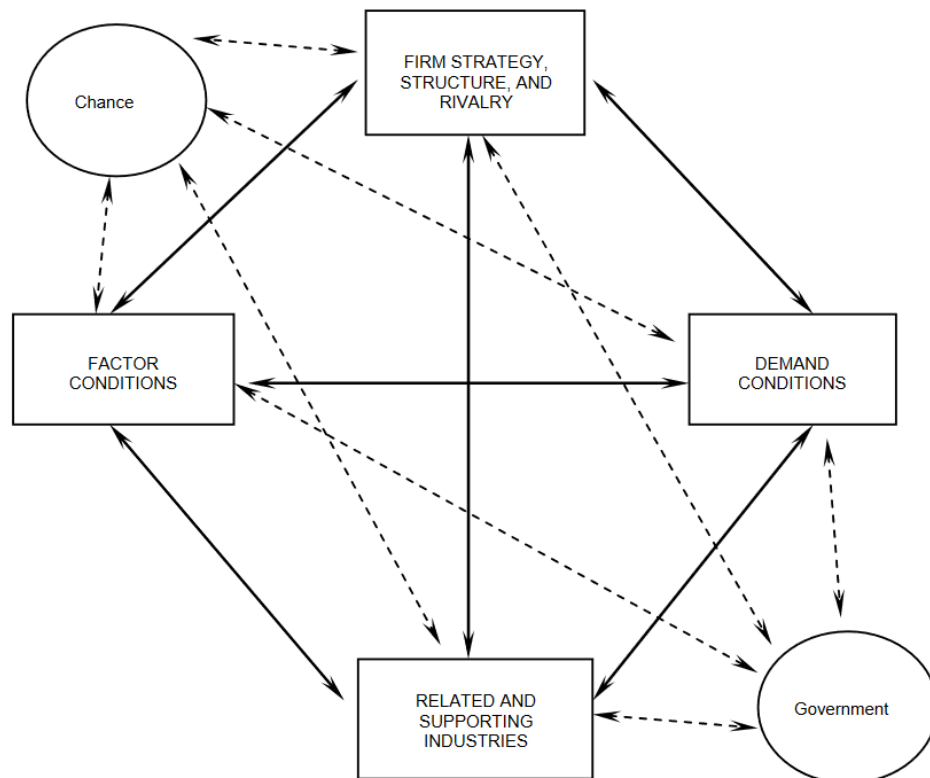
The diamond model is a mutually reinforcing system, where one determinant affects the others. For example, favorable demand conditions may not lead to competitive advantage when the state rivalry is insufficient to cause companies to respond to them. On the other hand advantages in one attribute may create and increase advantages in other attributes (M. E. Porter 1990b, 72).

Porter adds that competitive advantage of natural resource-dependent industries, or industries with lower levels of sophisticated technology or skills can be based on one or two determinants. However, knowledge intensive industries, such is the case for the TFT-LCD industry, need advantages throughout all four determinates to achieve competitive edge (M. E. Porter 1990b, 72–73).

In addition to the four above-mentioned endogenous determinants, Porter includes two exogenous determinants that can influence others: (5) chance events and (6) government. According to the author, the two exogenous determinants, government and chance, are not able to affect competitive advantage alone, but only through the other four determinants (M. E. Porter 1990a, 73). The complete structure is depicted in Figure 2.

The following sections will discuss in detail each of the six determinants that constitute the diamond model.

Figure 2: The complete diamond model



Source: (M. E. Porter 1990b, 127).

3.2 The Determinants of the Diamond Model

3.2.1 Factor Conditions

In Porter's view, an economy's endowment of factors plays an important part in the competitive advantage of its firms. These factors are often not inherited but created (M. E. Porter 1990b, 74). Factor conditions include different types of resources that can be found within a nation, such as: human resources, natural resources, knowledge resources, capital resources and infrastructure (M. E. Porter 1990b, 74–75). In addition, Chang (2005) states that in knowledge economies, intelligent capital (such as intelligent property) is especially important.

Japanese companies for example have controlled critical patents for TFT-LCD development for a long time and required licensing fees from Taiwanese companies to preserve intellectual property rights (S. C. Chang 2005, 207).

In Porter's view, every nation possesses these factors, yet there are different levels of quantity and quality. He suggests that competitive advantage depends on how efficiently these factors are deployed. Thus, factor advantage is not sufficient for competitive success, since all nations have attractive factor pools. Instead, factors need to be used efficiently and productively, which is determined by the other determinants of the diamond model (M. E. Porter 1990b, 76). Porter distinguishes between two sets of factor conditions, basic and advanced. Basic factor conditions include natural resources, climate, location, unskilled labor and debt capital. Advanced resources comprise skilled labor, specialist knowledge, capital, and infrastructure amongst others (M. E. Porter 1990b, 77). He suggests that competitiveness generated by basic factors is unsustainable. These factors are usually passively inherited by a country and take up little investment for their creation. Thus, if a firm's success is primarily based on basic factors advantages, it will face difficulties sustaining future competitiveness. Additionally, basic factor conditions are readily available and can be easily compensated through technological advancements. Advanced factors on the other hand, are scarce as their development requires more investment in human and physical capital. These factors are usually created rather than inherited. This type of factor can achieve advantage through product differentiation or upgrading production processes. For firms, they are an indispensable part for the design, the capacity to innovate, and the development of its products and processes (M. E. Porter 1990b, 77–78). Porter further differentiates between generalized and specialized factors. Generalized factors include a nation's highway system, its supply of debt capital or motivated semi-skilled workers. These factors can be employed in a variety of industries. On the contrary, specialized factors comprise personnel with special expertise or infrastructure with distinctive properties amongst others (M. E. Porter 1990b, 78). Generalized factors are available in many countries and easily accessible. While activities based on these factors can be performed outside the home base, specialized factors are necessary to take place at a firm's home base as they are less effective at a foreign place. They require a base of generalized factors and riskier private and social investments for their creation, which makes them rarer. Thus, in Porter's view higher-order competitive advantage requires specialized factors (M. E. Porter 1990b, 78–79). Porter derives to the conclusion that nations and firms are most competitive if they excel at creating and upgrading factors. Thus, nations that possess institutional mechanisms for the development of specialized factors are more likely to be competitive. These mechanisms are

also more important than the nation's current factor pool. The author further adds that especially advanced and specialized factors are necessary to achieve competitive advantage. These factors require permanent investments to upgrade their quality and avoid depreciation (M. E. Porter 1990b, 80). Which factors are generated and improved depends on the other determinants of the diamond model (M. E. Porter 1990b, 81).

Lastly, Porter adds that competitive advantage can also result from disadvantages in certain factors. For example, a disadvantage in basic factors may pressure firms to innovate, which further can lead to an upgrade and a more sustainable form of competitive advantage (M. E. Porter 1990b, 80–81).

3.2.2 Demand Conditions

The second determinant of the diamond is demand conditions. It focuses mainly on domestic market demand with attributes such as the composition of home demand, the size and pattern of growth of home demand, and the internationalization of domestic demand (M. E. Porter 1990b, 86). In Porters' view, home demand has three ways to increase competitive advantage: the composition of home demand is the base for a nation's competitive advantage, the size and pattern of growth of home demand intensifies the advantage and internationalization of home demand contributes through mechanisms that pull a country's products or services abroad (M. E. Porter 1990b, 97). Here, the author also stresses that "the quality of home demand (...) is more important than the quantity of home demand in determining competitive advantage" (M. E. Porter 1990b, 86).

Concerning the composition of home demand, Porter notes, that a strong market demand for a product or service provides competitive advantage for the industry. Strong domestic demand puts greater pressure on companies to innovate and improve products and services. Over time, this can accelerate competitive advantage for the nation (M. E. Porter 1990b, 86). In addition, sophisticated customer demand helps firms to gain competitive advantage in industries as knowledge about local and global buyer needs are acquired faster, which in turn gives firms a competitive advantage over foreign competitors (M. E. Porter 1990b, 86).

Porter sees domestic market demand as increasingly important amid globalization of competition. The domestic market offers the best conditions for observing and identifying customer needs. He provides several reasons for this: firstly, companies are more attentive and understanding towards home buyer's demand. Secondly, companies gain pride when they compete successfully in the home market. Lastly, the pressure to improve products is stronger in the home market as communication is more transparent (M. E. Porter 1990b, 86).

Porter provides three important factors for the composition of home demand that can achieve competitive advantage: the segment structure of demand, sophisticated and demanding buyers and anticipatory buyer needs. The segment structure of demand can help firms in creating and sustaining competitive advantage. When an industry's demand is segmented, firms usually focus on large and profitable segments rather than smaller or less profitable segments, which are often left to foreign companies. Thus, domestic firms tend to improve operation in large and profitable segments, which in turn will give them a competitive advantage on a global scale (M. E. Porter 1990b, 87).

The second factor, sophisticated and demanding buyers, refers to the nature of home buyers. In Porter's view, if a nation's domestic buyers are sophisticated and demanding, a domestic firm can gain competitive advantage, as the buyers provide an insight in their most superior needs. This pressures firms to achieve customer's high standards and demands (M. E. Porter 1990b, 89).

The final factor, anticipatory buyer needs indicates that a country's company may gain competitive advantage if the needs of home buyers predict those of foreign countries. In other words, home demand can be an indicator for future buyer needs. Sophisticated buyers in the home market are often early implementers of new products and services that will eventually become demand in other locations (M. E. Porter 1990b, 91).

In addition to these factors, Porter adds that the demand size and pattern of growth of home market can lead to competitive advantage. While, there is little agreement among scholars on how the size of home market affects the generation of national advantage, for Porter, a large domestic market can result in competitive advantage for industries when it has economies of scale or learning, and it requires companies to invest in technology developments or productivity improvements (M. E. Porter 1990b, 93). A large home market can be advantageous if it fosters investments and dynamism, but at the same time it may deter firms from pursuing international sales as demand is sufficient (M. E. Porter 1990b, 94).

Further, Porter adds that the growth rate of home demand can increase the ability of a nation's competitiveness. This is because the rate of investments made are based on the growth rate of the market or market segment rather than its size. Firms tend to invest in new technologies, when the market experiences high growth rates, since chances are higher that investments can be recompensated. Conversely, firms that compete in markets with moderate or little growth tend to invest less into new technologies (M. E. Porter 1990b, 94).

Finally, the internationalization of domestic demand is the last attribute for demand conditions. It takes place when a nation's buyers are mobile or are multinational companies. Consequent-

ly, they become domestic as well as foreign buyers and provide a base for foreign markets. This opens up the opportunity to establish operations abroad. Internationalization of domestic demand can also happen when domestic needs are transferred to foreign buyers. These transmissions of home demand can occur through exports of cultural products, political alliances or historical ties amongst others (M. E. Porter 1990b, 97–99).

It needs to be added that Porter views demand conditions as connected to other determinants of the diamond model. For example, a market of large size and high growth rates, yet without fierce competition, may lead to companies that often indulge in their own success instead of trying to improve and search for new investment opportunities (M. E. Porter 1990b, 99). Thus, the interplay with the other determinants is also important.

3.2.3 Related and Supporting Industries

The third determinant of the diamond model is related and supporting industries. Porter argues that the presence of supporting industries can facilitate competitive advantage in downstream industries in several ways. First, competitive suppliers can provide companies with access to cost-effective inputs, such as machinery, materials and equipment. However, inputs from home-based suppliers are not sufficient to achieve competitive advantage. Porter emphasizes that the availability of inputs is less important than the effective utilization of inputs, as in global competition, inputs are readily available on global markets and companies are not dependent on home-based supporting industries (M. E. Porter 1990b, 101–3). Second, home-based suppliers can facilitate coordination as essential activities and management are located nearby. Lastly, the process of innovation and upgrading can benefit greatly from home-based suppliers. Close working relationships help companies to gain quick access to information, new insights and supplier innovation. In addition, firms tend to exchange R&D or jointly solve issues and are thus more efficient in solution-finding. Another benefit is that suppliers are more likely to share information and innovation between firms, which accelerates the speed of innovation. This can also reduce transaction costs. Thus, effective cooperation with domestic upstream and downstream industries can accelerate the process of innovation and upgrade (M. E. Porter 1990b, 103).

Porter further believes that apart from an internationally competitive supplier industry, the cooperation between related industries can also accelerate competitive advantage. He sees companies as related when they share similar activities in the value chain or involve complementary products (M. E. Porter 1990b, 105). There are several benefits to companies in related industries. Having an internationally successful related industry nearby can increase the

information flow and technical interchange, since the conformity of culture makes communication easier. The presence of related industries can also advance the development of supplying industries. Additionally international success in an industry can attract demand for complementary products (M. E. Porter 1990b, 106).

In summary, companies connected with strong supportive industries or related industries benefit from the efficient use of inputs, the acceleration of innovation and lowered transaction costs. However, the author adds that having strong related and supporting industries does not suffice as the other determinants of the diamond can still inhibit competitive advantage. He sees the access to advanced factors, good home demand conditions and active rivalry as necessary to achieve competitive advantage (M. E. Porter 1990b, 107).

3.2.4 Firm Strategy, Structure and Rivalry

The fourth determinant refers to the context in which companies are created, organized and managed, as well as the conditions of domestic rivalry. A variety of goals, strategies and organizational structures can be found among firms, which are influenced by their national context. According to Porter, competitiveness of firms in an industry is determined by how those firms set up strategies and structure themselves. In addition, the pattern of rivalry has a strong impact on the process of innovation of a firm (M. E. Porter 1990b, 107).

In Porter's view, the national circumstances influence the structure and strategies and management style of firms. These differences can be experienced in management practices, such as trainings, the hierarchical style, and tools for decision making, amongst others. These can lead to competitive advantages or disadvantages. They usually derive from the nation's educational system, the social and religious background, or family structures etc. (M. E. Porter 1990b, 108–9). According to Porter's theory, the national environment also affects the orientation of companies to compete internationally. Fierce domestic rivalry and a saturated domestic market forces companies to export their products and services and move from national to global competition (M. E. Porter 1990b, 109).

Porter suggests that goals set by companies, management and employees are also an important element for competitive advantage. They can differ greatly within and among nations. Nations are usually successful when goals are aligned with the sources of competitive advantage. Company goals are primarily determined by the structure of ownership, the motivation of owners and holders of debt, the nature of corporate governance, and the incentive processes for senior managers (M. E. Porter 1990b, 110).

Ownership structure, capital market conditions and the style of corporate governance all influence national advantage in two ways, firstly, they stimulate how industries perceive risk, the appetite for funds, the investment time horizons, and the sustained rates of return. Secondly, they manipulate goal setting for different types of industries. This can create competitive advantage in certain segments, while in others it generates disadvantages (M. E. Porter 1990b, 112).

Goals set by companies are not the only determinant. Porter believes that goals set by individuals, such as managers and employees are also crucial for the success of firms in particular industries. Here he points out that especially the willingness to develop skills and expend their efforts can create and sustain competitive advantage (M. E. Porter 1990b, 113).

There are several determinants for individual goal setting, for example the characteristics of the reward system, the nation's tax structure, the attitude of individuals towards wealth and risk, and the geographic preferences, amongst others (M. E. Porter 1990b, 113–14).

Moreover, the behavior of individuals and shareholders can be modified by the prestige or national priority of an industry. When an industry increases its reputation and becomes a priority, it results in competitive advantage. These reputable industries usually attract talented human resources which create a national advantage (M. E. Porter 1990b, 114). However, sometimes it becomes difficult to distinguish between cause and effect, as the obtainment of international success can make an industry prestigious (M. E. Porter 1990b, 115).

Besides firm strategy and structure, Porter sees domestic rivalry as one of the strongest determinants for the creation and maintenance of competitive advantage in an industry. In contrast to other scholars, he views domestic rivalry as a major factor for competitive advantage as it pressures firms to improve, innovate, and increase productivity (M. E. Porter 1990b, 118). Rivalry in the home base is beneficial, since companies are pressured to enter other markets in order to increase sales, particularly when there are economies of scale. Rivalry can also strengthen a firm as it prepares the firm to succeed in foreign territory (M. E. Porter 1990b, 118–19). The presence of domestic rivals also nullifies advantages such as factor costs, access and preference in the domestic market, or local supplier base, since among competitors none can build its advantage on low labor costs or low debt financing. This pressures firms to find more sustainable sources, including proprietary technologies or exploit national advantages more effectively (M. E. Porter 1990b, 119–20).

In contrast to this, monopolies seldom achieve global leadership. They may be able to yield economies of scale in their home market but the pressure to innovate and improve products

and service is lower than in competitive markets. Thus, Porter believes that a more competitive home market is beneficial for competitive advantage (M. E. Porter 1990b, 117–18).

Finally, the author notes that the degree of rivalry between firms in the home market is more important than the number of domestic competitors. In addition, the country must achieve advantages in the other determinants of the diamond model to become internationally successful (M. E. Porter 1990b, 122–23).

3.2.5 The Role of Chance

Besides the four exogenous determinants of the diamond model, Porter adds “chance” or “chance events” as an exogenous determinant, which influences national competitiveness. Chance events are usually beyond the control of a company or a nation’s government, yet, they are important as they can affect national competitiveness by creating discontinuities that shift the competitive position of an industry. Porter provides several examples: acts of pure invention, major technological discontinuities, significant changes in input costs, substantial shifts in international financial markets or exchange rates, surges of demand for certain products, political decisions by foreign governments and wars (M. E. Porter 1990b, 124).

These events are unlike the former attributes of the diamond model. Their impact on the competitiveness of a given industry can be significant. Chance events can reverse previous advantages or create new potential. For example, in the TFT-LCD industry, the Asian financial crisis in 1997 can be viewed as such a chance event. The financial crisis in conjunction with a price war with Korea forced Japanese companies to release technologies to Taiwanese companies and obtain profits from the technology transfer fees. This provided Taiwan with an opportunity to establish itself in the TFT-LCD industry (Hsiao et al. 2011, 122).

Nonetheless, this thesis will exclude this factor from the analysis. Chance events such as natural disasters or wars are irregular occurrences, which makes it practically impossible to analyze. Some scholars, such as Bakan and Dogan (2012), which applied Porter’s framework chose to exclude this factor for simplification purposes. Furthermore, the several of the modifications of Porter’s diamond model omitted this factor (Cho, Moon, and Kim 2009, 93; Moon, Rugman, and Verbeke 1998, 138; Rugman and D’Cruz 1993, 30). Thus, this thesis decided to eliminate the determinant chance.

3.2.6 The Role of the Government

The final variable in Porter's diamond model is the role of the government. The state apparatus is often seen as a vital part in modern international competition. Especially in the East Asian region, in countries such as Japan and Korea, where it is associated with the nation's firms success (M. E. Porter 1990b, 126).

In Porter's diamond model, government is not included as fifth endogenous determinant as it solely influences the other four factors (M. E. Porter 1990b, 126). According to Porter, it has significant influence on national competitive advantage, but only plays a partial role, as the "government (...) can hasten or raise the odds of gaining competitive advantage (and vice versa) but lacks the power to create advantage itself" (M. E. Porter 1990b, 128). Thus, the government itself cannot generate competitive advantage as it depends on the other four determinants to increase competitiveness (M. E. Porter 1990b, 128).

The government can manipulate competitive advantage in a positive or negative way through the other determinants. It may affect factor conditions via subsidies or policies concerning capital markets and education. In demand conditions, the government can enact standards or regulations that direct and influence buyer needs. It can also affect related and supporting industries by controlling advertising media or by regulating supporting services. Lastly, government can shape firm strategies, structure and rivalry; such is the case when the capital market is regulated or tax policies are implemented or changed (M. E. Porter 1990b, 127–28). Government policy can also be influenced by the four endogenous determinants. Porter provides the example of government safety standards, which can be earlier introduced when there is a strong home demand for a product (M. E. Porter 1990b, 128).

There are manifold ways for governments to have a positive impact on a given industry. Porter offers several beneficial policy-approaches: focus on specialized factor creation; avoid intervening in factor and currency markets; enforce strict product, safety and environment standards; sharply limit direct cooperation among industry rivals; promote goals that lead to sustained investment; etc. These can help create an environment that supports and maintains national advantage of an industry (M. E. Porter 1990a, 87–88).

However, it should be noted that the government should not overstate its role as its strong intervention in the national economy can lead to firms that are dependent, backward looking and unsuccessful. If government interference is too strong, firms will not take necessary steps to develop sustainable competitive advantage and the upgrading of the economy slows down. Furthermore, too much government support makes it difficult to persuade industries to invest and take risks. Thus, according to Porter, the government should play the role of a pusher and

challenger. It should strengthen and upgrade the factors within the diamond (M. E. Porter 1990b, 681–82).

In the case of Taiwan, the government played a crucial role in the encouragement of high value-added industries. It offered incentives to firms that integrate resources, cooperate with global brand companies, and develop new products. Taiwan's government also implemented a 5-year plan to strengthen Taiwan's position in the TFT-LCD industry (S. C. Chang 2005, 209). Similar encouragement was experienced in Korea's establishment of its TFT-LCD industry. Korean authorities offered direct financial support for chaebols to activate the Korean TFT-LCD industry (T. Y. Park, Choung, and Min 2008, 2855).

3.2.7 The Dynamics of the Diamond Model

The previous sections introduced the different factors of the diamond model and described how these factors contribute or impede competitive advantage. According to Porter the diamond model is complex and evolves constantly (M. E. Porter 1990b, 131). Thus, in this section, the dynamics of the determinants and how they influence one another are discussed.

Porter suggests that the single determinants combine into a dynamic system. Especially the elements of domestic rivalry and geographic industry concentration strongly affect the diamond model, since domestic rivalry promotes upgrading of the entire national diamond, and geographic industry concentration increases the interaction within the diamond model. As a consequence, a nation's industries are often located in clusters (M. E. Porter 1990b, 131).

As has been suggested by the author, determinants of the diamond affect each other and cannot be isolated. The diamond is also in constant motion. Hence, it is essential to include the interplay of the factors in the analysis of competitive advantage of an industry. According to Porter, nations gain competitive edge on an international scale when their industries have the most favorable conditions in the diamond. Yet, for certain industries, advantages throughout all the attributes in the diamond are not always necessary in order to realize competitive edge. Especially in resource-intensive industries and standardized, lower-technology segments of advanced industries, where success is based on low factor costs, and advanced technologies are not crucial. However, in more sophisticated industries – as is the case for the TFT-LCD industry – success should not be based on only one or two factors of the diamond model as the dominant position cannot be detained for a long time. If competitive advantage is to be extended for a longer period, firms are required to generate advantages in more than two determinants of the diamond (M. E. Porter 1990b, 144–45).

3.2.8 Clusters

As has been stated above, the geographic concentration of firms, customers, suppliers and institutions, also known as “clusters”, plays an important role in the creation of competitive advantage (M. E. Porter 1990b, 148). For Porter, successful industries are characterized by vertical and horizontal relationships. Vertical relationships involve suppliers and buyers and are structured in upstream, midstream and downstream sectors of an industry. The horizontal dimension includes customers, technology and channels (M. E. Porter 1990b, 149).

Clusters emerge because a successful industry supports the development of other related and supporting industries. Clusters are also a vehicle for sustaining diversity and increase flexibility, while also intensifying information flow and spillovers to other segments of the value chain, into upstream, midstream or downstream segments. In addition, firms of clusters invest in related technologies, information, infrastructure and human resources (M. E. Porter 1990b, 149, 151). As a consequence, the geographic concentration of stakeholders in the industry can lead to an increase in the concentration of information, the speed of information flow, the rate of innovation and the prestigiousness of the cluster, which in turn attracts talents and the attention from the government (M. E. Porter 1990b, 156–57).

After reviewing the diamond model and its critics and modifications in detail, the next section provides the final framework for this thesis.

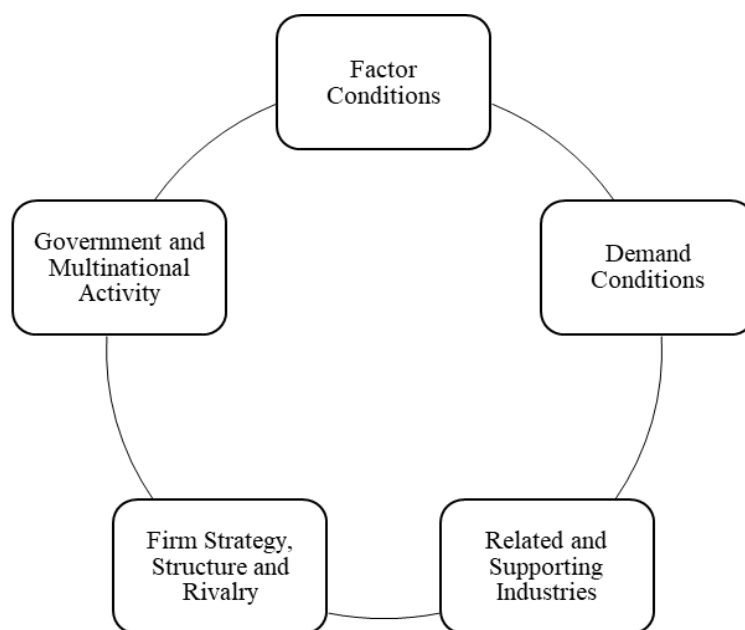
3.3 The Analytical Framework

This section presents the final framework that is applied for analyzing the competitive advantage of Taiwan’s and Korea’s TFT-LCD industry. The theory is based on Porter’s diamond model and the review on the modifications and critique of his theory. As studies from Dunning (1991, 1993), Rugman and D’Cruz (1993), and Moon et al. (1995, 1998) demonstrate, Porter’s diamond model requires several modifications. Thus, in order to provide a better equipped theory, this thesis will include some of the author’s suggestions.

The following changes are made to the original model: First, the framework will integrate multinational activities since the main players in the TFT-LCD industry contribute to more than 90 percent of the global capacity (Z. Y. Lee and Pai 2011, 4015) and arguably, foreign markets make a significant contribution to their success. Additionally, Korea and Taiwan are smaller countries and depend more on foreign markets than bigger nations (Moon, Rugman, and Verbeke 1998, 138). Thus, for determining demand conditions, not only domestic, but also international demand is examined. Furthermore, multinational activity includes the role of inbound and outbound FDI, such as how firms make use of advantages in other nation’s

diamonds. Furthermore, this thesis also analyzes government policy regarding foreign investment. These two categories are integrated in the section government and multinational activity. Second, the author follows the suggestion of Moon et al. (1998, 148) to implement the role of the government as a fifth endogenous determinant, rather than as an exogenous variable. Finally, the variable chance events will not be included in the final framework as chance is out of control of firms and governments, and impossible to predict. The final model is depicted in figure 3.

Figure 3: The final framework



Source: Author's own compilation based on (M. E. Porter 1990b, 127; Dunning 1993, 9; Rugman and D'Cruz 1993, 29; Moon, Rugman, and Verbeke 1998, 138).

The adjusted framework now includes five endogenous determinants: factor conditions, demand conditions, related and supporting industries, firm strategy, structure and rivalry, and government. These determinants will be dissected into smaller categories which are applicable to the TFT-LCD industry.

Porter provides several analytical sub-criteria for his determinants. According to him, factor conditions include: the availability of human resources, knowledge resources, natural resources, capital resources and infrastructure. Porter suggests to adjust these broad determinants to the specific industry (M. E. Porter 1990b, 73–75).

Porter argues that basic factor conditions such as natural resources, unskilled labor and debt capital are less crucial for competitiveness than advanced resources such as skilled labor, knowledge resources, capital and infrastructure. Thus, this study will concentrate on advanced resources. In addition, as Chang (2005) suggests, one of the main resources for the TFT-LCD industry is intelligent capital (e.g. intellectual property rights) (S. C. Chang 2005, 207). Hence, in addition to Porter's factors, this study will also include intelligent capital as a determinant for factor conditions.

Human resources are measured by the availability, amount and cost of labor. Concerning knowledge resources, this study follows Karia's (2018) concept and views it as a firm's ability to develop and acquire people with expertise, skills and knowledge. Knowledge resources are thus identified as skills, experience and educational background of workforce, as well as on job training and education (Kaira 2018, 417). Hence, this category entails the composition of the educational background of employees (e.g. degree of education), the mean years of schooling over 14 years and the enrollment ratio in university programs that are instrumental for the TFT-LCD industry² (T. Y. Park, Choung, and Min 2008, 2871). In addition, the expenditure on R&D by firms is also evaluated as these investments are often associated with knowledge creation of employees (Omerzel and Gulev 2011, 343).

Capital resources include financial supplies for an industry's development. Nan et. al. (2012) presents three important indices to measure a country's capital resources: Gross Capital Formation (GCF), Foreign Direct Investment (FDI) and Stock Market Capitalization (SMC) (Nan, Lei, and Johanson 2013, 30). According to the OECD, GCF is calculated by "the total value of the gross fixed capital formation, changes in inventories and acquisitions less disposals of valuables for a unit or sector" (OECD 2001). FDI are international investments made by a firm or individual in one economy into business interests located in another economy ("OECD Glossary of Statistical Terms - Foreign Direct Investment" 2001). Lastly, SMC refers to the amount of money it costs to buy every share of stock a company had issued at the then-current market price (World Bank Group n.d.).

Infrastructure includes the hard infrastructure of TFT-LCD clusters and the educational infrastructure such as universities.

The final element, intelligent capital, is measured by the number of patents owned by Taiwanese and Korean companies. Following these suggestions, the author has compiled several criteria for the analysis of factor conditions in the TFT-LCD industry:

² Park (2008, 2871) presents an index with previous studies on technological capability which suggest measuring human skills by tertiary science, math and engineering enrollment ratio.

Human resources:

- Amount of labor in TFT-LCD (number of employees in TFT-LCD industry)
- cost of labor in TFT-LCD (average monthly wage in manufacturing)

Knowledge resources:

- skill level of labor (highest educational degree; mean years of schooling over 14; Tertiary science, math, and engineering enrollment ratio)
- R&D expenditure of TFT-LCD firms

Capital resources:

- Gross Capital Formation (GCF)
- Foreign Direct Investment (FDI)
- Stock Market Capitalization (SMC)

Infrastructure:

- Hard infrastructure of display panel clusters (proximity of clusters to airports, ports, cities and universities)
- Educational infrastructure (number of universities and research institutes offering training and educational programs that benefit the TFT-LCD industry)

Intelligent capital:

- number of existing TFT-LCD-related patents

For the analysis of demand conditions, Porter provides three attributes: the composition of home demand, the size and pattern of growth of home demand, and the internationalization of a nation's domestic demand. He emphasizes that quality is more significant than quantity (M. E. Porter 1990b, 86). Based on this, the author compiled the following factors:

Market size:

- total domestic sales of TFT-LCD panels from manufacturers

Market growth rate:

- market growth from year 2014 to 2017

International demand:

- total export of TFT-LCD panels
- main global customers

Market segment structure:

- segment structure by panel type (Large-size TFT-LCDs and small/medium-size TFT-LCDs)

The third determinant, related and supporting industries, refers to the presence of supplier industries or related industries in a home nation, their competitiveness in relation to the global context, and the level of integration between companies and suppliers (M. E. Porter 1990b, 100–101). As an example for a related industry, the semiconductor industry was chosen since the production process of TFT-LCD panels, particularly the array part, is overlapping. Firms in the semiconductor and TFT-LCD industry tend to share and compete for human resources and technology (Chen and Chen 2009, 2). In addition, spillovers from semiconductor industry can increase know-how sharing and establish technology distribution channels (T. Y. Park, Choung, and Min 2008, 2868). The TFT-LCD industry has benefited greatly from the semiconductor industry. For example, in Taiwan, the TFT-LCD industry acquired knowledge in precision equipment, new talent and related fabrication facility management (Hsiao et al. 2011, 121)

In addition, as an example for supporting industries, the competitiveness of upstream display equipment, materials and parts industry are evaluated. The upstream supporting industries for TFT-LCD manufacturing are crucial for the competitiveness of the TFT-LCD industry. Manufacturing equipment for the TFT-LCD panels include glass substrate, liquid crystal, color filters, polarizers, driver IC, and backlight module amongst others (S. C. Chang 2005, 208; P. L. Chang, Chiang, and Chou 2007, 143). In order to analyze their competitiveness, this chapter will investigate the size of the industries and the number of domestic companies. The final analytical criteria relevant for the analysis of related and supporting industries read as follows:

The Semiconductor industry:

- Size of the semiconductor industry (by total sales)
- Number of domestic companies in the semiconductor industry

Supporting upstream industries:

- Size of upstream supporting industries (by total sales)
- Number of domestic companies in manufacturing TFT-LCD equipment and material

The determinant firm strategy, structure and rivalry, describes conditions on how companies are created, organized, managed and the nature of domestic rivalry (M. E. Porter 1990b, 71). The first section will analyze the company structure (ownership structure) of the main TFT-LCD players in both countries. In addition, strategies of the major players will be analyzed using Porter's (1980) three generic strategies that he proposes in his book "Competitive Strat-

egy: Techniques for Analyzing Industries and Competitors”. The book offers insights into how firms pursue competitive advantage. The three strategies are: cost leadership, differentiation and focus (M. Porter 1980, 35). Porter explains that firms which follow cost leadership strategies focus on reducing costs in order to provide cheaper products and services than competitors. These companies also try to minimize overhead costs, expenses for research and development and service or advertising. In order to achieve this, many firms need to achieve a high market share to realize economies of scale in purchasing or gain favorable access to basic factors including cheap workforce and raw materials (M. Porter 1980, 35–36).

The second strategy, differentiation, pursues the creation of something special and unique, that differs from standardized products and cheap prices. This can be achieved through product design, introduce new or proprietary technology, special product features or outstanding service. The focus of this strategy is not on cost-cutting, but on offering higher quality services and products (M. Porter 1980, 37).

The final strategy, focus, is applied in companies that target a certain group of customers, a segment of product line or a geographic market. These companies concentrate on offering best product or service for their target customers. The focus strategy is based on maintaining low cost position or providing highly differentiated products and services (M. Porter 1980, 38–39).

Additionally, this section analyzes the degree of rivalry and competition within the TFT-LCD industry. Porter offers several criteria on how to measure the intensity of rivalry in an industry. If competitors are numerous and have equal size and market share, rivalry tends to increase. This can be further intensified by slow industry growth (M. Porter 2008, 32). Thus, the rivalry section will evaluate the number of competitors, as well as the intensity of domestic rivalry in the TFT-LCD industry. Accordingly, rivalry includes the size and market share of competitors and the industry growth. The following criteria were compiled:

Firm strategy and structure:

- Ownership structure of the largest TFT-LCD companies (public, private or state owned)
- Strategies of major TFT-LCD companies (cost leadership, differentiation or focus)

Rivalry:

- Intensity of domestic rivalry (number, size and market share of domestic competitors, industry growth)

The last dimension of the framework is government. Contrary to Porter's framework, this study investigates government as an endogenous variable, since many scholars argue that governments have more impact on other dimensions than previously suggested by Porter. The government has also played an important role in Taiwan's and Korea's success in the TFT-LCD industry. Since the TFT-LCD industry is technological and capital intensive, financial support from governments is essential. For example, financial aid from the government can support the creation new production lines; governments can also promote competition in the global market by lowering production costs (Hu 2012, 544).

Furthermore, this section also includes multinational activity. The author decided to investigate government policy towards FDI in the domestic TFT-LCD market, as well as inbound and outbound FDI in the TFT-LCD industry in Taiwan and Korea. This study follows Moon et al.'s method of investigating multinational activities, which looks at foreign multinational firms in the home nation (inbound FDI) and domestically owned firms in foreign countries (outbound FDI) (Moon, Rugman, and Verbeke 1998, 139). This section analyzes the following categories:

Government:

- Government policies concerning the TFT-LCD industry (e.g. subsidies, incentives, regulations, standards, taxes etc.)

Multinational activity:

- Government policy concerning FDI in the domestic TFT-LCD industry
- Inbound and outbound FDI in the TFT-LCD industry (by number of foreign owned companies in domestic TFT-LCD industry and number of domestically owned firms abroad)

This chapter discussed the final framework including all determinants and their sub-criteria for the analysis of competitive advantage in the TFT-LCD industry. The final analytical criteria are shown in Table 1 below. In chapter four, the criteria of the modified diamond model is applied to the TFT-LCD industry of Taiwan and Korea in order to compare their competitiveness.

Table 1: Analytical criteria for analyzing competitive advantage in the TFT-LCD industry

Factor Conditions	Human Resources	– Amount of labor – Cost of labor
	Knowledge resources	– Highest educational degree

		– Mean years of schooling over 14 – Tertiary enrollment ratio in science, math, and engineering – R&D expenditure of firms
	Capital resources	– Gross Capital Formation – Foreign direct investment – Stock market capitalization
	Infrastructure	– Hard infrastructure of display clusters – Educational infrastructure
	Intelligent capital	– Number of TFT-LCD patents
Demand Conditions	Market size	– Total domestic sales of TFT-LCD panels
	Market growth rate	– Market growth (2014-2017)
	International demand	– Total export sales of TFT-LCD panels – main global customers
	Market segment structure	– Segment structure by TFT-LCD size
Related & Supporting Industries	Semiconductor industry	– Size of semiconductor industry – Number of domestic companies in the semiconductor industry
	Supporting upstream industries	– Size of upstream supporting industries – Number of domestic companies in upstream supporting industries
Firm Strategy, Structure & Rivalry	Firm Strategy and Structure	– Ownership structure of major TFT-LCD companies – Strategies of major TFT-LCD companies
	Rivalry	– Intensity of domestic rivalry: number, size and market share of domestic TFT-LCD companies, industry growth
Government & Multinational Activity	Government policies towards TFT-LCD industry	– Subsidies, incentives, regulations, standards, taxes, etc.
	Government policies towards FDI in the TFT-LCD industry	– Tax reductions, export barriers, investment incentives, etc.
	Inbound and outbound FDI in the TFT-LCD industry	– Number of foreign owned companies in domestic TFT-LCD industry (e.g. Fully owned, joint ventures) – Number of Korean/Taiwanese owned TFT-LCD manufacturers abroad (e.g. subsidiaries, joint ventures)

Source: Author's own compilation based on (M. E. Porter 1990b, 127).

3.4 Data Collection

The previous section introduced the finalized framework used in this thesis to analyze the competitiveness of the Taiwanese and Korean TFT-LCD industry. After having reviewed the framework, the final section of the theoretical part presents the method of data collection. Various kinds of documents were obtained for the analysis. These are listed below:

- Academic journals and books
- Governmental reports and data from the Taiwanese and Korean government
- Reports and data from national agencies and institutions in Taiwan and Korea (e.g. Invest KOREA or the Korea Trade-Investment Promotion Agency)
- Newspaper articles
- Websites and annual reports of TFT-LCD manufacturers
- Reports from international organizations including the World Bank, the United Nations Educational, Scientific and Cultural Organization (UNESCO), or the Organisation for Economic Co-operation and Development (OECD)
- Homepages and Reports of research institutes that analyze the TFT-LCD industry (e.g. Industrial Technology Research Institute (ITRI))

4 Comparison of Taiwan's and South Korea's TFT-LCD Industry

4.1 The TFT-LCD Industry in Taiwan and South Korea

This chapter examines the competitiveness of the TFT-LCD industry in Taiwan and South Korea, based on the previous theoretical part of the thesis, which discussed Porter's diamond model and its modifications. Before starting the analysis, this section provides a comprehensive introduction to the Taiwanese and Korean TFT-LCD industry, including aspects, such as the general industry infrastructure (upstream, midstream, downstream) and major companies to gain insights on important characteristics of the industry.

The industry structure of the TFT-LCD industry can be divided into three levels: upstream, midstream and downstream. The upstream level involves material components manufacturing; the midstream comprises panel manufacturing and in the downstream process, TFT-LCD panels are incorporated into product application channels (e.g. laptop screens, smartphones, TV screens, etc.) (P. L. Chang, Chiang, and Chou 2007, 143).

During the upstream level, different material components are produced, such as glass substrate, backlight module, color filter and liquid crystal. Amongst the many components, backlight modules and color filters are the most expensive as they make up around 50 percent of the total costs for producing LCD panels (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 6).

The midstream panel manufacturing can be divided into three subdivisions: TFT circuit array engineering, top/bottom cell engineering and module engineering. The array engineering process is similar to semiconductor fabrication. The cell engineering stage requires most experience in technology and has the highest yield rate. The last stage, module engineering, is the most labor-intensive process of the whole TFT-LCD manufacturing chain. The process is simple yet requires much manpower as it cannot be automated and is thus often transferred to countries with low-labor costs (P. L. Chang, Chiang, and Chou 2007, 143).

In the downstream level, companies apply the TFT-LCD panels fabricated during the midstream process into salable products, such as TVs and computers (P. L. Chang, Chiang, and Chou 2007, 143).

Table 2: The TFT-LCD industry structure

Upstream → (material, part, equipment)	Midstream → (panel manufacturing)	Downstream (application process)
• Glass substrate • Chemical material • Glass • Liquid crystal • Polarizer film • Driver IC • Backlight module • ...	Array manufacturing	• LCD TVs • Notebooks • Tablets • Smartphones • LCD Monitors • Cars • ...
	Cell manufacturing	
	Module manufacturing	

Source: (P. L. Chang, Chiang, and Chou 2007, 143).

In Taiwan, many domestic and foreign firms are involved in the upstream process of manufacturing material components. For example, glass substrate is produced by several companies from Taiwan and abroad, such as China Optoelectronics, Picvue Electronics, Asahi Glass Fine Technology or TW Crowning. Nine color filter production and other materials such as IC products or backlight module production also involve Taiwanese and foreign companies (P. L. Chang, Chiang, and Chou 2007, 144).

The midstream stage involves a significant number of large Taiwanese panel manufacturers, such as AU Optronics Corporation (AUO) or Chimei Innolux Corporation (Innolux), HannStar Display Corporation (HannStar), Chunghwa Picture Tubes (CPT), Giantplus Technology Co., Ltd. (Giantplus) and E Ink Holdings Inc. (E Ink) (Industrial Technology Research Institute (ITRI) 2014, secs. 10–7; 2016, secs. 10–7). Additionally, Taiwan panel manufacturers acquired most of their technology from arrangements with Japanese companies, such as IBM or Panasonic. As a consequence, Taiwanese TFT-LCD manufacturers pay high royalties to Japanese firms (P. L. Chang, Chiang, and Chou 2007, 144).

In terms of downstream application channels, Taiwan is one of the largest locations for outsourced production of information technology products, especially for personal computers, notebook computers and monitors (Hsiao et al. 2011, 121). The country has good relationships with notebook and display producers, which gave them an advantage in comparison to Korean manufacturers (P. L. Chang, Chiang, and Chou 2007, 145).

Contrary to Taiwan, Korea's upstream and midstream level is dominated by LG Display and Samsung Display, which are amongst the largest TFT-LCD manufacturers worldwide. Both are subsidiaries of two Korean chaebols LG and Samsung Electronics. The upstream supply and the technology involved is supplied by the corporate organizations themselves. For example, the Samsung Group has several subsidiaries in material components: Samsung Corning, Samsung SDI, Samsung Electro-Mechanics and Samsung Semiconductor (P. L. Chang, Chiang, and Chou 2007, 145). Yet, some core materials in the upstream stage still depend on Japanese, U.S. and European companies, including liquid crystal, glass and some equipment (Korea Trade-Investment Promotion Agency (KOTRA) 2020a, 21).

Concerning the downstream application channel, the key-customers are international brands PC giants and companies with long-term agreements, such as Apple and Dell (P. L. Chang, Chiang, and Chou 2007, 145).

The TFT-LCD industry is characterized by capital-intensiveness, economies of scale, a high doorsill of technology and is closely related to other information technology and consumer electronics products (Chen and Chen 2009, 2; Tseng and Chiu 2006, 1). Concerning capital intensiveness, high costs are associated with building production plants for new generations of panels, and costs rise with each new generation plant that needs to be constructed. This puts high pressure on manufacturers as the technology advances speedily. Within a period of 15 years, eight generations of TFT-LCD technology were generated (Chen and Chen 2009, 2–3). Generations are differentiated by the size of glass substrate used during production. The newer generations have increased in size and thus need larger substrate measurements ("Innolux Corporation. Panel Size Evolution" n.d.).

In addition, the industry has high material costs as up to 80 percent of the total costs are related to material costs (Chen and Chen 2009, 3). Moreover, the TFT-LCD industry is very competitive as its technology can only be utilized for display-purposes. In recent years, the TFT-LCD display technology is facing more competition, especially from organic light emitting diodes (OLED), TN/STN LCDs and flexible display technologies (Chen and Chen 2009, 2). Hence, for companies working in the display industry it is essential to stay ahead of competitors and invest in new technologies.

The following chapters comprise the analytical investigation of the five determinants of the diamond model and discuss the following determinants: factor conditions, demand conditions, related and supporting industries, firm strategy, structure and rivalry, and government and multinational activity. Each of the determinant is analyzed following the analytical criteria from Table 1 in chapter 3.3.

4.2 Factor Conditions

4.2.1 Factor Conditions in Taiwan

The chapter, factor conditions, discusses the amount, cost and availability of the TFT-LCD labor force. In addition, knowledge resources, capital resources, the infrastructure and intelligent capital of the TFT-LCD industry are analyzed. Knowledge resources includes the educational background of the labor force as well as R&D expenditures of firms. Capital resources involves gross capital formation, foreign direct investment and stock market capitalization. Infrastructure concerns the hard infrastructure of display clusters and the nation's educational infrastructure clusters. Lastly, intelligent capital includes the number of existing patents in the industry.

Human Resources

Taiwan's total population increased from 23,1 million people in 2009 to around 23,5 million people in 2018 ("Statistics" 2019). Like many industrialized countries, Taiwan's society faces various demographic issues such as an aging population, which is further accelerated by a declining fertility rate and a long-life expectancy (Cheng and Loichinger, 2017, p. 442). Nonetheless, the total labor force experienced a steady increase from 10,8 million in 2009 to around 11,8 million in 2018 ("Manpower Survey Results in March 2020" 2020, 3). Yet, the National Development Council states, that around 78 percent of employers in 2018 faced a talent shortage, especially concerning engineers and IT technicians (e.g. plant and machine operators, technicians and associate professionals) ("Industry's Talent Shortages: The Current Situation and Policy Response" 2019). These talents are especially relevant for firms in the TFT-LCD industry as they employ technicians and engineers. Such is the case for Innolux, one of the major TFT-LCD manufacturers in Taiwan. According to the company's 2018 Corporate Social Responsibility (CSR) Report, the composition of employees is arranged accordingly: positions are organized in management (low- and middle management, and executives), specialists, administrative personnel and technicians, with the highest percentage of employees in the section of technicians (64 percent) and specialists (27 percent) (Innolux Corporation 2018, 115).

According to the Taiwanese flat panel display yearbook of 2014 and 2016, created by the Industrial Technology Research Institute (ITRI), the manpower of Taiwan's TFT-LCD industry in 2011 was around 70,300 and declined to 69,000 in 2015 (see Table 3 below). The report specifies that the number of employees decreased as demand of flat panels declined during that time (Industrial Technology Research Institute (ITRI) 2014, secs. 2–13; 2016, secs. 2–13).

Table 3: Taiwan's LCD industry workforce, 2011 to 2015 (Unit: one person)

Taiwan's display industry workforce					
Display types	2011	2012	2013	2014	2015
TFT-LCD	70,300	66,714	68,382	70,071	69,002
Other LCDs	8,866	7,890	6,180	5,692	5,090
OLED	1,000	1,100	1,150	1,160	1,200
Micro-display	256	253	250	244	242
Total	80,422	75,957	75,962	77,167	75,534

Source: Author's own compilation based on (Industrial Technology Research Institute (ITRI) 2014, secs. 2–13; 2016, secs. 2–13).

Precise data on wages of workers in TFT-LCD industry was not available, thus instead the average monthly wage of workers in manufacturing are analyzed. An employee working in manufacturing in Taiwan earned around 1330 USD per month in 2009. The monthly salary increased to 1580 USD in 2014 and further to 1720 USD in 2017 (Department of Statistics 2020, 33). In comparison, a worker in manufacturing sector in China earned as little as 310 USD per month in 2009 and 770 USD in 2017 (Textor 2019).

Knowledge Resources

The educational background of the Taiwanese workforce is similar to standards found among many OECD countries. In 2010, the mean years of schooling in Taiwan was 11 years and by 2018 the number of years had increased to 12.1 years (“National Statistics Bulletin. International Comparison of Human Development Index (HDI)” 2011, 1; Schwab 2018, 545).

The information on educational background of employees in the annual reports from Taiwanese TFT-LCD manufacturers (Innolux, AUO, HannStar and Gianplus) reveals a demand for skilled labor. The majority of workers in Taiwanese TFT-LCD manufacturers attained a bachelor's degree, followed by employees with a senior high school diploma and a master's degree (AUO, 2019, p. 75; GiantPlus Technology, 2019, p. 77; HannStar, 2019a, p. 59; Innolux Corporation, 2019, p. 80). In the past decade, Taiwan's gross school enrollment ratio in tertiary programs was stable with around 80 percent (Ministry of Education, Republic of China 2020). In 2009, around 30 percent of students in institutions of higher education were enrolled in programs instrumental for the TFT-LCD industry (i.e. mathematics and statistics 1.2 percent; information and communication technologies 5.8 percent; engineering, manufacturing and

processing 23 percent). In 2018 the percentage dropped to 24.7 percent (mathematics and statistics 1 percent; information and communication technologies 6.6 percent; engineering, manufacturing and processing 17.1 percent) (National Statistics Republic of China 2019, 30). Taiwan experienced a general decrease in students and graduates of science and technology programs since 2007, where the highest number of students recorded was around 639,000 students. In 2018, the number dropped to around 538,000 students (Ministry of Education, Republic of China 2020, sec. V.1). Evidently, the number of scholars in mathematics, engineering and related programs are declining, however it needs to be added that the total number of students enrolled in tertiary programs also dropped during the same time (National Statistics Republic of China 2019, 29).

Apart from human resources, R&D investments are also crucial for the competitiveness of firms. According to Porter, fierce competition stimulates companies to invest in factor creation. In order to stay ahead of competition, firms invest in R&D activities to develop new technologies and specialized infrastructure or training for their employees to improve their skills (M. E. Porter 1990b, 134–35). This is especially the case for TFT-LCD manufacturers as the market has entered a period where prices have become competitive and firms need to invest in advanced technologies to stay ahead of competitors (Innolux Corporation 2018, 33). To analyze the expenses of Taiwanese TFT-LCD firms, the study chose six manufacturers listed on the Flat Panel Display Report from 2016, which include the two largest manufacturers AUO and Innolux, as well as other important producers such as E Ink, Giantplus, HannStar and CPT. These TFT-LCD manufacturers spend between 3 to 15 percent of their annual net sales revenue for R&D (AU Optronics Corp. (AUO) 2019, 115; Chunghwa Picture Tube 2018, 86; E Ink Holdings Inc. 2019, 95; GiantPlus Technology 2019, 151; HannStar 2019, 51; Innolux Corporation 2019, 126). Innolux invested around 405 million USD in R&D, which is 3.3 percent higher than the average R&D expenditure of companies in Taiwan. The firm ranked on ninth place among all Taiwanese companies on the 2018 Global Innovation 1000 Study. In their CSR Report from 2018, Innolux states that its R&D expenditures on technical and product design innovation are a key ingredient to maintain their competitiveness (Innolux Corporation 2018, 33). Similarly, AUO focuses its R&D on new technologies such as 8K4K TV display panels, extra-large gaming LCD displays and multi-purpose information display solutions amongst others (AU Optronics Corp. (AUO) 2019, 68).

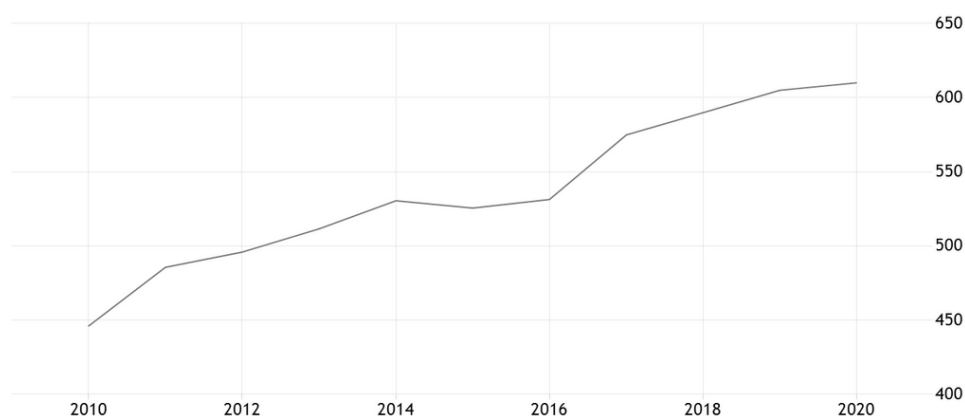
Table 4: Research and development expenses in 2018

TFT-LCD companies	R&D expenses in USD	Percentage of net sales revenue
AUO	319 million USD	3%
Innolux	405 million USD	4.3%
E Ink	69 million USD	15%
Giantplus	9.21 million USD	3%
HannStar	29 million USD	5.15%
CPT*	85 million USD	9%
*Data only available from 2017		

Source: Author's own compilation based on (AU Optronics Corp. (AUO) 2019, 115; Innolux Corporation 2019, 126; E Ink Holdings Inc. 2019, 95; GiantPlus Technology 2019, 151; HannStar 2019, 51; Chunghwa Picture Tube 2018, 86).

Capital Resources

Capital resources are financial supplies that are necessary for the development of an industry. They mainly manifest via Gross Capital Formation (GFC), Foreign Direct Investment (FDI), and Stock Market Capitalization (SMC) (Porter 1990 in Nan, Lei, and Johanson 2013, 10). In addition to these factors, the Gross Domestic Product (GDP) is included to show the growth of the economy. In the past decade, Taiwan's GDP rose steadily and reached around 605 billion USD by 2019, which is equal to 0.50 percent of the world economy (World Bank Group n.d.).

Figure 4: GDP of Taiwan, 2010 to 2020 (in billion USD)

Source: (World Bank Group n.d.).

The gross capital formation (formerly gross domestic investment) of Taiwan is depicted in the Figure 5 below. It shows “the total value of the gross fixed capital formation, changes in inventories and acquisitions less disposals of valuables for a unit or sector”(OECD 2001). Thus, GCF refers to net additions made to existing capital goods (physical assets) in a given period of time. Taiwan has seen an overall upward trend in investments in its economic assets following the global financial crisis in 2009. In 2010, the GCF increased to almost 31.8 billion USD (935 billion NTD). The following years show a slow increase in GCF, however, by the end of 2018 another surge is visible at around 34 billion USD (1000 billion NTD) (OECD 2019). Generally, a high level of capital formation leads to growth of an economy’s aggregate income. A country’s capital formation is also connected to the country’s GDP. If the GCF increases, so does the GDP, which is the case for Taiwan.

Figure 5: Taiwan’s Gross Capital Formation, 2010 to 2019 (in thousand New Taiwanese Dollars)



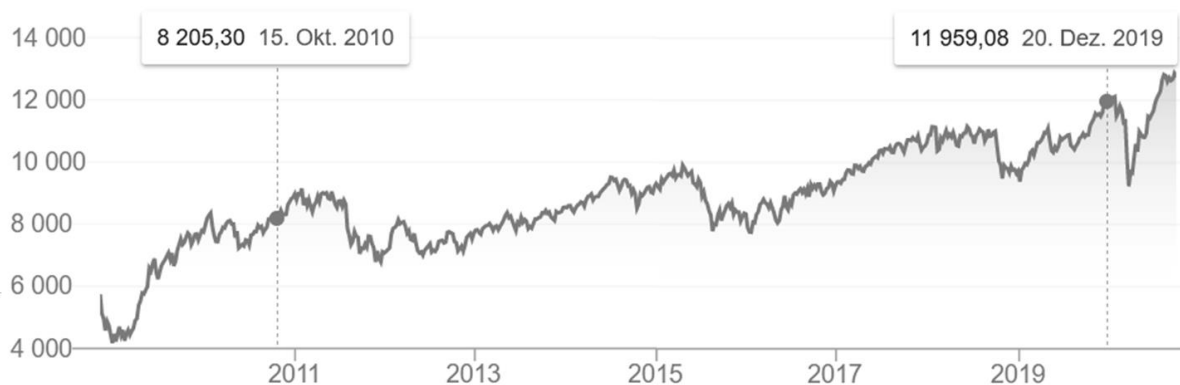
Source: (OECD 2019).

Foreign direct investment, or FDI, is a resource of capital and can indicate how overseas investors perceive a country's economic environment. Taiwan is considered a popular destination for FDI since it features economic dynamism, a high purchasing power and strong growth in its high-tech sector (European Commission 2018, 6). According to the UNCTAD World Investment Report of 2019, FDI flows to Taiwan stood at almost 7 billion USD in 2018, up from 3.59 billion USD in 2013 (United Nations Conference on Trade and Development (UNCTAD) 2019, 213). China, the Netherlands and British Virgin Islands are the largest investors. Especially electronic components and manufacturing attracts most foreign investment (“Taiwan: Foreign Investment” 2020). Taiwan's business environment is still very attractive for foreign investors, as can be seen in the Doing Business report from 2020 where it ranks on

the 15th place out of 190 (World Bank Group 2020a, 4). Furthermore, the country provides the highest performance in corporate transparency for the protection of minority investors (World Bank Group 2020a, 79).

Taiwan relies heavily on the export of its IT products, with companies such as the Taiwan Semiconductor Manufacturing Company (TSMC), which takes up over 30 percent of Taiwan's total stock market (A. J. Park 2020). The TAIEX, which is a capitalization-weighted index for companies traded on the Taiwan Stock Exchange (TWSE), increased around 45 percent during 15. October 2010 and 20. December 2019. The growth of the TAIEX is fortified by Taiwan's strong IT sector performance and the large proportion (62.7 percent as of 2019) it captures of their stock markets. In 2019, the TAIEX grew 23 percent, while the KOSPI (Korean index) increased more slowly by 7 percent. (A. J. Park 2020).

Figure 6: Taiwan's TAIEX Index, 2008 to 2020



Source: ("Taiwan TAIEX" 2020).

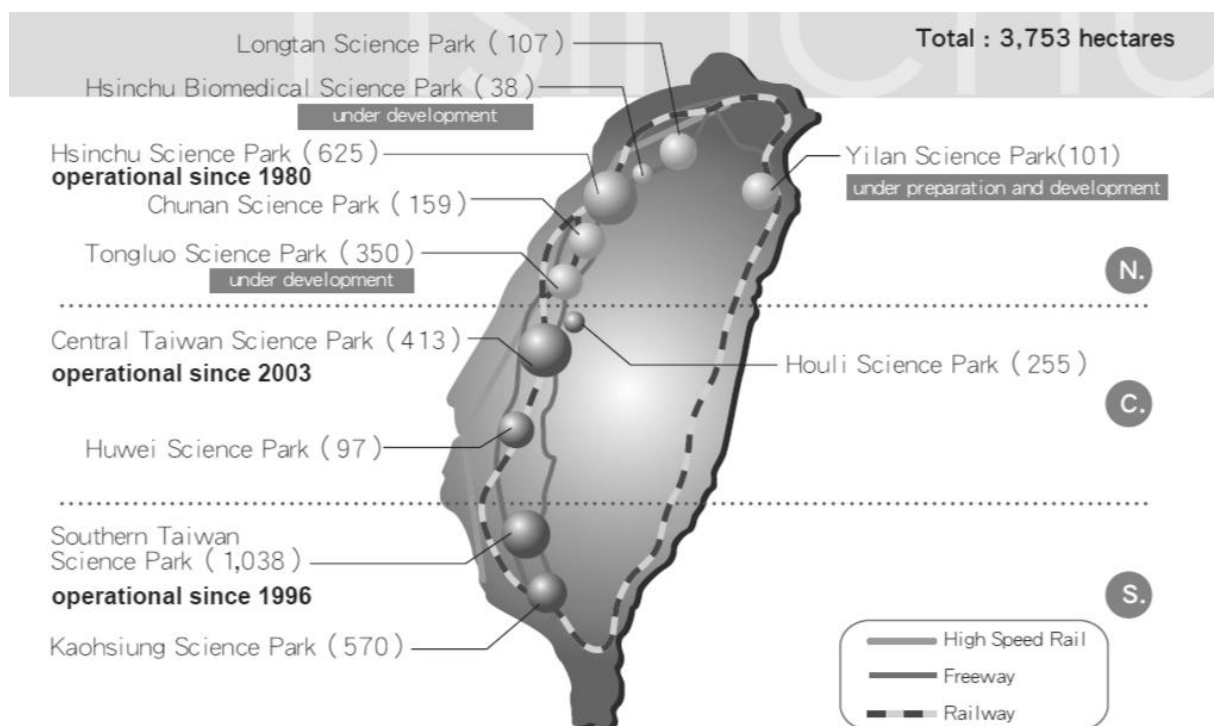
Infrastructure

This section focuses on the infrastructure of the Taiwanese TFT-LCD industry. The section is divided into two categories, the hard infrastructure of display clusters and the nation's educational infrastructure. The hard infrastructure is measured by the proximity of clusters to nearby cities, airports, ports, and the existence of equipment and material suppliers and universities. These factors facilitate logistics for exports and imports, increase attractiveness for skilled workforce and support the cooperation with suppliers. The educational infrastructure includes the number of universities that offer educational programs relevant for the TFT-LCD industry.

The regional settlement of the TFT-LCD industry in Taiwan can be categorized into three geographical locations or clusters: the Hsinchu Science Park in the north, the Central Taiwan Science Park in the center and the Southern Taiwan Science Park in southern Taiwan (Indus-

trial Technology Research Institute (ITRI) 2016, secs. 6–3). The northern and central science parks are dominated by AUO, while the Southern Taiwan Science Park is led by Innolux (Industrial Technology Research Institute (ITRI) 2014, secs. 2–9). The three parks are located along the west coast of Taiwan and form a high-tech corridor which accommodates technology firms covering the entire spectrum of the supply chain (“Hsinchu Science Park. Introduction” 2019). A high speed railway, railways and freeways connect all the science parks (D. R. Huang 2007, 10)

Figure 7: IT clusters in Taiwan



Source: (D. R. Huang 2007, 10).

The Hsinchu Science Park houses 91 optoelectronics³ companies and comprises of six different science parks (Hsinchu Science Park, Zhunan Science Park, Longtan Science Park, Tongluo Science Park, Yilan Science Park and Hsinchu Biomedical Science Park) (“Industry and Companies Statistics” 2020). The park is strategically located near Taipei City (80 km) and Taoyuan City (50 km). The closest airports are the Taiwan Taoyuan International airport (60 km distance) and the Taipei Songshan Airport (80 km). In addition, the High-speed rail Hsin-

³ Optoelectronics is a term combining optics and semiconductor electronics and, in the broadest sense, includes all products and processes that enable the conversion of electronically generated data and energies into light emission and vice versa.

chu station, and other railways and national highways are located nearby (W. J. Huang 2013, 167). Finally, the park is 100 km from the Keelung Port and 80 km from the Taichung Port (D. R. Huang 2007, 16). Nearby universities, such as the Tsinghua University and National Chiao Tung University are located in proximity to the Hsinchu Science Park. Within the park, the Industrial Technology Research Institute (ITRI) and centers for synchrotron radiation research, high speed data and precision are situated (Industrial Technology Research Institute (ITRI) 2016, secs. 6–5). The close interaction with academia created a very competitive workforce. Around 45,000 master's degree holders and 3,900 doctorate degree holders work in the Hsinchu Science Park (European Commission 2018, 21).

The Central Taiwan Science Park consists of five sites (Taichung Park, Huwei Park, Houli Park, Erlin Park, and Chung Hsing Park). The parks are close to Taichung city (10 km) and has convenient links to several freeways and expressways. In addition the sites are close to the Taiwan high-speed railway and adjacent to the Taichung Port (20 km) and the Taichung International Airport (5 km) that ensures quick air, sea, and land transportation access (“Introduction to the Central Taiwan Science Park” 2018). The park houses in total 30 optoelectronic firms (“Industry and Companies Statistics” 2020). Amongst them are suppliers and manufacturers, that produce display systems and components (“Introduction to the Central Taiwan Science Park” 2018). In addition, the site established close relation with 28 universities that promote academia-industry cooperation via the integration of R&D, talent and know-how exchange (European Commission 2018, 22).

The Southern Taiwan Science Park comprises of the Tainan Science Park and the Kaohsiung Science Park. Innolux and HannStar formed, along with TFT-LCD component, material, and equipment makers an integrated touchpad industry cluster in Tainan Science Park (“Southern Taiwan Science Park” 2018). Together, the two science parks house in total 42 optoelectronics-related companies (“Industry and Companies Statistics” 2020). Nearby cities are Kaohsiung (60 km) and Tainan (20 km), in which the airports of Kaohsiung (70 km) and Tainan (30 km) reside. The park is around 40 km from the Kaohsiung Port (Southern Taiwan Science Park Bureau, Ministry of Science and Technology 2019, 5). It is linked by railways and highways to the other clusters. The Kaohsiung Science Park, located in the south, is surrounded by around 50 well-known public and private colleges and universities, where abundant professional and technological workforce is supplied to satisfy the demand of manpower (“Kaohsiung Science Park” 2019). The park also cooperates with the Yanchao University to construct a R&D center for high-tech industries (European Commission 2018, 23).

Concerning the educational infrastructure, there is no specific data on programs related to TFT-LCD education, however, many of the employees working in this industry come from a technology and engineering background. The Ministry of Education lists 82 technical colleges in Taiwan (“List of colleges and universities” n.d.). In 2018, there were a total of 326,897 students registered in industrial technology related programs, including industry-related senior vocational schools, engineer-related junior colleges, engineering undergraduate, master’s and Ph.D. programs (Ministry of Education Republic of Taiwan 2019a, sec. V.3). In total 61 out of 70 general universities offer programs such mathematics and statistics, information communication technology and engineering (“List of Colleges and Universities in the 108 Academic Year” 2019). 23 of Taiwan’s universities (e.g. the National Taiwan University) even offer specialized graduate programs in optoelectronics, which is a subfield of photonics and instrumental for the TFT-LCD industry (Ministry of Education Republic of Taiwan 2019b). These programs are specialized on TFT-LCD processes and essential for the TFT-LCD workforce, as they integrate a broad spectrum of photonics and optoelectronics technologies (“Graduate Institute of Photonics and Optoelectronics. Research Scope” n.d.). As can be seen, Taiwan’s educational system focuses intensely on developing a skilled workforce that specializes in mathematics, technical and engineering skills.

Table 5: The infrastructure of Taiwanese TFT-LCD clusters

Classification	Hsinchu Science Park	Central Science Park	Southern Taiwan Science Park
Distance to cities	Taipei 80 km Taoyuan 50 km	Taichung 10 km	Kaohsiung 60 km Tainan 20 km
Distance to airports	Taiwan Taoyuan International Airport 60 km Taipei Songshan Airport 80 km	Taichung International Airport 5 km	Kaohsiung Airport 70 km Tainan Airport 30 km
Distance to harbors	Keelung Port 100 km Taichung Port 80 km	Taichung Port 20 km	Kaohsiung Port 40 km
Access to transportation	Taiwan high-speed railway, railway, national highway	Taiwan high-speed railway, freeways, expressways	Taiwan high-speed railway, railway, national highway
Number of optoelectronic-related companies	91 companies	30 companies	42 companies
Institutions for higher education and research	Cooperation with Tsinghua University	Cooperation with 28 universities	Cooperation with 50 universities and

	ty, National Chiao Tung University, ITRI		colleges
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Source: Author's own compilation based on (Industrial Technology Research Institute (ITRI) 2016, secs. 6–5; D. R. Huang 2007, 16; “Introduction to the Central Taiwan Science Park” 2018; “Industry and Companies Statistics” 2020; European Commission 2018, 22–23; Southern Taiwan Science Park Bureau, Ministry of Science and Technology 2019, 5; “Southern Taiwan Science Park” 2018; “Kaohsiung Science Park” 2019).

Intelligent Capital

The final section of factor conditions analyzes the number of TFT-LCD related patents registered by Taiwan and Korea. Chang states that it is important for companies in TFT-LCD industry to be attentive towards intellectual property rights in order to stay competitive (S. C. Chang 2005, 208). Companies pay a lot of money to acquire technology licenses, which diminishes their profit margin while the profit goes to other more technology-advanced countries (S. C. Chang 2005, 213–14). Generally, TFT-LCD companies that entered the industry later can easily violate patents if firms that entered first are unwilling to license technology or demand excessive licensing fees (Hsiao et al. 2011, 119).

In order to analyze the sources of innovation and knowledge flows of the Taiwanese and Korean TFT-LCD industry, this paper used the Espacenet patent data site to trace citation flows of TFT-LCD patents. The website is provided by the European Patent Office (EPO) and uses a patent classification system, the International Patent Classification (IPC), which classifies almost all patents. It is maintained by the World Intellectual Property Organization (WIPO) and used in more than 100 countries worldwide (“Espacenet. IPC” n.d.). The site's settings allow to filter results into country of origin, time period and country of release. This allows to retrieve the necessary information from the website.

Table 6: Number of registered TFT-LCD patents, 2000 to 2018

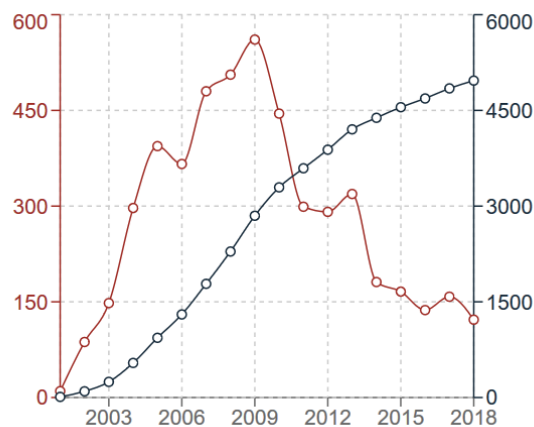
Country of registration	Number of patents
South Korea	34,019
U.S.	15,281
Mainland China	10,185
Taiwan	4967
Japan	4258

total	68,710
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Source: Author’s own compilation based on (“Espacenet. TFT-LCD” n.d.).

The time frame was set from January 2000 to December 2018 and included Korea, the U.S., China, Taiwan and Japan in the section for “registering country”. The keyword search “TFT-LCD” found in total 68,710 matches. According to the Espacenet, most patents were registered by Korea, followed by the U.S., China, Taiwan and Japan. Taiwan had registered in total 4967 patents during that time period. The highest amount of TFT-LCD patents (almost 600 patents) was registered in 2009, but experienced a huge drop thereafter (“Espacenet. TFT-LCD” n.d.).

Figure 8: Patents registered by Taiwan, 2000 to 2018 (Unit: number of patents)



Description: red line: count, black line: cumulative.

Source: (“Espacenet. TFT-LCD” n.d.).

4.2.2 Factor Conditions in Korea

Human Resources

Korea’s total population increased from 49.3 million in 2009 to 51.6 million in 2018 (World Bank Group 2020b). The total labor force also saw an increase from 24.9 million to 28.2 million in the same period (World Bank Group 2019a). Even though both, Korea and Taiwan are among the smaller countries in East Asia, Korea has more than double the amount of workforce of Taiwan in 2018.

Similar to Taiwan, Korea's demographic issues are characterized by an aging population, a low fertility rate and a long-life expectancy with around 83 years. As a result, the proportion of people entering the workforce is shrinking ("Republic of Korea. Education and Literacy" 2020). Competition in Korea's job market is tough, but the electronics industries are said to be one of the most attractive industries to young people in Korea (Organisation for Economic Co-operation and Development (OECD), Working Party on Shipbuilding 2014, 54). Korea's IT and electronics industries has been globally competitive for a long time. The country's human resources are of high quality, since employees have a strong educational background with advanced degrees in electronics or chemistry and professional on-site experience (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 11). According to the display report of 2017, the 55.4 percent of human resources engaged in the display industry graduated high school, while 7.5 percent of employees carried a Master's and doctoral degree (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 30).

There is no specific data on the labor force of the TFT-LCD industry, however, the Korea Trade-Investment Promotion Agency (KOTRA) published data concerning the number of employees in the Korean display industry. In 2014, approximately 102,000 workers were engaged in 775 display companies. In 2017 the number of business increased to 914, yet the number of employees sunk to 95,600 employees (Korea Trade-Investment Promotion Agency (KOTRA) 2020a, 20).

Table 7: Businesses and employees in Korea's display industry, 2014 to 2017

(Unit: One company, one person)				
Classification	2014	2015	2016	2017
Businesses	775	770	880	914
Employees	102,103	91,106	97,177	95,668

Source: Statistics Korea cited in (Korea Trade-Investment Promotion Agency (KOTRA) 2020a, 20).

The cost of workers in manufacturing are almost double of that in Taiwan. The average monthly wage in manufacturing in Korea amounted to around 2098 USD in 2009 and increased to 3340 USD in 2014. In 2017, the wage saw a slight decrease to 3240 USD ("Population 2019" 2019).

Knowledge Resources

The mean years of schooling in Korea increased from 11.6 years in 2010 to 2018 12.3 years, which is slightly higher than Taiwan (Schwab 2018, 325). In the past ten years, the school enrollment in tertiary programs has dropped in Korea. While in 2009 the ratio was at a 104 percent (gross), it decreased to 94.35 percent (gross) in 2017 (World Bank Group 2019b). The OECD provides data on the share of new entrants in tertiary educational programs in Korea starting from 2015. In the same year, the share of new entrants in science technology, engineering and mathematics programs was 30.9 percent, while engineering, manufacturing and construction programs had a share of 23 percent. In comparison to other programs such as arts and humanities, which had a share of 5.7 percent (2015), or health and welfare with a 14.4 percent share (2015), tertiary science and engineering programs are the most popular. In 2017 the share of science technology, engineering and mathematics entrants rose to 31 percent, while the share of engineering, manufacturing and construction entrants decreased to 21.2 percent. Yet, these studies still constitute of the highest share compared to all other study programs (Organisation for Economic Co-operation and Development (OECD) 2019). This was also evidenced by the UNESCO, which states that Korea's prime scientific focus throughout the years was engineering (*Higher Education in Asia: Expanding out, Expanding up. The Rise of Graduate Education and University Research* 2014, 149).

Lastly, according to LG Display, the R&D expenditure of 2018 amounted to 1.69 billion USD or 8.5 percent of its net sales revenue (LG Display Co., Ltd. 2019, 16). In their 2018 annual report, the company states that their R&D activities focused especially on new products and technologies such as large-sized OLED and plastic OLED panels (LG Display Co., Ltd. 2019, 37). While there was no data on the R&D expenditures of Samsung Display, there is information on the R&D costs of Samsung Electronics, which owns most of the shares of Samsung Display. Samsung Electronics spent around 15.28 billion USD in 2018 or the equivalent of 7.7 percent of its sales revenue (Samsung Electronics Co., Ltd. 2019, 59). The company is also one of the world top 5 spenders on R&D (Skillicorn 2019). In comparison to Taiwanese TFT-LCD manufacturers, the amount of investments is relatively high in Korean TFT-LCD companies. However, LG Display and Samsung Electronics differ in size as they are not only TFT-LCD manufacturers, but also specialize in other electronic products. The companies do not specify how much of their expenditure is spend on TFT-LCD R&D, hence, a direct comparison to Taiwanese TFT-LCD manufacturers is not possible. However, both companies are among the largest R&D spenders in Korea (*Maeil Business News Korea* 2019).

Table 8: Research and development expenses in 2018

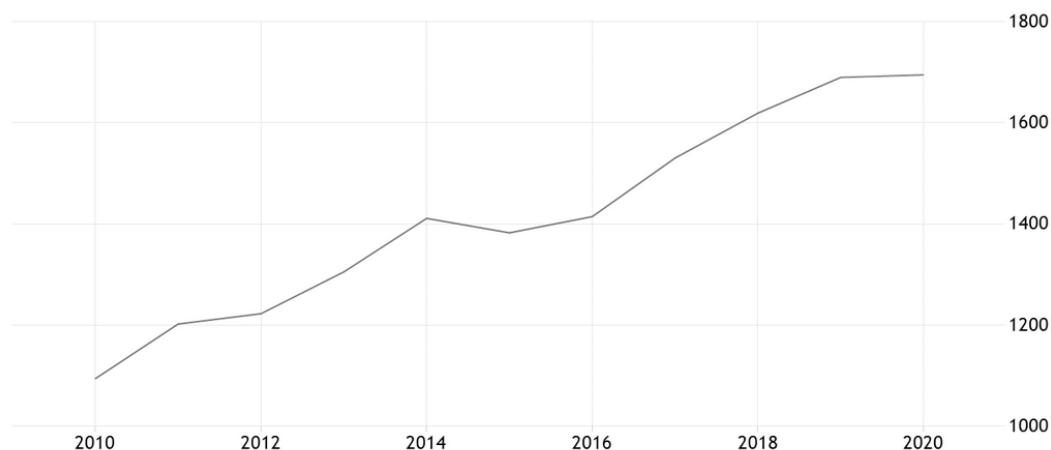
TFT-LCD companies	R&D expenses in million USD	Percentage of net sales revenue
LG Display	1.69 billion USD	8.5%
Samsung Electronics	15.28 billion USD	7.7%

Source: Author's own compilation based on (LG Display Co., Ltd. 2019, 16; Samsung Electronics Co., Ltd. 2019, 59).

Capital Resources

Korea's GDP increased to 1690 billion US dollars in 2019 and represents a GDP value of 1.39 percent of the world economy ("South Korea GDP" n.d.).

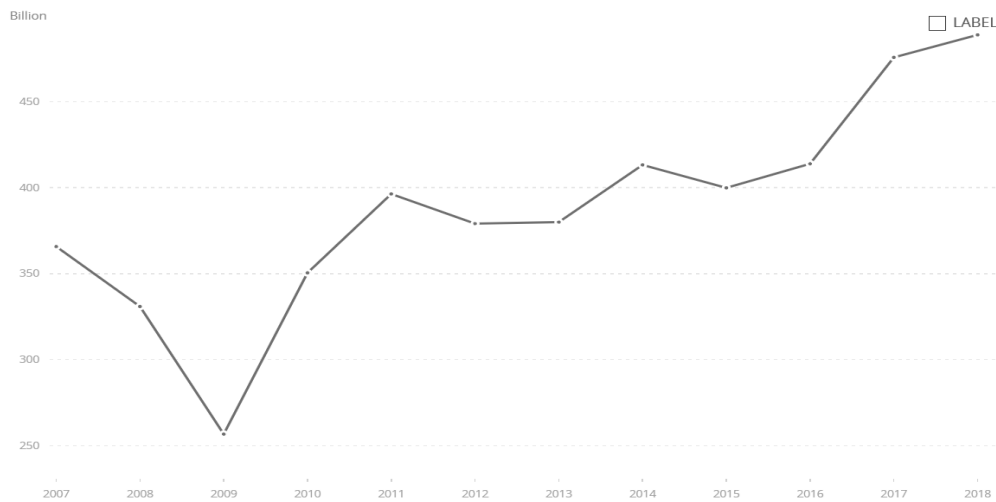
Figure 9: GDP of Korea, 2010 to 2020 (in billion USD)



Source: World Bank cited in ("South Korea GDP" n.d.).

The World Bank databank illustrates the GCF of Korea, comprising "outlays on additions to the fixed assets of the economy" (e.g. plant, machinery, equipment etc.) and "net changes in the level of inventories" (raw materials and goods available for sale) (World Bank Group n.d.). The GCF of Korea has seen a steady increase after the global financial crisis, especially in 2009 and 2016 as an effect of stimulating economic policies. The lowest drop in 2009 reached 256 billion USD, while in 2018 it peaked at 488 billion USD (see figure 10 below).

Figure 10: Korea's Gross Capital Formation, 2007 to 2018 (in billion USD)

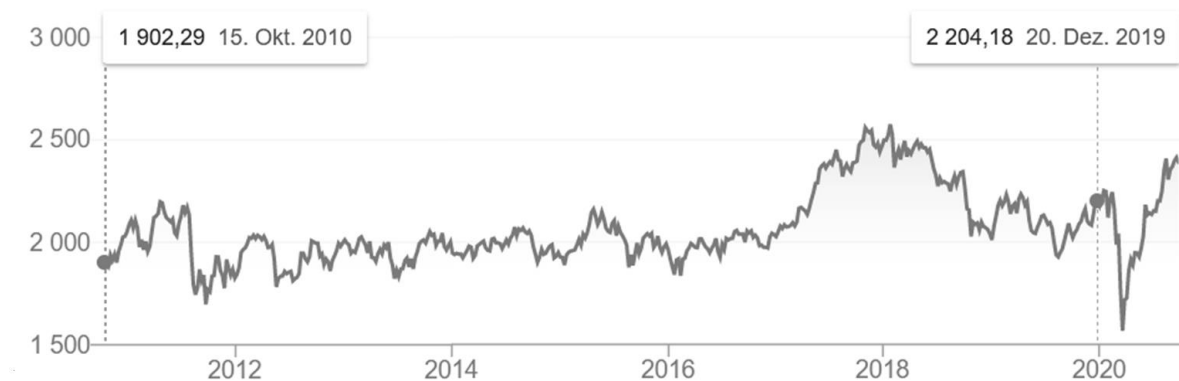


Source: (World Bank Group n.d.).

The FDI inflows to Korea were 12.7 billion USD in 2013 and increased to 14.4 billion USD in 2018, and ranked as 19th the top recipient of FDI inflows in the world in 2018 (United Nations Conference on Trade and Development (UNCTAD) 2019, 213, 4). However, FDI inflows have dropped by 19 percent in 2018 due to a significant decrease in intracompany loans (United Nations Conference on Trade and Development (UNCTAD) 2019, 42). Major investments derive from China, the United States, the European Union and Japan. Investments were mainly oriented towards finance and insurance, trade, manufacturing, real estate, information and communication, mining and quarrying and transportation (“South Korea: Foreign Investment” 2020). In the Doing Business Report of 2020, Korea is ranked 5th right behind Denmark, and ten places ahead of Taiwan (World Bank Group 2020a, 4).

Similar to Taiwan, Korea heavily relies on the export of IT products, with companies such as Samsung and LG. Samsung is the largest company in terms of market capitalization and captures over 30 percent of Korea's total stock market (A. J. Park 2020). Yet, Korea's KOSPI index experienced a slower increase from 15. October 2010 to 20. December 2019, with a 15,8 percent growth. In comparison, Taiwan's TAIEX index had a 45 percent growth in the same period.

Figure 11: Korea's KOSPI Index, 2008 to 2020



Source: ("KOSPI" 2020).

Infrastructure

Korea has five LCD-related clusters: Paju, Tangjeong, Giheung, Cheonan and Gumi. Amongst them, the largest clusters are the Paju and Tangjeong industrial complex, which house the newest production facilities for display production (Korea Trade-Investment Promotion Agency (KOTRA) 2014, 5). The Paju cluster is situated around 35 km north of Seoul and is home of LG Displays and 80 other display companies. Some of them are affiliated companies for LG Display, specializing in high-tech parts and materials, such as LG Chem (glass substrate) or LG Innotek (LED, Backlight unit) (Korea Trade-Investment Promotion Agency (KOTRA) 2017b, 3). The Paju cluster is situated about 50 km from the Incheon International Airport and 50 km from the Incheon port, which provides easy access to a variety of export routes (Korea Trade-Investment Promotion Agency (KOTRA) 2017b, 19). In addition, the Gimpo International Airport, is located within a 50 km distance from the cluster and National Highway 1 is close by (Kotra Express 2017). Due to the close proximity to the airport and port as well as a convenient transportation network, more than 90 percent of the products can be exported (Korea Trade-Investment Promotion Agency (KOTRA) 2020a, 28). Even an office of the Korea Customs Service is located within the region which facilitates logistics for customs clearance (Kotra Express 2017). The surrounding metropolitan areas supply the Paju cluster with high-quality human resources from universities and specialized high schools (Korea Trade-Investment Promotion Agency (KOTRA) 2020a, 28).

The Tangjeong industrial complex or Crystal Valley is located near Asan and Choenan city and generates around 54 percent of the total domestic output and 27 percent of the total global

display production. It is located around 85 km south of Seoul. Around 210 display-related companies, including Samsung Display are located there (Korea Trade-Investment Promotion Agency (KOTRA) 2017b, 3). The distance to the Incheon International Airport is 164 km, but the cluster is very close to the Pyeongtaek and Dangjin port (Korea Trade-Investment Promotion Agency (KOTRA) 2017b, 19). In addition, the complex has a secured supply of workforce from the 35 colleges (Korea Trade-Investment Promotion Agency (KOTRA) 2020a, 29).

Table 9: The infrastructure of South Korean TFT-LCD clusters

Classification	Paju Industrial Complex	Tangjeong Industrial Complex
Distance to cities	Seoul 35 km	Seoul 85 km
Distance to airports	Incheon International Airport 50 km Gimpo International Airport 50 km	Incheon International Airport 164 km Cheongju Airport 45 km
Distance to harbors	Incheon Port 50 km	Pyeongtaek Port 30 km Dangjin Port 30 km
Access to transportation	expressways, railway	Korea Train Express, expressways, railways
Number of display-related companies	80 companies	210 companies
Institutions for higher education and research	Cooperation with several colleges and high schools	Cooperation with 35 colleges

Source: Author's own compilation based on (Korea Trade-Investment Promotion Agency (KOTRA) 2015, 13–16; 2020a, 29).

Both clusters are located near Seoul and are close to other semiconductor industrial complexes, such as Cheonan Valley. Thus, numerous facilities that manufacture parts, materials and equipment are in close proximity. In addition, it is easy to hire local talent and professionals as Seoul is nearby (Korea Trade-Investment Promotion Agency (KOTRA) 2017b, 3).

Figure 12: Display industry clusters in South Korea



Source: (Korea Trade-Investment Promotion Agency (KOTRA) 2017b, 3).

The educational infrastructure in Korea is marked by a particularly high degree of enrollments in at the university level in engineering, manufacturing, and construction, in mathematics and physical sciences (Grubb et al. 2009, 33). In 2018, Korea had 191 universities and colleges (Ministry of Education 2018), however, no data was available on the exact number of universities that offer educational programs such as engineering, mathematics or science technology. In 2018 the total amount of departments in all Korean universities accounted for 11,529. Among them, engineering departments such as machinery and metal, electrical and electronic, computer and communication etc. accounted for 2055. In comparison, the number of departments for humanities amounted to 1617 and natural sciences to 1624 (“Educational Statistics. 2018. Universities” 2018). Thus, the demand for engineering related programs seems to be higher than that for other programs.

Similar to Taiwanese educational institutes, Korean universities (e.g. Dankook University and Pukyong National University) offer programs, such as display engineering, which focus on display technologies and are specifically aimed at creating professionals for the display industry (“Departments. Display Engineering” n.d.).

Intelligent Capital

Korea filed 34,019 patents from 2000 to 2018. The country registered 50 percent of all TFT-LCD patents during the time frame. The majority was registered by LG Electronics INC, with around 6200 patents. Samsung Electronics Co., Ltd. followed with 1920 patents (“Espacenet. TFT-LCD” n.d.). The figure below illustrates the number of TFT-LCD related patents filed between 2000 and 2018. Unlike Taiwan, where the number of registered TFT-LCD related patents decreased after 2009, Korean firms are still active in filing new patents every year.

Figure 13: Patents registered by Korea, 2000 to 2018 (Unit: number of patents)



Description: red line: count, black line: cumulative

Source: (“Espacenet. TFT-LCD” n.d.).

Conclusion

The analysis of factor conditions concerning Taiwanese and South Korean TFT-LCD manufacturers has yielded several results. Taiwanese TFT-LCD manufacturers enjoy several advantages, including low labor cost, a skilled workforce, strong capital resources and a favorable hard and educational infrastructure. Korea offers similar advantages, such as skilled labor, strong capital resources, a good hard and educational infrastructure as well as high investments in intelligent capital. However, both countries’ TFT-LCD industries struggle with a shrinking amount of labor force, even though the general labor pool is increasing. This is due to a declining demand of flat panel displays and the aggressive expansion of the Chinese TFT-LCD industry. In addition, the investment of TFT-LCD-related patents among Taiwanese manufacturers is much lower than compared to Korean companies. Korea on the other hand has much higher labor costs as monthly manufacturing wages are almost double of that in Taiwan.

4.3 Demand Conditions

4.3.1 Demand Conditions in Taiwan

After reviewing the factor conditions of the Taiwanese and Korean TFT-LCD industry, this section compares the demand conditions of the two markets. Demand conditions include the size of home demand, measured in total domestic sales, and the market growth rate of home demand. Since Taiwan and Korea manufacture panels for the global TFT-LCD market, international demand for their products is also integrated in this analysis. For this purpose, the total export sales of Taiwanese and Korean TFT-LCD manufacturers are calculated as well as their main global export countries are investigated. Lastly, the market segment structure of demand by TFT-LCD size is analyzed.

The domestic market size of Taiwan's TFT-LCD industry is evaluated by the total domestic sales of TFT-LCD companies in the fiscal year 2014 and 2017 (depicted in Table 10). These years were chosen as there was information on the number of active TFT-LCD manufacturers located in Taiwan. The 2014 flat panel display yearbook of Taiwan listed the companies AUO, Innolux, CPT, HannStar, E Ink and Wintek as manufacturers of TFT-LCDs (Industrial Technology Research Institute (ITRI) 2014, secs. 10–6). However, Wintek is not included in the calculation as most of their sales are based on touch panels (around 92 percent) and TFT-LCD sales were very low with only 8 percent (Wintek Corporation 2014, 23). In addition, the company discontinued to upload annual reports on their homepage after the year 2013.

The 2014 annual report from AUO listed 4.28 billion USD of total net revenue made from domestic sales of display panel (AU Optronics Corp. (AUO) 2015, 31). Innolux announced that it had 3.05 billion USD domestic sales of TFT-LCD panels (Innolux Corporation 2015, 81). The domestic sales of the remaining Taiwanese manufacturers CPT, HannStar and E Ink accounted for 79 million USD, 40 million USD and 54 million USD (Chunghwa Picture Tube 2015, 50; HannStar 2015, 57; E Ink Holdings Inc. 2015, 15). Thus, in total, the domestic sales of all five companies yielded 7.47 billion USD in 2014.

The flat panel display yearbook of 2016 provides six company names for TFT-LCD manufacturing, which are AUO, Innolux, CPT, HannStar, E Ink and Giantplus (Industrial Technology Research Institute (ITRI) 2016, secs. 10–6). The calculations include the domestic sales of 2017, as the companies were still the major producers of TFT-LCDs in that year. Compared to the total domestic sales of 2014, the sales of all six companies in 2017 had decreased to 7.29 billion USD (AU Optronics Corp. (AUO) 2019, 74; Innolux Corporation 2019, 79; Chunghwa Picture Tube 2018, 52; HannStar 2019, 59; E Ink Holdings Inc. 2019, 60; GiantPlus Technology 2019, 77).

Table 10: Domestic sales of Taiwanese TFT-LCD manufacturers, 2014 and 2017

Domestic sales			
Companies	2014	2017	Product
AUO	4.25 billion USD	3.27 billion USD	TFT-LCD
Innolux	3.05 billion USD	3.87 billion USD	TFT-LCD
CPT	79 million USD	39 million USD	TFT-LCD
HannStar	40 million USD	1.9 million USD	TFT-LCD
E Ink	54 million USD	66 million USD	TFT-LCD
Giantplus		45 million USD	LCD module/panel
total sales:	7.47 billion USD	7.29 billion USD	

Sources: Author's own compilation based on (AU Optronics Corp. (AUO) 2015, 31; 2019, 74; Innolux Corporation 2015, 81; 2019, 79; Chunghwa Picture Tube 2015, 50; 2018, 52; HannStar 2015, 57; 2019, 59; E Ink Holdings Inc. 2015, 15; 2019, 60; GiantPlus Technology 2019, 77).

As data in Table 10 indicates, Taiwanese TFT-LCD demand had shrunk and thus, market growth rate was negative. Between 2014 and 2017, the market growth rate of home demand in Taiwan decreased by 2.4 percent.

In contrast to the domestic sales of Taiwanese TFT-LCDs, the export sales of the same companies in 2014 was around three times higher at 22.6 billion USD (AU Optronics Corp. (AUO) 2015, 32; Innolux Corporation 2015, 81; Chunghwa Picture Tube 2015, 50; HannStar 2015, 57; E Ink Holdings Inc. 2015, 15). In 2017, export sales dropped to 16.6 billion USD, a decline of 26.54 percent, but were still high compared to domestic sales (AU Optronics Corp. (AUO) 2019, 74; Innolux Corporation 2019, 79; Chunghwa Picture Tube 2018, 52; HannStar 2019, 59; E Ink Holdings Inc. 2019, 60; GiantPlus Technology 2019, 77).

The TFT-LCD industry is arguably a global industry with high international demand. Compared to domestic demand, global demand is more important for Taiwanese TFT-LCD manufacturers. A similar conclusion can be drawn from the 2018 annual report of Innolux, one of the biggest TFT-LCD manufacturers in Taiwan. They state, that in 2018, around 27 percent of their sales were domestic. The majority of sales were foreign, accounting for almost 73 percent. Most of the products from Innolux were sent to Hong Kong and China (Innolux Corporation 2019, 73). Evidently, most of the demand for TFT-LCD panels is foreign while domestic demand is relatively small. Nonetheless, the foreign demand as well as domestic demand of TFT-LCD panels dropped significantly during that period. Compared to 2014, total domestic and export sales had decreased by 20.33 percent in 2017.

Table 11: Export sales of Taiwanese TFT-LCD manufacturers, 2014 and 2017

Export sales Taiwan			
Companies	2014	2017	Product
AUO	8.6 billion USD	7.1 billion USD	TFT-LCD
Innolux	11.2 billion USD	7.1 billion USD	TFT-LCD
CPT	1.7 billion USD	1.1 billion USD	TFT-LCD
HannStar	0.7 million USD	0.7 billion USD	TFT-LCD
E Ink	0.4 billion USD	0.4 billion USD	Monitors
Giantplus		0.2 billion USD	LCD module/panel
total sales:	22.6 billion USD	16.6 billion USD	

Sources: Author's own compilation based on (AU Optronics Corp. (AUO) 2015, 32; 2019, 74; Innolux Corporation 2015, 81; 2019, 79; Chunghwa Picture Tube 2015, 50; 2018, 52; HannStar 2015, 57; 2019, 59; E Ink Holdings Inc. 2015, 15; 2019, 60; GiantPlus Technology 2019, 77).

Although the domestic and foreign sales of Taiwanese manufacturer's was shrinking, the global TFT-LCD market has been growing. According to the market research company IMARC Group, from 2014 to 2019, the global TFT-LCD panel market increased at an compound annual growth rate of 5.7 percent ("TFT LCD Panel Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2020-2025" n.d.). The research organization IHS Markit estimated the TFT-LCD market size reached around 149 billion USD in 2018 and 156 billion USD in 2019 and expects further growth ("Global TFT-LCD Panel Market to Reach US\$ 208.6 Billion by 2024" n.d.; "Global TFT-LCD Market Report, Size, Price Trends and Forecast 2020-2025" n.d.).

The demand of Taiwanese TFT-LCD products comprises global IT, consumer electronics and industrial electronics manufacturers. Products are sold to a wide range of markets, including Asia, the United States, Europe and other emerging markets. In 2010, the biggest export markets for TFT-LCD panels from Taiwan was domestic Taiwan (41.8%), followed by China (including Hong Kong) (24.5%), Japan (13.5%), North America (10.4), and Europe (5.3%). Taiwan had the highest demand for its TFT-LCD panels as it produced more than 60 percent of notebook computers globally (Hung et al. 2012, 13).

By 2013, however, the main importer of Taiwanese TFT-LCD end-products was Mainland China (including Hong Kong) with 85.5 percent, followed by the US with 2.5 percent (Industrial Technology Research Institute (ITRI) 2014, secs. 6–11). China is an important place for manufacturers to assemble TFT-LCD products as the country is the base of original equip-

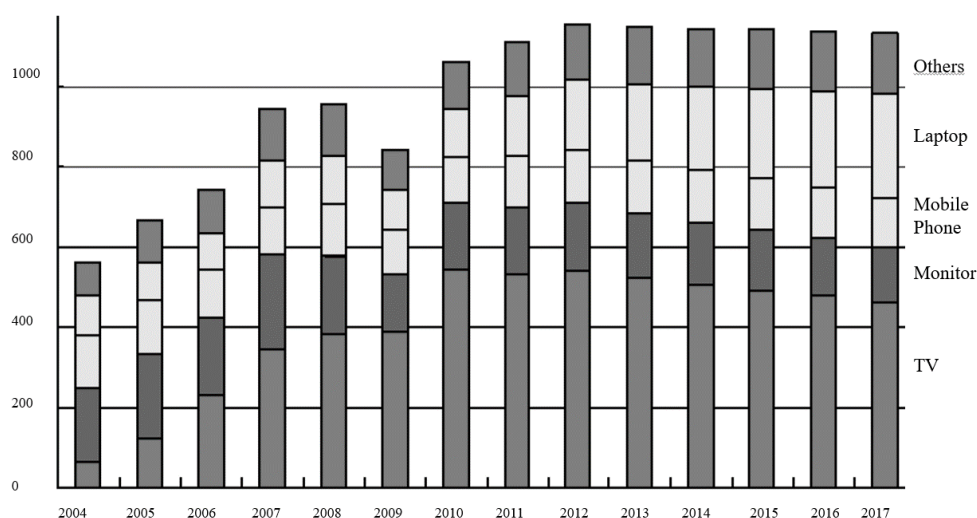
ment manufacturers (OEMs), original design manufacturers (ODMs) and electronics manufacturing service (EMS) factories. After the panel assembly in China, panels are directly delivered to downstream factories for final product channels and sold to other markets, thus Taiwan’s export sales to China are particularly high (Industrial Technology Research Institute (ITRI) 2014, secs. 6-15,16).

In 2015, China and Hong Kong captured an even higher share of Taiwanese TFT-LCD panel exports with 88.5 percent. Only a small part was exported to assembly plants in United States and Europe and other countries in Asia (Industrial Technology Research Institute (ITRI) 2016, secs. 6–11). Overall, a shift from domestic to foreign downstream application can be detected, where China plays an especially important role.

Lastly, the segment structure of demand for TFT-LCDs is analyzed in this section. While the amount of domestic and foreign sales of TFT-LCD manufacturers indicates the “quantity” side of home and foreign demand, the examination of market segment structure reveals the preferences and the sophistication of consumer needs and functions as an indicator for the “quality” side of TFT-LCD demand.

The market segment of TFT-LCD products is categorized into large- and small/medium-size panels (Innolux Corporation 2019, 187). Large-size TFT-LCDs are panels above 9 inches and are applied for TVs, digital signage, desktop monitors and notebook computers. Small and medium-size panels are used for tablets, portable video players, mobile phones, automotive displays, aircraft displays, watercraft displays and smart home-based LCDs (Innolux Corporation 2018, 5). The small and medium-size panels application area includes panel sizes as small as 1 inch to 9 inches (Industrial Technology Research Institute (ITRI) 2014, secs. 5–16).

Figure 14: The global market size trend of TFT-LCDs, 2004 to 2017 (in billion USD)



Source: (Ministry of Trade, Industry and Energy 2015, 4).

As depicted in the Figure 14 above, the current trend of large-size TFT-LCD panel production is mainly driven by the global demand of TVs, Laptops and Monitors. As for the small and medium-size product market, it is primarily pushed by the demand for smartphones and tablet PCs, which have evolved toward a high screen-to-body ratio, larger sizes, and higher resolution (AU Optronics Corp. (AUO) 2019, 68).

In Taiwan, the output value of large-size TFT-LCD panels accounted for 23.5 billion USD in 2012. In the following years the output value steadily decreased. In 2015 it reached the lowest point so far with 19.4 billion USD. (Industrial Technology Research Institute (ITRI) 2014, secs. 6-20,22; 2016, secs. 6–22; M. J. Liu et al. 2015, 6).

Within the large-size panel segment, Taiwanese manufacturers gradually moved towards high-end technologies. They focused on new sizes such as 39 inch and 50 inch panels as well as the high definition video format 4K 2K to attract demand (Industrial Technology Research Institute (ITRI) 2014, secs. 6–21). Even though the output value of large-size panel has experienced a continuous drop, Taiwan was still one of the top large-size TFT-LCD manufacturers in 2018, with a market share of 35.3 percent, right behind China with a share of 37.4 percent in large-size panel output (AUO, 2019, p. 66).

Similarly, Taiwan's small and medium-size panel industry has experienced a decline. From 2012, with an output value of 6.5 billion USD, demand decreased to 5.6 billion USD in 2015 (Industrial Technology Research Institute (ITRI) 2014, secs. 6-26,27; 2016, secs. 6-30,31; Component Research Department, IEK of ITRI 2012, 6).

In 2013, Taiwan's small and medium TFT-LCD market ranked second globally with a market share of 24.1 percent, followed by Korea with 19 percent. The highest market share was captured by Japan with 44 percent. Taiwanese manufacturers pursued a low-end strategy for panels applied in smartphones and tablet PCs. Japan and Korea on the other hand focus on high-end quality for products (Industrial Technology Research Institute (ITRI) 2014, secs. 2–9).

As depicted in the Table 12 below, Taiwan's TFT-LCD manufacturers main segment are large-size panels. Yet, the output value of small and medium is relatively high compared to Korea.

Table 12: The output value of Taiwan's TFT-LCD panels, 2012 to 2015

Segments	2012	2013	2014	2015
Large TFT-LCDs	23.5 billion USD	24.1 billion USD	23.6 billion USD	19.4 billion USD
Small/Medium TFT-LCDs	6.5 billion USD	7.5 billion USD	7.4 billion USD	5.6 billion USD
Total output value	30 billion USD	31.6 billion USD	31 billion USD	25 billion USD

Source: Author's own compilation based on (Industrial Technology Research Institute (ITRI) 2014, secs. 6-20,21,22,26,27; 2016, secs. 6-22,30,31; M. J. Liu et al. 2015, 6).

In general, a decrease in the total production of large and small to medium-size TFT-LCD panels can be detected. While Taiwanese manufacturers follow a high-end strategy in the large-size panel segment, manufacturers in the small to medium-size segment pursue a low-end strategy.

4.3.2 Demand Conditions in South Korea

Similar to Taiwan, the domestic demand for displays is relatively small as around 84 percent of all display products manufactured in Korea are exported. The percentage is even higher concerning LCDs, with 91 percent of Korean LCD panels being exported to foreign countries (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 9). According to LG Display, most of their panels (TFT-LCDs and OLED) are sold overseas. Their annual report states, that in 2017 around 93 percent of their display panels were sold abroad and merely 7 percent were traded domestically (LG Display Co., Ltd. 2019, 9). Samsung Display does not publish an annual report, hence data on domestic and export sales was not available. As depicted by Table 13 below, LG Display's domestic sales revenue from 2014 was 2.1 billion USD, while in 2017 it decreased to 1.6 billion USD (LG Display Co., Ltd. 2015, 11; 2019, 10). Due to the lack of data, the size and market growth rate of the Korean TFT-LCD market cannot be measured, however, it is evident that the growth rate of LG Display's sales decreased by 23.8 percent between 2014 and 2017.

Table 13: Domestic sales of Korean TFT-LCD manufacturers, 2014 and 2017

Domestic Sales in Korea			
Company	2014	2017	Product
LG Display	2.1 billion USD	1.6 billion USD	TFT-LCD, OLED
Samsung Display	N/A	N/A	N/A
total sales:	N/A	N/A	N/A

Source: Author's own compilation based on (LG Display Co., Ltd. 2015, 11; 2019, 10; Samsung Electronics Co., Ltd. 2019, 36).

Exact data on Korean manufacturer's TFT-LCD export sales was not available, however, KOTRA's 2017 investment report for displays provides data on the export of LCDs. As TFT-LCDs are the most dominant category within the LCD panels, the data is still relevant for this purpose. From 2006 to 2010, exports of Korean display panels were strong with an annual growth rate of 27.7 percent (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 10). In 2014, the export of Korean LCD display panels stood at 28 billion USD, however, by 2017 exports decreased to 18 billion USD and in 2018 exports reached a new low with 14.3 billion USD (Korea Trade-Investment Promotion Agency (KOTRA) 2017b, 20). Similar to Taiwan, the market growth rate of LCD exports from 2014 to 2017 was negative, with minus 35.7 percent. LCD panel exports are continuously declining due to the drop in LCD prices, which is caused by the increased production in China. In contrast to the slow-down of LCD panel export, OLED panel export are gaining momentum as global demand is expanding (Korea Trade-Investment Promotion Agency (KOTRA) 2017b, 19).

Table 14: Export of LCDs in Korea, 2014 to 2018

LCD Export of South Korea						
year	2014	2015	2016	2017	2018	Product
total exports:	28 billion USD	24.1 billion USD	18.2 billion USD	18 billion USD	14.3 billion USD	*LCD panels

Source: Korea International Trade Association (KITA) and Korea Display Industry Association (KDIA) cited in (Korea Trade-Investment Promotion Agency (KOTRA) 2020a, 20).

Although the total export of Korean LCDs decreased over time, the export sales for LG Display's panels increased between 2014 and 2017 (LG Display Co., Ltd. 2015, 11; 2019, 10). However, it needs to be added that this is also due to the strong demand of OLEDs (see Table 15 below). Data on Samsung Display's export sales was not available.

Table 15: Export sales of Korean TFT-LCD manufacturers, 2014 and 2017

Export Sales of Korea			
Company	2014	2017	Product
LG Display	19.9 billion USD	21.5 billion USD	TFT-LCD, OLED
Samsung Display	N/A	N/A	N/A
total sales:	N/A	N/A	N/A

Source: Author's own compilation based on (LG Display Co., Ltd. 2015, 11; 2019, 10; Samsung Electronics Co., Ltd. 2019, 36).

In 2018, the majority of Korean display panels (including LCDs and OLEDs) were exported to China (47 percent) and Vietnam (34 percent), since these countries house global TV and IT production plants and module plants of Korean companies. Mexico (5 percent) and Poland (2 percent) also received a small amount of Korean display panels (Korea Trade-Investment Promotion Agency (KOTRA) 2020a, 19).

Data on the output value of large-size and small and medium-size TFT-LCDs was not available for the Korean market. However, evidence from other resources indicate that Korea's strongest market segment is the large-size panel segment. According to Park (2020), Korean manufacturers are withdrawing from LCD production and are shifting towards advanced display technologies. This is highlighted by a drop in the production of small and medium-size TV panels of older generations and an increase of sales in TV panels of 60 inches and larger (R. Park 2020).

In 2015, Korea's share of capacity for large-size LCD panels was 38.5 percent. A year later it decreased to 34.1 percent. In the same period, Taiwan experienced a reduction of capacity share from 30.2 percent to 28.9 percent. The only growth in share was captured by China, who aggressively increased their large-size LCD panel production (Statista Research Department 2020).

Table 16: Share of capacity in area for large-size LCD panels, 2015 to 2016

Country	2015	2016
Japan	7.5%	6.9%
China	23.8%	30.1%
Taiwan	30.2%	28.9%
South Korea	38.5%	34.1%
total	100%	100%

Source: (Statista Research Department 2020).

According to the investment report from KOTRA (2017), Korea's market share of small and medium-size LCD grew from 2010 to 2012, but experienced a drastic plunge in 2013 (see Table 17 below). By 2015, the share of Korea's small and medium-size LCDs decreased to around 19 percent (Korea Trade-Investment Promotion Agency (KOTRA) 2017b, 14). Similarly, the Flat Panel Display Industry Yearbook from 2014 ranked Korea third globally in the small and medium TFT-LCD market segment, with a share of 19 percent. The biggest and second biggest market share was captured by Japan with 44 percent and Taiwan with 24 percent. According to the report, Korean manufacturers pursued a high-end quality strategy for products in this segment (Industrial Technology Research Institute (ITRI) 2014, secs. 2–9).

Table 17: Korea's market share of small and medium-size LCDs, 2010 to 2015

Country	2010	2011	2012	2013	2014	2015
Korea	21.6	26.4	34.9	18	18	19.6
Japan	39.3	36.7	32.4	37.8	36.5	40.6

Source: (Korea Trade-Investment Promotion Agency (KOTRA) 2017b, 14).

Conclusion

From the comparison of demand conditions in Taiwan and South Korea several conclusions can be drawn. Firstly, both nations have higher international demand than home demand. Due to the lack of data, the exact size of home demand and international demand cannot be compared. However, it can be observed that even though the global TFT-LCD market is growing, Taiwan's and Korea's market share has been decreasing over the past ten years, while China's share is steadily growing. Both nations' main export nation is China, where a lot of OEMs, ODMs and EMS are located. Concerning their segment structure, Taiwan as well as Korea have a higher capacity of large-size panels. In the medium and small-size panel segment, Taiwan has a higher share than their Korean counterparts. Yet, in this segment, Japan captured the largest share in the past decade. While Korean manufacturers pursue a high-end strategy in both segments, Taiwanese manufacturers follow a high-end strategy in the large-size segment, but a low-end strategy in the small to medium-size segment. Most Evidently, both nations are challenged by China's aggressive expansion plans in the TFT-LCD industry and try to adapt to the new situation.

4.4. Related and Supporting Industries

4.4.1 Related and Supporting Industries in Taiwan

This chapter examines related and supporting industries in the TFT-LCD market based on their market size, which is calculated by total sales, and the number of firms. The semiconductor industry is given as an example of a related industry since the TFT-LCD array fabrication overlaps with the semiconductor wafer manufacturing process (Chien, Hong, and Guo 2017, 556). In addition, the supporting industries are analyzed in this section, focusing on upstream suppliers of the TFT-LCD industry. The upstream industries involve different materials, parts and equipment for the production of TFT-LCDs, such as glass, backlight modules and liquid crystals (Korea Trade-Investment Promotion Agency (KOTRA) 2014, 4).

Taiwan's Semiconductor Industry

The semiconductor industry can be categorized into semiconductor types and industrial areas. Different semiconductor types include memory semiconductors, which store data, system semiconductors that have data processing functions, and optical and discrete devices, such as LEDs (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 1).

Industrial areas can be separated into Integrated Device Manufacturers (IDM), which design and manufacture semiconductors, fabless that focus on design, foundry that specializes in manufacturing circuits on consignment, and firms that assemble and test finished wafers. Korea houses some of the largest IDMs such as Samsung Electronics and SK Hynix, while the market leader in foundry, the Taiwan Semiconductor Manufacturing Company (TSMC), is located in Taiwan (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 1).

The semiconductor industry plays a significant role in the support of Taiwan's economic growth. It is a leading industry in Taiwan in terms of industry output, export ratio and investment amount. In 2018, the Taiwanese semiconductor industry chain was worth 86.8 billion USD, ranking third globally, behind the U.S. and South Korea ("Taiwan. Semiconductor Industry" 2019, 4). Taiwan's total sales of semiconductors in 2018 were estimated at 10.1 billion USD ("Taiwan. Semiconductor Industry" 2019, 10). Concerning the foundry sector in Taiwan, it was ranked first globally in 2017, with a value of 59.2 billion USD and a global market share of 72.2 percent ("Taiwan. Semiconductor Industry" 2019, 4).

The Taiwan Semiconductor Industry Association published a list on the export of ICs, a subset of semiconductors. Their report from 2018 states that the total export of ICs in 2017 reached 87.8 billion USD, of which more than half was exported to China and Hong Kong (Taiwan Semiconductor Industry Association (TSIA) 2018, 12,13).

The Semiconductor industry report from the Ministry of Economic Affairs in 2019 states that there were around 300 Taiwan-based semiconductor companies active, with 230,000 employees. The majority were located in the Hsinchu Science Park area, the Taoyuan region and in the Kaohsiung Science Park region (“Taiwan. Semiconductor Industry” 2019, 7).

Taiwan’s TSMC is the market leader in foundry, accounting for more than half of the global market share and ranked first in the world based on sales in 2017 and 2018 (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 7; “Taiwan. Semiconductor Industry” 2019, 4). Other major companies include MediaTek in the IC design field, Advanced Semiconductor Engineering, Inc. (ASE) in IC packaging and testing, and Nanya Technology Corporation in the field of memory (“Taiwan. Semiconductor Industry” 2019, 4).

Table 18: Global Top 10 semiconductor sales leaders, first half of 2018 and 2019 (in million USD)

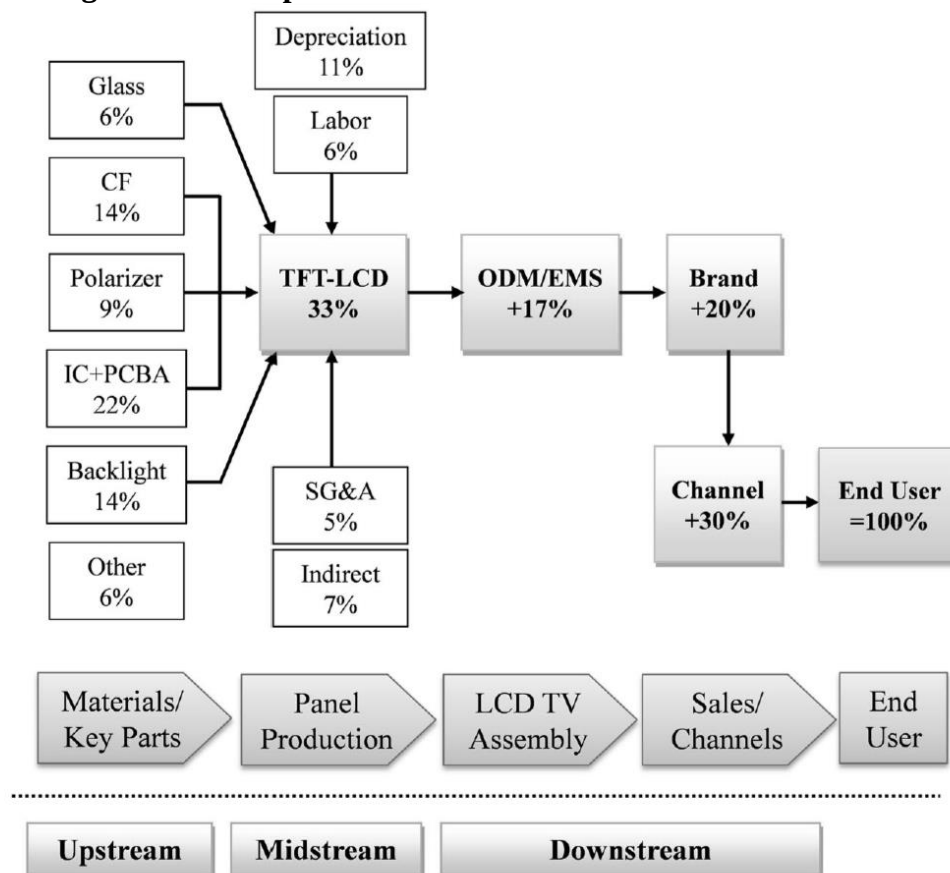
1H19 Rank	1H18 Rank	Company	Headquarters	1H18 total Semiconductor sales	1H19 total Semiconductor sales
1	2	Intel	U.S.	32,585	32,038
2	1	Samsung	South Korea	39,785	26,671
3	4	TSMC *	Taiwan	16,312	14,845
4	3	SK Hynix	South Korea	17,754	11,558
5	5	Micron	U.S.	15,478	10,175
6	6	Broadcom Inc.**	U.S.	9,020	8,346
7	7	Qualcomm**	U.S.	7,984	7,289
8	9	TI	U.S.	7,346	6,884
9	8	Toshiba/Toshiba Memory	Japan	7,717	5,643
10	10	Nvidia**	U.S.	6,259	4,674
*foundry **fabless					

Source: (“Top-15 Semiconductor Suppliers’ Sales Fall by 18% in 1H19” 2019).

Upstream TFT-LCD Industries in Taiwan

The display industry involves a variety of materials, parts and equipment. Industrial materials such as liquid crystal polymer, inorganic pigment, glass tube, resin etc. are needed to produce TFT-LCDs. These are then inserted into parts such as glass plate, liquid crystal and color filters, which are applied to TFT-LCD modules (Korea Trade-Investment Promotion Agency (KOTRA) 2014, 4). According to Hsiao, the proportion of material costs accounts for around 50 percent of the total production cost of TFT-LCDs (Hsiao et al. 2011, 122). Zhang (2008) estimates, that the cost for raw materials can even amount to 60 to 70 percent of the TFT-LCD production costs, depending on the size, generation and yield rate. Key components, such as glass substrate, polarizer, color filter, backlight unit and driver IC are the costliest and need to be designed to match with the specific needs of TFT-LCD panels. Thus the production of key components is a vital aspect to achieve competitiveness in the industry (Zhang et al. 2008, 14). Additionally, the cyclical and fluctuant trajectory of the TFT-LCD industry can cause unstable component supply, which also affects the production of panels (Zhang et al. 2008, 15).

Figure 15: Example of a cost structure for a 32-inch LCD TV



Source: (C. Lee, Chang, and Wang 2020, 11).

The data on total sales of upstream suppliers was not available as it involves a multitude of different businesses. However, Invest Korea evaluated the market size of the upstream display market in their 2014 report and ranked Taiwan second to Korea with a market size of 33 billion USD and a market share of 37 percent (see Table 19) (Korea Trade-Investment Promotion Agency (KOTRA) 2014, 5).

In case of Taiwan, much of the equipment for the array process is imported from the U.S., Europe and Japan. Advanced material technology and primary materials are also developed abroad in Japan (Hsiao et al. 2011, 122; C. Lee, Chang, and Wang 2020, 10). However, Taiwan produces other key upstream components, such as tools for power systems and testing as well as key parts such as driver IC and backlight module. Other components, including substrate and polarizer are also produced by Taiwanese companies themselves (C. Lee, Chang, and Wang 2020, 10). Over the years, AUO, Innolux and other Taiwanese panel manufacturers followed an aggressive vertical integration strategy in order to overcome competitors' preemption on key components and to reduce costs (Zhang et al. 2008, 19).

Table 19: Comparison of upstream display markets, by country, 2014

Classification	Korea	Taiwan	Japan	China
Market size (USD million)	36,217	33,053	17,210	2,411
Market share	41%	37%	19%	3%

Source: (Korea Trade-Investment Promotion Agency (KOTRA) 2014, 5).

The upstream manufacturing of components involves a multitude of firms since many different parts are required. No data was found that listed how many of the upstream suppliers are Taiwan-owned, but according to the 2016 Flat Panel Display Industry Yearbook, more than 40 different suppliers existed in Taiwan in 2016 that produced materials for the production of TFT-LCD panels. Taiwan's upstream industry had a relatively low localization rate since the country imported core parts and components from Japan and depended heavily on Japanese manufacturing equipment (Han, Oh, and Yoo 2012, 26). However, a trend towards a more localized upstream display industry can be detected (2016 Flat Panel Display Industry Yearbook, 2016, secs. 6–3,4).

Additionally, Taiwan maintained a competitive edge in the downstream application channels. Taiwan was one of the largest bases for outsourced production of information technology products, including computers and monitors. The country was an important global exporter of

notebook computers, which drove the demand for domestically produced LCD panels, as they make up for almost 30 percent of the total cost of notebook computers (Hsiao et al. 2011, 121). However, in the past few years most of the panels were exported to China for downstream application (Industrial Technology Research Institute (ITRI) 2014, secs. 6–11).

4.4.2 Related and Supporting Industries in Korea

Korea's Semiconductor Industry

In 2013, the total sales of Korea's semiconductors accounted for 50.5 billion USD. Since 2017, the sales performance of Korean semiconductors increased drastically to 92.2 billion USD, especially due to the increase of sales of memory semiconductors. In 2018, it increased to 114.7 billion USD, with the highest percentage in memory semiconductors accounting for 88.6 percent (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 2). Based on sales in the same year, Korean companies gained 63.7 percent of the global memory market, especially concerning the DRAM (72.4 percent) and NAND market (49.5 percent) (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 4).

While Korea is very competitive in the field of memory semiconductors, the share of Korean companies in the system semiconductor field is relatively small with only 3 percent (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 2).

Table 20: Sales performance of Korean semiconductors, 2013 to 2018

(Unit: USD million)

Classification	2013	2014	2015	2016	2017	2018
Memory semiconductor	34,297	43,815	46,634	47,059	80,048	101,618
(Ratio)	67.8	76.1	79.1	80.4	86.8	88.6
System semiconductor	10,651	8,035	7,459	6,394	6,840	7,544
(Ratio)	21.1	14.0	12.7	10.9	7.4	6.6
Optical and discrete devices	5,603	5,718	4,835	5,073	5,353	5,496
(Ratio)	11.1	9.9	8.2	8.7	5.8	4.8
Total	50,551	57,568	58,928	58,526	92,241	114,658

Source: IHS Markit 2019 as cited in (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 2).

The Korean semiconductor industry is highly competitive in terms of proactive investment and advanced process technology (Korea Trade-Investment Promotion Agency (KOTRA)

2020b, 2). Semiconductors were the leading export item of Korea gaining 97.9 billion USD in 2017, experiencing an increase of around 57 percent compared to the previous year. Memory semiconductors recorded 67.1 billion USD in exports, followed by system semiconductors worth 25.3 billion USD and optical and discrete devices with 5.4 billion USD (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 3).

Table 21: The export trend of Korean Semiconductors, 2013 to 2018

(Unit: USD million)

Classification	2013	2014	2015	2016	2017	2018
Semiconductor	57,144	62,647	62,916	62,228	97,937	126,712
(Rate of increase/decrease)	13.3	9.6	0.4	△1.1	57.3	29.4
Memory semiconductor	25,507	33,984	33,785	35,223	67,167	94,078
(Rate of increase/decrease)	32.2	39.1	-0.6	4.3	90.7	40.1
System semiconductor	24,973	22,518	23,133	20,471	25,366	26,480
(Rate of increase/decrease)	1.7	△9.8	2.7	-11.5	23.9	4.4
Optical discrete devices	6,664	6,144	5,998	6,536	5,407	6,154
(Rate of increase/decrease)	△1.1	△7.8	△2.4	9.0	△17.3	13.8

Source: Korea Semiconductor Industry Association (KSIA) as cited in (Korea Trade-Investment Promotion Agency (KOTRA) 2020a, 3).

As of 2018, the Korean semiconductor industry comprised a workforce of 165,000 employees and 3700 semiconductor-companies. The employee rate has a yearly growth of about 6.5 percent (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 3). The industry leaders in Korea are companies such as Samsung Electronics and SK Hynix, which offer the most advanced technologies for DRAM and NAND (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 4). These companies also held the second and third largest market share in 2015 (Samsung Electronics with 11.6 percent and SK Hynix with 4.8 percent) (“Korea’s Leading Industries. Semiconductors,” n.d., 2).

In addition, Korea maintains a competitive edge in other related industries, including TVs and smartphones, which generate most of the current demand for displays. Moreover, the automobile industry is also expected to increase its demand for displays in the future (Korea Trade-Investment Promotion Agency (KOTRA) 2017b, 2).

Upstream TFT-LCD Industries in Korea

According to the Display report from Invest Korea (2014), Korea's 2014 upstream display market size was measured at 36.2 billion USD, with a market share of 41 percent, closely followed by Taiwan (37 percent), Japan (19 percent) and China (3 percent) (see Table 19 in Taiwan upstream industries) (Korea Trade-Investment Promotion Agency (KOTRA) 2014, 5). Data on the number of Korean-owned upstream suppliers for TFT-LCDs was not available, however, the Invest Korea Report from 2014 registered around 70 upstream display suppliers located in Korea, that produce core electronic parts and materials for TFT-LCD manufacturing (Korea Trade-Investment Promotion Agency (KOTRA) 2014, 6–11).

LG Display receives key raw materials for their production of TFT-LCDs from several Korean suppliers, including HeeSung Electronics, LG Chem, Korea SMT, and Paju Electric Glass, but also from Japanese suppliers such as Asahi Electric Glass (LG Display Co., Ltd. 2019, 11). Korea's technology for color film, driver IC, backlight unit and cold cathode fluorescent lamp is advanced, nevertheless, the technology for other parts such as glass substrate, polarizer or liquid crystal is still lacking (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 14). Over the years, the localization rate has improved, however, key materials such as liquid crystal and glass as well as core equipment are still imported from Japan, the U.S. and Germany (Korea Trade-Investment Promotion Agency (KOTRA) 2020a, 21). According to the Report of Invest Korea, components such as glass, target, wet chemical, organic chemical, gas and backlight unit plastic have a high rate of local production (70 to 100 percent), with many suppliers having secured production bases in Korea (Korea Trade-Investment Promotion Agency (KOTRA) 2014, 6–11). Accordingly, the upstream supplying industries for TFT-LCD panels have become more localized and increase the competitiveness of the Korean TFT-LCD industry.

Conclusion

Several conclusions can be drawn from the comparison of Taiwan's and Korea's related and supporting industries. Taiwan and Korea are amongst the most competitive players in the semiconductor industry concerning market share and size. Taiwanese semiconductor manufacturers primarily focus on foundry and companies such as TSMC lead the market in this segment. Korea has the highest market share in the semiconductor industry and specializes on memory semiconductors. Samsung Electronics and Hynix, both market leaders, are located in Korea. The nation also houses a much higher number of semiconductor companies and employed a larger number of employees compared to Taiwan.

Concerning the upstream supplying industry, Korea and Taiwan are the biggest and second biggest market for the upstream parts and materials industry. The countries are still dependent on foreign technology and material imports but show an increasingly strong vertical integration of the TFT-LCD supply chain, which also facilitates and improves production of TFT-LCDs.

4.5 Firm Strategy, Structure and Rivalry

4.5.1 Firm Strategy, Structure and Rivalry in Taiwan

This chapter examines firm strategy, structure and rivalry of Taiwan and South Korea's TFT-LCD industry. Porter describes firm strategy, structure and rivalry as conditions on how companies are created, organized, managed and the nature of domestic rivalry (M. E. Porter 1990b, 71). Firm strategy and structure include the company structure, more precisely the ownership structure, and strategies of the largest TFT-LCD companies in the home market. Strategies are analyzed based on Porter's three types of strategies: cost leadership, differentiation and focus (M. Porter 1980, 35). Rivalry focuses on the number of TFT-LCD manufacturers in the home market and the intensity of domestic rivalry, which is analyzed by the size and market share of competitors, and the TFT-LCD industry growth.

Company Structure of Major TFT-LCD Manufacturers in Taiwan

Firstly, this section will examine what type of ownership structure is typical for TFT-LCD manufacturing firms in Taiwan and Korea. For the purpose of this study, this section distinguishes between public, private and state-owned businesses. The thesis follows Porter's definition: public businesses are companies whose shares are owned by private individuals, other companies and are traded on public stock markets. Private companies are in the hands of a few individuals and state-owned enterprises are owned by the government (M. E. Porter 1990b, 787).

Taiwan's industries are characterized by small and medium enterprises (SMEs), which are companies that employ less than 250 workers ("OECD Glossary of Statistical Terms - Small and Medium-Sized Enterprises" 2005). However, concerning Taiwan's TFT-LCD industry, most manufacturers employ significantly more employees. Taiwan's high-tech industries are not bound by strong personal ties, rather, they are characterized by network governance mechanisms that are based on formal institutions such as technological standards. The industry is open to collaborative relationships between firms, which are based on a formal network of trust (Tabata 2014, 196–97).

Taiwan's currently largest TFT-LCD manufacturers, AUO, Innolux, E Ink Holding, Giantplus and HannStar, are all listed on the Taiwan Stock Exchange or the Taipei Exchange and are thus considered public companies ("Taiwan Stock Exchange Corporation" n.d.). The annual reports from AUO, Innolux, E Ink and Giantplus show similar structures of ownership. Most shares are in domestic and foreign private hands, while only a small percentage (around one percent or less) is held by governmental agencies (AU Optronics Corp. (AUO) 2019, 61; E Ink Holdings Inc. 2019, 44; GiantPlus Technology 2019, 58; Innolux Corporation 2019, 60).

Table 22: Major shareholders of Taiwanese TFT-LCD manufacturers, 2018

Company	1. Shareholder	2. Shareholder	3. Shareholder	4. Shareholder
AUO	Qisda Corporation 6.9%	ADR of AU Optronics Corp. 4.63%	Quanta Computer Inc. 4.61%	Fubon Life Insurance Co. 3.82%
Innolux	Chimei Corporation 5.74%	Terry Gou 1.96%	Hyield Capital Co. 1.77%	Hon Hai Precision Ind. Co. 1.49%
E Ink	YFY Venture Capital Investment Co. 11.7%	S.C. Ho 7.05%	Cathay Life Insurance Co. 5.99%	Shin-Yi Enterprise Co. 2.88%
Giantplus	Toppan Printing Co. 34.65%	Yuanta Commercial Bank 18.46%	Citibank Taiwan 2.17%	
HannStar	Jinxin Investment (share) company Division 9.67%	Huaxin Lihua (share) company Division 7.57%	Winbond Electronics Co., Ltd. Division 3.51%	Cathay United Bank 2.04%

Source: Author's own compilation based on (AU Optronics Corp. (AUO) 2019, 61; Innolux Corporation 2019, 55; E Ink Holdings Inc. 2019, 41; HannStar 2019, 37).

Strategies of major TFT-LCD manufacturers in Taiwan

The second determinant is strategies. This section follows Porter's three strategies for competitive advantage: cost leadership, differentiation and focus (M. Porter 1980, 35), which are discussed in chapter 3.3.

In the beginning stages, Taiwanese companies focused on low-cost TFT-LCD panel production, however, in recent years, with China's determined expansion plans in the TFT-LCD industry, Taiwanese manufacturers changed their strategies. TFT-LCD manufactures such as AUO attempt to gain leverage over China's production capacity by focusing on technology, management, operations and clientele (AU Optronics Corp. (AUO) 2019, 73). Moreover, manufacturers shifted to high-end and niche products, such as 4K TV, AMOLED and LTPS (C. Lee, Chang, and Wang 2020, 9).

AUO produces differentiated products in a TFT-LCD mature market and avoids head-to-head competition in new generations (Zhang et al. 2008, 12). The company is focusing on niche markets with a high growth rate, such as the commercial market, the automotive panel market or wearable devices. In addition, the company is trying to gain competitive edge through advanced technologies and differentiated product design. In recent years, AUO launched various UHD 4K and 8K TV products with high resolution, curved design and faster transmission, concentrating on high-end specifications (AU Optronics Corp. (AUO) 2019, 73).

Innolux attempts to secure competitive advantage in the international TFT-LCD market by focusing on competitive costs, high quality, fast market response, differentiated products and favorable cooperation with suppliers. They create products for niche markets and invest into R&D production application in new domains to enhance profitability (Innolux Corporation 2018, 33).

Giantplus pursues a niche-market strategy to avoid a saturated market and explores other market applications such as industrial control and vehicle use. The company endeavors to increase benefits from 3rd and 4th generation production lines, while also committing to its differentiation strategy (GiantPlus Technology 2019, 72,74).

The majority of Taiwanese TFT-LCD manufacturers pursue a focus and differentiation strategy. This comes as no surprise as China has entered the TFT-LCD market and has begun mass production of TFT-LCD panels gaining leverage through their low-cost production and cheap labor.

Rivalry in Taiwan

According to the Flat Panel Display Report of 2014 and 2016, there were eight TFT-LCD manufacturers resident in Taiwan: AUO, Innolux, CPT, HannStar, Wintek, E Ink, Giantplus and Star World Technology (Industrial Technology Research Institute (ITRI) 2014, secs. 6–4; 2016, secs. 6–4). Amongst them, AUO and Innolux were the biggest manufacturers of TFT-LCDs in terms of size and market share. AUO gained 11.5 billion USD in 2017 and employed a workforce of around 57,000 people. In the same year, AUO’s biggest competitor, Innolux, had around 60,000 employees and a sales revenue of 11.1 billion USD. The other manufacturers CPT, HannStar, E Ink and Giantplus are smaller in size.

Table 23: Size of Taiwanese TFT-LCD manufacturers in 2017

Company	Total sales revenue	Total number of employees
AUO	11.5 billion USD	57,205
Innolux	11.1 billion USD	60,339
CPT	979 million USD	4,680
HannStar	804 million USD	2,823
E Ink	514 million USD	2,653
Giantplus	422 million USD	5,091
Star World Technology	N/A	N/A

Source: Author’s own compilation based on (AU Optronics Corp. (AUO) 2019, 75, 115; Innolux Corporation 2019, 80, 126; Chunghwa Picture Tube 2018, 52, 86; GiantPlus Technology 2019, 77, 151; HannStar 2019, 59, 92; E Ink Holdings Inc. 2019, 60, 95).

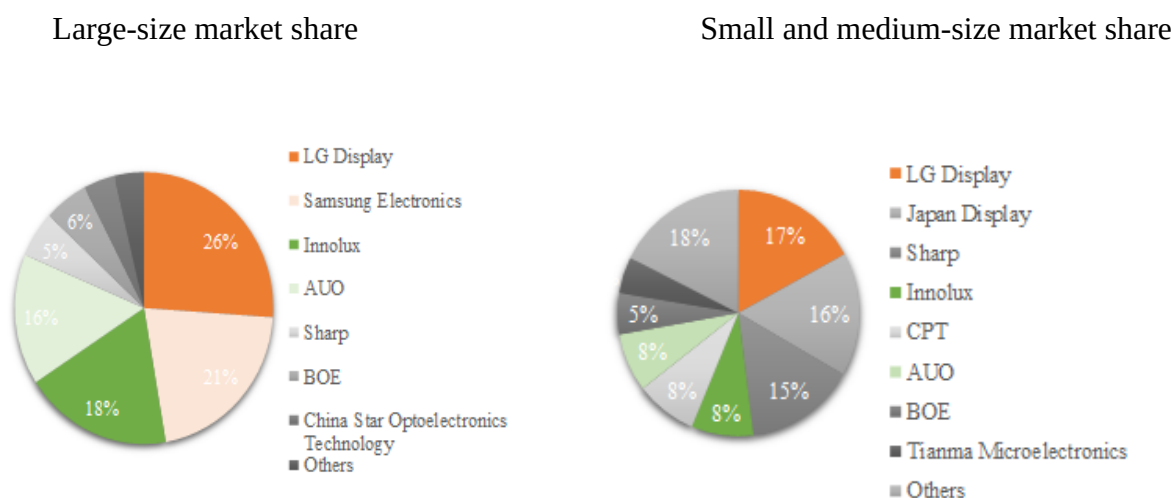
This thesis decided to investigate the rivalry on a global scale, by analyzing the global market share of TFT-LCD manufacturers and the growth of the global display market, rather than focusing on domestic rivalry. Although Porter (1990, 117) states that domestic rivalry is superior to rivalry with foreign competitors, Moon et al. (1998, 144) suggest that this is only the case for large economies. Small economies are more concerned about international rivalry than domestic rivalry (Moon, Rugman, and Verbeke 1998, 144). Thus, this section integrates the global market share of TFT-LCD manufacturers as well as the global TFT-LCD industry growth.

In 2014, Innolux captured 18.5 percent of the global market share for large-size LCD panels. AUO followed closely with 15.6 percent of market share. Nonetheless, in the same year, the

global large-size LCD market was dominated by LG Display and Samsung Electronics which together retained 47.3 percent of the global market share (Yamashita 2015).

In the small and medium-size LCD panel field, Innolux captured 8.3 percent in 2014, followed by CPT with 8.2 percent and AUO with 7.7 percent. The strongest manufacturer of small and medium-size LCD panels was LG Display (Hosokawa 2015). Data on the smaller TFT-LCD manufacturers in Taiwan was not available.

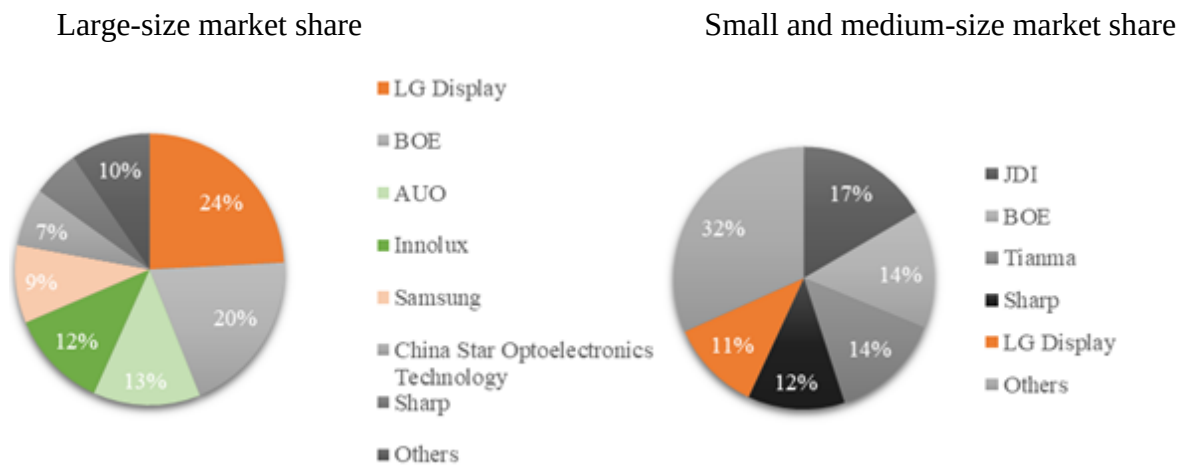
Figure 16: Global market share for LCD panels in 2014



Source: (Yamashita 2015; Hosokawa 2015).

In 2019, the global market share for large-size LCD panels of Innolux had diminished to 11.8 percent. Similarly, AUO's market share dropped to 12.9 percent. The strongest manufacturer remained LG Display (Hosokawa 2020). In the small and medium-size LCD panel segment, Innolux and AUO's share decreased to 8 percent by 2019 while Chinese and Japanese manufacturers captured most shares (Hosokawa 2020).

Figure 17: Global market share for LCD panels in 2019



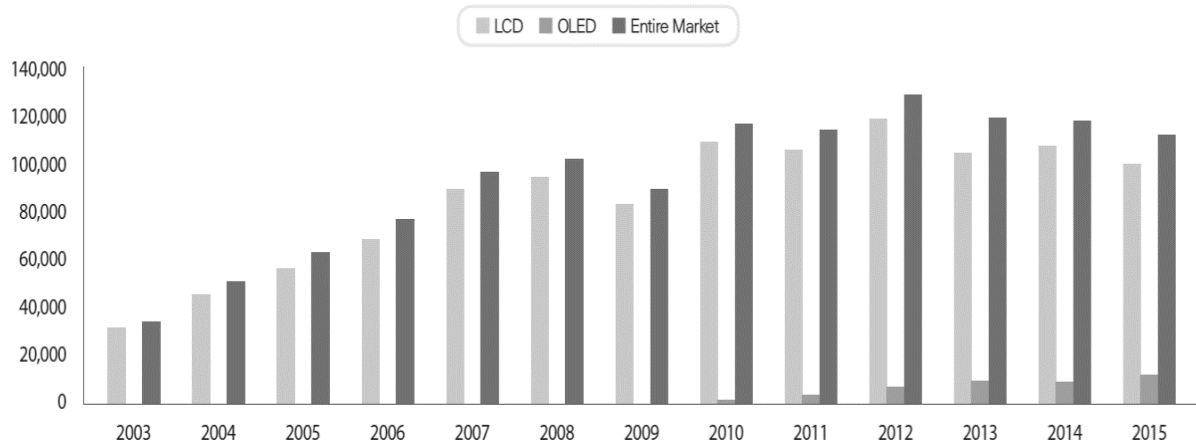
Source: (Hosokawa 2020).

According to the annual reports from AUO, Innolux, CPT, HannStar, E Ink and Giantplus, the majority of Taiwanese TFT-LCD panels were exported in 2017 and 2018 (AU Optronics Corp. (AUO) 2019, 74; Chunghwa Picture Tube 2018, 52; E Ink Holdings Inc. 2019, 60; GiantPlus Technology 2019, 77; HannStar 2019, 59; Innolux Corporation 2019, 79). AUO, for example, lists approximately 185,000 export shipments and 96,000 domestic shipments in 2018 (AU Optronics Corp. (AUO) 2019, 74). Innolux reports that 27 percent of its sales are domestic, while 73 percent are foreign sales (Innolux Corporation 2019, 73). Consequently, more than half of Taiwan's manufactured TFT-LCDs are exported, which indicates that the domestic display market is much smaller than foreign markets. Hence, rather than analyzing the growth of domestic market, the growth of the global display market is reviewed in order to analyze rivalry.

According to Invest Korea (2017), the global display market developed rapidly until 2012. Between 2003 and 2012, the average annual growth rate was 15.8 percent. However, as a consequence of the economic downturn, the average annual growth rate decreased to 4.5 percent after 2012. Electronic products such as TVs, laptop computers and monitors are sensitive to economic conditions and sales can drop during an economic recession, which also affects the TFT-LCD market (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 8). From 2014 to 2019, the global TFT-LCD panel market made more progress with an compound annual growth of 5.7 percent ("TFT LCD Panel Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2020-2025" n.d.). Generally, the initial growth of the TFT-

LCD market has slowed down after the economic crisis and market growth has been sluggish ever since.

Figure 18: Global display market trend from 2003 to 2015 (in million USD)



Source: (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 8).

As Porter states, the intensity of rivalry is high when competitors are numerous and roughly in size and power, when industry growth is slow and exit barriers are high (M. Porter 2008, 32). Taiwan has eight TFT-LCD manufacturers of which AUO and Innolux are the biggest producers with a similar size and market share. The remaining TFT-LCD manufacturers are smaller in size as well as in market share. The growth of the TFT-LCD industry has been slow ever since 2012 and in future only little growth is expected as demand is saturated. In addition, the industry is known for its existence of high entry and exit barriers as companies can expect high sunk costs if they are to exit from the industry (W. C. Lee and Wang 2017, 274; Hsiao et al. 2011, 119). Generally, the TFT-LCD industry is often identified as uncertain and fiercely competitive. Thus, Taiwanese manufacturers are experiencing a relatively high degree of rivalry, since there are a handful of firms of similar size, competing for shares in a stagnating market and are faced with high exit barriers. This competitive environment increases the ability of Taiwanese manufacturers to meet challenges and changes emanating from other nations.

4.5.2 Firm Strategy, Structure and Rivalry in Korea

Company structure of major TFT-LCD manufacturers in Korea

Traditionally, Korea's electronics industry has been dominated by big business groups or chaebols (Yun et al. 2010, 221). Chaebols are family-owned business conglomerates. They

usually have close ties with the government and involve a large number of subsidiaries located across different industries. Chaebols are often controlled by a powerful chairman and have a complex system of cross-unit equity investment (Jung 2004, 299–300). This is also the case for the TFT-LCD industry. In Korea, the chaebols – LG Display and Samsung Display – dominate TFT-LCD panel manufacturing. Due to their dominance, the Korean TFT-LCD industry is fairly concentrated.

LG Display is part of the LG Group, which comprises other companies, such as LG Electronics, LG Innotek or LG Chem. It is a public company, listed on the Korea Exchange (KRX). In 2018, LG Display’s largest shareholder was LG Electronics with around 39 percent, followed by the National Pension Service, a governmental entity, with around 7 percent (“Listed Company” 2020). The Korean government does not operate state-owned TFT-LCD enterprises but has state-owned entities such as the National Pension Service, which function as shareholders of other companies. This is also the case for LG Display.

In contrast to LG Display, Samsung Display is a privately-owned company. It is one of the 62 domestic affiliates of the Samsung Group and a subsidiary of Samsung Electronics Co., Ltd. In 2018, 84.8 percent of Samsung Display’s common shares were owned by Samsung Electronics and 15.2 percent by another affiliate company of the Samsung Group. The company was not listed (Samsung Electronics Co., Ltd. 2019, 6, 85). LG Display and Samsung Display both depict the typical method of chaebols that involves cross holdings through affiliated enterprises or subsidiaries as can be seen in the Table 24 below.

Table 24: LG Display’s and Samsung Display’s Shareholders with more than 5 percent of shares, 2018

Company	Shareholder 1	Shareholder 2
LG Display	LG Electronics 37.9%	National Pension Service 7.2%
Samsung Display	Samsung Electronics 84.8%	Samsung SDI 15.2%

Source: Author’s own compilation based on (LG Display Co., Ltd. 2019, 44; Samsung Electronics Co., Ltd. 2019, 85; “Public Disclosures” n.d.).

Strategies of major TFT-LCD manufacturers in Korea

In the early stages beginning from 1999, Korean companies LG Display and Samsung Display used a low price strategy coupled with mass production capacity and government support

to gain dominance in the TFT-LCD market (Tseng and Chiu 2006, 2–3). However, in recent years and especially with China’s entrance in the market, their strategy has transformed.

Korea’s LG Display states that their competitiveness lies in the ability to differentiate through the development of new and premium products and technological advances. Furthermore, LG Display recruits experienced key personnel and skilled operators. It opted for product differentiation via IPS technology, which includes ultra-large and high definition UHD television panels, large-size/borderless monitors, high-resolution/oxide notebooks and automotive and commercial products with in-TOUCH technology (LG Display Co., Ltd. 2019, 10). Additionally, the company has also set foot in the OLED segment.

Samsung Display also focused more on OLED technologies in the past few years. The company minimized its TFT-LCD production and focused on the integration of OLED panels for their products (Asakawa 2019, 151–52). The OLED market is still mainly dominated by Korean manufacturers and rivalry is less intense than in the LCD market (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 21).

In general, there is a trend amongst Korean companies to move away from LCD to OLED production as competitors like China are taking over the LCD mass production (Korea Trade-Investment Promotion Agency (KOTRA) 2020a, 22).

Evidently, both companies follow a differentiation strategy. LG Display is moving towards premium LCD products and advanced technologies, while Samsung Display is said to cease LCD panel production to focus on OLED technologies (Baker 2020).

Rivalry in Korea

There is no specific data on the exact number of TFT-LCD manufacturers in Korea. However, the KOTRA’s investment report from 2020 counts as many as 914 businesses that are active in the field of display manufacturing, manufacturing machine and glass, with numbers growing (Korea Trade-Investment Promotion Agency (KOTRA) 2020a, 20). Nonetheless, the Korean display market is consolidated as it is dominated by two tech giants, Samsung Electronics and LG Display.

Samsung Display’s revenue is depicted in Samsung Electronics’ Display Segment, which includes the display technologies of OLED and LCD. In 2017, Samsung’s Display segment gained a sales revenue of 28.5 billion USD, higher than that of LG Display, which acquired a sales revenue of 21.3 billion USD.

Table 25: Size of Korean TFT-LCD manufacturers in 2017

Company	Sales revenue	Number of employees
Samsung Electronics' Display Segment	28.5 billion USD*	N/A
LG Display	21.3 billion USD*	33,335
*revenue from LCD and OLED products		

Source: Author's own compilation based on (LG Display Co., Ltd. 2019, 13; 2018, 43; Samsung Electronics Co., Ltd. 2018, 2).

LG Display had the biggest market share of large-size LCD panels in 2014 with 26.1 percent, closely followed by Samsung Electronics with a market share of 21.2 percent. Together, the two Korean companies captured almost 50 percent of the global market share (see Figure 16) (Yamashita 2015). In the small and medium-size LCD panel segment, LG Display was the second biggest manufacturer in 2014, with 17.1 percent, right behind Japan Display. Samsung Electronics on the other hand played no significant part in the small and medium-size panel segment (see figure 16) (Hosokawa 2015).

In 2019, LG Display was still the number one manufacturer of large-size LCDs with 24.2 percent. However, Samsung Electronics' share decreased significantly to 9.3 percent while China's BOE captured almost 20 percent. Moreover, LG Display lost some of its shares in the small and medium-size LCD segment in 2019, as it held only 11.9 percent. The small and medium-size segment was mainly dominated by Chinese and Japanese LCD panel manufacturers (see figure 17) (Hosokawa 2020).

Similar to Taiwan, the scale of Korea's domestic display market is relatively small, as most of their manufactured products are exported. It was estimated that in 2016, around 91 percent of all LCD products made in Korea were exported (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 9). Thus, Korea faces a comparable situation to Taiwan, as it needs to deal with a saturated market, a slow market growth and oversupply caused by the expansion of production in China (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 8–9).

Rivalry in Korea is high, as the two dominating companies, LG Display and Samsung Display, have a similar size and market share in the TFT-LCD industry. The competition between the two companies has led to higher investments in new product development, savings in energy and the development of new technologies (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 9). Both companies focus on higher quality and niche products, such as OLED,

which makes competition even more fierce. In addition, rivalry has increased due to high exit barriers and a stagnating market growth.

Conclusion

This section analyzed the structure, strategies and rivalry of firms in the Taiwanese and Korean TFT-LCD market. Several conclusions can be drawn from the analysis. In Taiwan, most TFT-LCD manufacturers are publicly listed and are in the hands of domestic and foreign investors. There is little involvement of the state concerning the ownership structure of these companies. The majority of companies are similar in size and market share and follow a differentiation and niche-strategy. Korea's TFT-LCD industry is dominated by the large chaebols LG Display and Samsung Display. LG Display is a publicly held subsidiary of the LG Group, while Samsung Display is privately owned by two shareholders belonging to Samsung Electronics. In the case of LG Display, the state owns a higher percentage of share through the national pension service. The Korean manufacturers also pursue a differentiation strategy, similar to Taiwanese firms. In Taiwan as well as in Korea, the degree of rivalry is relatively high as both countries are faced with a stagnating market growth, high exit barriers and companies of similar size and market share.

4.6 Government Policies and Multinational Activity

4.6.1 Government Policies and Multinational Activity in Taiwan

This chapter analyzes government policies concerning the TFT-LCD industry, such as subsidies, incentives, regulations, standards, or taxes amongst others. For the purpose of multinational activity, government policies towards FDI in the domestic TFT-LCD industry and inbound and outbound FDI in the TFT-LCD industry are inspected. In order to do this, the study follows Moon et al.'s method, which looks at foreign multinational firms in the home nation (inbound FDI) and domestically owned firms in foreign countries (outbound FDI) (Moon, Rugman, and Verbeke 1998, 139). Thus, this section examines the number of foreign owned TFT-LCD manufacturers (fully owned or joint ventures) in the domestic TFT-LCD industry and the number of domestically owned TFT-LCD manufacturers in foreign markets (subsidiaries or joint ventures).

Government Policies towards the Taiwanese TFT-LCD Industry

The Taiwanese government provided several beneficial policies and incentives for the LCD industry. In 1986 the “Production Industry Reward Items and Standards” policy targeted the LCD industry and provided a five-year tax exemption and 30 percent reductions on taxed gains for shareholders. A year later the LCD industry was classified as a “Strategic Industry Appropriate Range” and in 1991 laws including the “High-Tech Type 3 Stock Market Listing Law” and the “Law Encouraging Private Development of New Products” were passed to raise capital, reduce investment risks and increase R&D (Hsiao et al. 2011, 120).

The Ministry of Economic Affairs (MOEA) further encouraged industrial development through the education of human resources and the cooperation with international brand companies. Furthermore, the MOEA supported companies to establish partnerships with foreign institutes and provided budget allocations (S. C. Chang 2005, 209).

In 1989, the Taiwanese government sponsored the Industrial Technology Research Institute (ITRI) (Chen and Chen 2009, 9). This government-owned R&D institute helped increase technological knowledge flows between Taiwanese and foreign enterprises by transferring advanced technology from the U.S. to private Taiwanese companies (Tabata 2014, 197). In addition, the ITRI recruits and trains young, talented engineers to work on new technologies. The government even passed a policy that allows young Taiwanese men to waive the military service if they work for four years in ITRI (Chen and Chen 2009, 8).

Furthermore, the Taiwanese authorities developed several plans, such as the “Microelectronics Technology Development Plan” (1989-1992), the “Flat Panel Display Technology Development 4-year Plan” (1993-1997) and the “Flat Panel Display Key Technology Development 6-year Plan” (1997-2003), which aimed at establishing industry technologies through R&D cooperation. The plans supported the transfer of technologies into the domestic industry, especially focusing on R&D technologies rather than mass-production technologies (Hsiao et al. 2011, 120–21).

From 2002 to 2008, governmental agencies spurred technological advancements of TFT-LCDs by funding the “Two Trillion And Twin Star Development Program” (C. Lee, Chang, and Wang 2020, 9). During this period, the industry expanded production capacity and developed large-size panels for LCD TVs (C. Lee, Chang, and Wang 2020, 12). In addition, the government provided a generous tax-incentive package to support capital formation (W. C. Lee and Wang 2017, 270).

Taiwanese authorities also spurred industrial development through financial support. It provided large capital investments for production activities, such as the establishment of latest

generation of production lines in order to lower production cost. This strategy increased the competitiveness of Taiwanese TFT-LCD manufacturers as it gave them the opportunity to apply their resources to process-innovation, a critical element for mass production in high-tech facilities (Hu 2012, 543).

In recent years, the display industry has seen comparatively less governmental support. There is, however, one significant policy passed in the Tsai administration — the “5+2 Innovative Industries Policy”. The proposal aims at shifting Taiwan’s industrial base away from contract manufacturing towards a high-value-added, service and solution-oriented model. The campaign aims at promoting innovation, job creation as well as future technological and market developments in several industries, including the semiconductor and IC Design industries. The proposal includes funds and investments in new technologies and should stimulate R&D as Taiwan’s economy is primarily driven by SMEs that lack in R&D investments. In addition, the policy amends regulations that limit industrial transformation. This should help increase skilled foreign talent accumulation (Ferry 2017).

In 2020, the Taiwanese government began developing another five-year action plan for Taiwan’s display industry and related industries. This plan focuses on the development of advanced display technologies and the cooperation between panel display and semiconductor industries to ensure Taiwan’s competitive edge (“Government and Industry to Join Forces in Developing Display Technology” 2020).

Multinational Activity in Taiwan’s TFT-LCD Industry

Governmental policies can have significant impact on foreign investments. Governments can attract foreign investment through favorable tax and credit policies or deter it by setting up regulatory barriers (Feldstein 1995, 44).

Taiwan’s TFT-LCD industry has been strongly influenced by FDI, especially deriving from Japan. In 1995, Japanese firms transferred technologies to Taiwan to initiate TFT-LCD manufacturing due to an economic downturn. Much of Taiwan’s FDI derived from Japanese businesses (Wang 2006, 29).

In general, governmental authorities in Taiwan pursue various measures to attract FDI in order to strengthen technology, manufacturing, and R&D. This has been especially significant for the construction of science parks and the development of information technology industries (Yun et al., 2010, p. 220). The government offers investment opportunities for foreign companies in science parks, industrial parks, export processing zones and free trade zones, such as tax incentives, tariff exemptions, and low-interest loans, amongst others. Additionally,

the MOEA and its Department of Investment Services (DOIS) provide simplified procedures for foreign investors. For example, they offer a project manager for investments over 17 million USD. The department also runs a homepage for foreign investors for easy access of information and application materials. Moreover, the government passed the “Foreign Talent Retention Act”, which aims at attracting foreign workforce and provides easier access to visa and work permits as well as tax incentives. The government also offers subsidies and tax incentives for R&D expenses and investments through the “Statue of Industrial Innovation” act (“2019 Investment Climate Statements: Taiwan” 2019).

However, there are also several impediments. Taiwanese authorities are reluctant in approving foreign investments in innovative industries that are based on disruptive business models, such as sharing economy platforms. Additionally, foreign investment deriving from Mainland China is more restricted than others. Since 2009, the restrictions have been eased, but there are still many impediments for Chinese FDI, such as prohibited sectors, or limited ownership and management control rights. The “Act Governing Relations between the People of the Taiwan Area and the Mainland Area” states that approval of the Investment Commission must be attained before investing in technology-oriented cooperation projects with Mainland China (“2019 Investment Climate Statements: Taiwan” 2019).

Another factor for multinational activity is outbound and inbound FDI. Companies may acquire existing foreign businesses, start new businesses with green field investments, or increase investments in foreign businesses they already own. Foreign investments can be wholly owned by the parent firm or jointly owned with a foreign partner company. Incentives for companies to do foreign investment are usually to find low-cost labor, proximity to raw materials, increase foreign sales and market share or to establish closer relations with customers (Feldstein 1995, 43–44).

Concerning outbound FDI, Taiwan’s TFT-LCD manufacturers operate several production facilities abroad. AUO operates production lines in Taiwan, China, Singapore and Slovakia. The company lists six fabs (fabrication plant for semiconductors) located in those regions and 17 in Taiwan. Except for one fab in Kunshan (China), which is owned by 51 percent, all the fabs are wholly-owned subsidiaries of AUO (AU Optronics Corp. (AUO) 2019, 97–100). Innolux lists eight manufacturers of which six plants are located in China, one in the Philippines and one in Malaysia (Innolux Corporation 2019, 111–13). All of its subsidiaries are wholly owned (Innolux Corporation 2019, 104). Additionally, the company lists eleven Taiwanese fabs (Innolux Corporation 2019, II). Giantplus owns three manufacturing plants in China for the assembly of LCD modules, which are wholly-owned subsidiaries (GiantPlus Technology

2019, 104–5). E Ink also established four wholly-owned module assembly plants in Yangzhou, China (E Ink Holdings Inc. 2019, 78–80). In 2018, before its bankruptcy, CPT followed a similar scheme with nine production lines in Mainland China and one in Malaysia, where panels were assembled, designed, and developed. However, most of CPT’s plants were not wholly owned (Chunghwa Picture Tube 2018, 179–81). HannStar operates three wholly-owned manufacturing facilities in China (HannStar 2019, 79–81).

As can be seen from the above-mentioned examples, Taiwanese TFT-LCD manufacturers have invested in several manufacturing facilities abroad, especially in China where labor is cheaper. Many of the foreign production facilities are used for module assembly and testing, which is the most labor-intensive process in the TFT-LCD panel production (Chen and Chen 2009, 6). Another characteristic is that most manufacturing facilities are either wholly owned or the majority of shares belong to the Taiwanese parent company.

Table 26: Outbound FDI of Taiwan’s TFT-LCD industry

Company name	Number of overseas manufacturing facilities	Manufacturing countries
AUO	6	China, Singapore, Slovakia
Innolux	8	China, Philippines, Malaysia
Giantplus	3	China
E Ink	4	China
CPT	9	China, Malaysia
HannStar	3	China

Source: Author’s own compilation based on (AU Optronics Corp. (AUO) 2019, 97–100; Chunghwa Picture Tube 2018, 179–81; E Ink Holdings Inc. 2019, 78–80; GiantPlus Technology 2019, 104–5; HannStar 2019, 79–81; Innolux Corporation 2019, 111–13).

A survey conducted by the Ministry of Economic Affairs Investment Commission (MOEAIC), from 2014, found that the primary motives for manufacturers to invest in China was low labor cost, collaboration with midstream and downstream manufacturers, and closer relationship to clients (C. J. Liu 2017, 207). As income levels have risen over the past decades in Taiwan,

companies outsourced their production activities to countries such as China and Vietnam, which provide lower wages. This led to higher outbound FDI flows. China, as the world's "factory", became the most important economy for Taiwanese outbound FDI since the late 1980s and early 1990s. The Taiwanese government also removed some restrictions on direct investment in China (Kuo and Kao 2018).

Contrary to the high level of outbound FDI, there is only little inbound FDI in Taiwan's TFT-LCD industry. The author found two foreign-owned manufacturers that are located in Taiwan: Kaohsiung Opto-Electronics and Microtips Technology. Kaohsiung Opto-Electronics is a wholly-owned subsidiary of Japan Display Inc., which manufactures TFT-LCD display modules in Taiwan since 2012 ("Background: Kaohsiung Opto-Electronics Inc." n.d.). Microtips Technology, a U.S. based manufacturer and supplier of LCD modules, also established a manufacturing plant in Taiwan ("Microtips Technology USA - About Us" n.d.). Apart from these companies, no information on foreign-owned TFT-LCD manufacturers in Taiwan was found. This comes as no surprise, as most TFT-LCD companies prefer to set up facilities in China to save costs.

Although there are not many overseas TFT-LCD manufacturers in Taiwan, the upstream display material and equipment industry has seen avid investments coming from abroad. Companies such as AvanStrate, Corning, ULVAC, Merck, AGC and Nippon Electric Glass have opened manufacturing facilities in Taiwan, most of them being subsidiaries (Corning Inc. 2019; "Group Companies" n.d.; "Locations Section" n.d.; "ULVAC, Inc. Group Companies" n.d.; Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 34; Nippon Electric Glass 2020). Taiwanese TFT-LCD manufacturers work closely with upstream material and equipment suppliers, which are located near the industrial clusters of Taoyuan, Hsinchu and Tainan. This helps to integrate them into the supply chain.

4.6.2 Government Policies and Multinational Activity in Korea

Government Policies towards the Korean TFT-LCD Industry

The national state played a crucial role as the container of laws and practices in the creation of Korea's display industry. Scholars argue that the Korean government's support and in particular its direct financing of chaebols has played a vital role in activating the Korean TFT-LCD industry and expanding Korea's market share (C. Lee, Chang, and Wang 2020, 5; T. Y. Park, Choung, and Min 2008, 2855). The government's financial support provided Korean TFT-

LCD manufacturers with a first-mover advantage, which differs from Taiwanese manufacturers who depended on Japanese FDI (T. Y. Park, Choung, and Min 2008, 2857).

The Korean government established supportive policy measures for the development of the TFT-LCD industry via establishing regional clusters for firms to develop TFT-LCD-related technologies, and train professionals and technicians for new generation technologies (S. H. Lee, Yun, and Jeon 2020, 178). Korean authorities also invested large sums in new generation production fabrication plants. This allowed domestic manufacturers to compete with Japanese companies, as they were able to concentrate their limited resources and capabilities on process innovation (Hu 2012, 543).

In recent years several acts have been passed to strengthen the display industry. The government legislated the “Industrial Development Act,” which supports knowledge-based industries and promotes sustainable industrial development. The act offers fund, taxation and location-related benefits for advanced technologies and products. In addition, the “Industrial Technology Innovation Promotion Act” is designed to foster an environment for developing materials and parts of the industry and promote innovation of industrial technology (Korea Trade-Investment Promotion Agency (KOTRA) 2015, 25). Another act, the “Act on Special Measures for the Promotion of Specialized Parts and Materials Enterprises”, aims to foster enterprises that specialize in materials and parts industry. Under this act, manufacturers of display parts are not subjected to the “Financial Investment Services and Capital Markets Act”, which limits acquisition of foreign trading securities and exchange-traded derivatives (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 28).

Korean authorities also invested in projects for creating human resources and for the support of SMEs in materials and equipment through cultivating professions in these industries. The project helped generate professionals with master’s degrees in local universities (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 26).

Additionally, the government provides financial support for display clusters. There are several benefits for companies to move into the Paju LCD industrial complex, including full exemption of acquisition tax, 50 percent exemption of property tax for the first five years of acquisition, as well as support funds for SMEs and start-ups. The authorities provide similar incentives for companies moving to the Tangjeong industrial complex (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 29–30).

However, in the past few years, a shift in governmental policies from LCD to OLED technologies can be observed. Newer policies focus on the development of human resources and research in AMOLED technologies.

Multinational Activity in Korea's TFT-LCD Industry

Korea is an attractive destination for foreign investments. However, its complicated and opaque regulatory system often deters foreign investors. Investors targeting Korea may face numerous impediments, including limited regulatory transparency, conflicting interpretation of regulations, regulatory revisions, high cost of labor, antiquated governance structures and burdensome consumer protection measures, as well as market domination by chaebols ("2019 investment climate statements: Korea, Republic of," n.d.). Hence, in 1998, the basic law guiding foreign investment is the "Foreign Investment Promotion Act" (FIPA) was enacted, which provides simplified procedures for registration, expanded tax incentives for high-technology investments, lower rental fees and lengthened lease durations for government land, and governmental support for FDI incentives. Under FIPA, two support centers for foreign investments were established, the Invest Korea center and the Foreign Investment Ombudsman. Additionally, other agencies, such as the Korea Trade Investment Promotion Agency (KOTRA) facilitate foreign investments, by assisting investments over 88,000 USD for domestically incorporated foreign companies. KOTRA and the Ministry of Trade, Industry and Energy (MOTIE) also organize annual Foreign Investment Weeks to attract new FDI ("2019 Investment Climate Statements: Korea, Republic Of" 2019).

In addition, outward investment is relatively easy and several offices are in place to assist small and medium-sized businesses (e.g. KOTRA, ASEAN-Korean Centre and the Defense Acquisition Program Administration) ("2019 Investment Climate Statements: Korea, Republic Of" 2019).

South Korea is well above the OECD average concerning the accessibility of industrial sectors open for FDI. Foreign private entities can engage in almost all remunerative activities, with only a few restrictions. Around 30 industries are limited to foreign investment, where access must be approved or is generally restricted ("2019 Investment Climate Statements: Korea, Republic Of" 2019).

Similar to Taiwan, Korea's government provides tax incentives, free or low rent and a good business environment for investments towards free trade zones, investment zones and industrial parks under FIPA and the "Restriction of Special Taxation Act". For example, in the Masan Free Trade Zone, a high-tech industrial park, government support involves technology, informatization and SME development amongst others, longer loan periods and access to funds (Korea Trade-Investment Promotion Agency (KOTRA) 2016, 7). Other benefits for industrial parks include exemption of taxes, employment and training subsidies, as well as support funds (Korea Trade-Investment Promotion Agency (KOTRA) 2016, 10,16).

Concerning outbound FDI, Korea's situation is similar to Taiwan. LG Display has set up eight manufacturing bases abroad of which six are situated in China, one in Vietnam and one in Poland. Most of their subsidiaries, except for two Chinese manufacturers who are partially owned, are wholly owned (LG Display Co., Ltd. 2019, 22). Samsung Display followed a similar strategy and opened four manufacturing plants in China, of which two are wholly owned and two partly owned, and one wholly-owned plant in Vietnam (Samsung Electronics Co., Ltd. 2019, 90).

Table 27: Outbound FDI of Korea's TFT-LCD industry

Company name	Number of overseas manufacturing facilities	Manufacturing countries
LG Display	8	China, Vietnam, Poland
Samsung Display	5	China, Vietnam

Source: Author's own compilation based on (LG Display Co., Ltd. 2019, 22; Samsung Electronics Co., Ltd. 2019, 90).

Both Korean companies set up module factories in China and Vietnam, which are also the main export countries for their display panels (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 23). LG Display and Samsung Display follow a similar strategy to that of Taiwanese manufacturers. They set up module plants in China and Vietnam as module assembly is labor intensive and labor costs are lower in those nations. The strategy of finding cheaper labor was already suggested by Moon et al. in 1998, who reported that the price of the Korean labor market has increased over the years. They suggested that Korean companies will eventually turn to other nations to find cheap labor and to enhance production capabilities (Moon, Rugman, and Verbeke 1998, 139). Still, around 80 percent of LCDs are produced in Korea. However, the proportion of LCDs produced in China is on the rise. While in 2014, 6.1 percent were produced in China, in 2018 it amounted to 24 percent (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 24).

Compared to outbound FDI, inbound FDI in midstream level of the TFT-LCD production process in Korea is less common. Only one Japanese company was found, Kyocera, which opened a subsidiary in Korea, named the Kyocera Precision Tools Korea. The parent compa-

ny Kyocera has a 90 percent ownership of the subsidiary and uses it as a manufacturing base for finished goods and raw materials (Kyocera Corporation, 2020, p. 13).

Nonetheless, Korea's display market is attractive for FDI, as it is home to LG Display and Samsung Display, two of the world largest display manufacturers. In addition, the country offers a good infrastructure, as it has formed industrial clusters, and related industries such as smartphones, semiconductors and TV's are thriving (Korea Trade-Investment Promotion Agency (KOTRA) 2017a, 11). Several overseas companies made key investments in Korea's display material and equipment industry. The semiconductor and display report from 2020 lists 26 major foreign-owned companies that opened manufacturing plants for display materials, components or equipment. The majority are Japanese and U.S. owned companies, but also parent companies from the U.K. and Germany established subsidiaries in Korea (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 26–27). Representative foreign-owned companies in material such as Meck (Germany), Chiso (Japan), Corning Precision Materials (U.S.), Paju Electric Glass Co., Ltd. (Japan), and ULVAC Korea (Japan) etc. set up subsidiaries in Korea. Some of these companies even operate multiple production bases, sales and R&D centers (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 24). The localization rate of parts and materials and equipment is still high as more than 60 percent is produced in Korea (Korea Trade-Investment Promotion Agency (KOTRA) 2020b, 24).

Conclusion

The evaluation conducted in this chapter has revealed that the Taiwanese as well as the Korean government played a strong role for the success of their TFT-LCD industries. The Taiwanese and Korean governments directed the development of industries in the past decades. Both governments support domestic TFT-LCD manufacturing through a number of subsidies, tax policies and other support measures. In Taiwan, government support most notably targets display clusters, R&D investments and SMEs. Additionally, the government is liberal concerning FDI and maintains strong foreign-domestic cooperation. However, there are still several restrictions on FDI, especially when deriving from China. Korea shows similar levels of government support, especially concerning display clusters, human resources, and technological developments. Moreover, Korea is very welcoming towards overseas FDI, yet, there are some impediments, such as its opaque and complicated regulatory system. Both nations have strong outbound FDI in the midstream level, while inbound FDI is apparent in the upstream level. Taiwanese as well as Korean companies started to open manufacturing plants in China and other countries where labor costs are lower.

5 Analysis

5.1 Assessment of the Diamond Framework

The object of this thesis was to examine and compare the competitiveness of the Taiwanese and Korean TFT-LCD industries based on Michael Porter's diamond model of national advantage. With a few adjustments, Porter's diamond framework proves to be a valuable tool to understand the sources of competitiveness in Taiwan's and Korea's TFT-LCD industry. The comparison based on the modified framework has not only revealed strengths and success factors of both nation's TFT-LCD industry, but also highlighted some of the shortcomings that should be dealt with.

This chapter of the thesis assesses each dimension of the modified diamond model according to Barragan's (2005) framework. Barragan divides competitive advantage into three levels: high (H), medium (M) and low (L), and in some cases into transition stages (i.e. from low to medium (L-M) etc.) (Barragan 2005, 67). The assessments are based on the author's judgement of the results in the previous chapter.

5.2 Evaluation of Factor Conditions

The first dimension of Porter's diamond framework concerns factor conditions. Factor conditions include the amount, cost and availability of human resources, the quality concerning knowledge resources, the abundance of capital resources, as well as the constitution of infrastructure and intelligent capital. The results of the empirical part of this thesis revealed the following results.

The Taiwanese labor pool is slowly increasing, however, according to the national development council, Taiwan's employers are facing a talent shortage, especially concerning engineers and IT technicians. In addition, a decline in labor force in the Taiwanese TFT-LCD industry is evident. While in 2011 around 70,000 people were employed in TFT-LCD related companies, in 2015 the number has dropped to 69,000.

Korea's population is around two times bigger than Taiwan's and its labor pool is thus much larger. Yet, the country experiences a similar decrease in the number of TFT-LCD-related manpower. Nonetheless, the display industry as part of the electronics industries is considered very attractive amongst young people and appeals to new labor force.

The cost of labor in Taiwan is relatively cheap compared to Korea, where wages in manufacturing in 2018 were almost half of the wages in Korea. Yet, when compared to China, the factory of the world, they offer no cost advantages in terms of labor cost.

Concerning the skill level of the TFT-LCD labor force, Taiwan and Korea enjoy many advantages. Both nation's educational background is in accordance with OECD standards. The majority of Taiwan's TFT-LCD workforce has attained a university degree. Additionally, each year around one third of freshman students enroll into display industry-related programs, such as mathematics or engineering programs. Although the number declined in the past years, there is still high demand for these programs. Taiwan's universities even specialize in photonics and optoelectronics graduate programs, which are instrumental for the TFT-LCD industry. Data on Korea's enrollment ratio shows similar trends. Korea's prime scientific focus over the years was engineering, with science technology, and engineering programs enjoying the highest enrollment rates amongst new students. In addition, Korea's universities also offer specialized programs focusing on display technologies.

Additionally, Taiwan's and Korea's leading TFT-LCD manufacturers have above-average R&D expenditures, which is a key driver for competitiveness for companies as it promotes technological developments (C. W. Yang and Chen 2020, 145172).

Another factor within this category is capital resources, which includes Gross Domestic Investment (GDI), Foreign Direct Investment (FDI), and Stock Market Capitalization (SMC). Both nations show favorable conditions concerning their capital resources. Taiwan and Korea experienced an overall upward trend in their GDP as well as in investments in its economic assets following the global financial crisis in 2009. Moreover, the economies are welcoming FDI. Taiwan is considered a popular destination for FDI as it features economic dynamism, a high purchasing power and strong growth in its high-tech sector. The electronic components sector is among one of the most attractive sectors for foreign investments. Korea is also a popular destination for FDI inflows, especially concerning the manufacturing, information and communication sectors. Moreover, both nations' business environments are very attractive for foreign investors according to the Doing Business Report of 2020, where Taiwan was ranked 15th and while Korea scored the 5th place. The countries also have strong IT sectors that make a significant contribution to these export-oriented economies. When comparing both economy's key indexes, Taiwan's TAIEX index and Korea's KOSPI index, the TAIEX increased more than 45 percent, while KOSPI increased about 15 percent between October 2010 and December 2019.

The results of the analysis further indicate that the infrastructure of both nations is very advanced. Taiwanese and Korean clusters have an advantageous hard infrastructure. Display clusters are well connected to airports, ports, nearby cities, and universities, enjoy easy access to transportation and thus attract new labor force. Taiwan's three display clusters are well

linked along a high-speed railway and several freeways. Nearby cities accommodate workforce, universities are located in proximity, and equipment and material suppliers are well integrated. Taiwan's TFT-LCD industry further benefits from a well-organized educational infrastructure. Most universities offer related study programs and 23 universities even specialize on display-related programs such as optoelectronics.

Similarly, Korea's two main display clusters, the Paju and Tangjeong industrial complex, are also well connected to nearby airports, ports and cities, which makes the transportation of products convenient. Many of the affiliated suppliers can be found within the clusters and manpower is supplied by nearby colleges and universities. As has been stated above, the Korean educational infrastructure is specialized on technical and engineering programs and many universities offer display related programs.

The final category of factor conditions, intelligent capital, analyzed the number of patents registered by Taiwan and Korea. The analysis revealed that between 2000 and 2018, Korea had registered the highest amount of TFT-LCD related patents. Korea filed around 64,000 patents, while Taiwan registered less than 5000 patents in the same period. Interestingly, China and the U.S. had filed more TFT-LCD related patents than Taiwan, while Japan had filed the least among the countries.

Overall, many favorable conditions can be detected in both nations. Taiwan's strength concerns its skilled, but cheap labor force, ample capital resources, and strong educational and hard infrastructure. Korea's main advantages lay in its skilled manpower, the attractiveness of the display industry, its scientific focus on engineering, its abundant capital resources and competitive infrastructure, as well as strong investments in intelligent capital.

However, the analysis revealed several significant disadvantages in both economies. Both nations are facing demographic issues, a decrease in manpower and higher wages. Taiwan's TFT-LCD industry further needs to increase its investments in intelligent capital, otherwise most profits concerning technology licenses will go to other advanced countries. Chang stated that Taiwan lags behind their competitors in patent investment and thus often pays large amount of license fees and heavy penalties. Yet, the situation has not changed as Taiwan's TFT-LCD manufacturers are still lacking IPRs (Intellectual Property Rights).

For the reasons mentioned above the authors assess the contribution of factor conditions to the competitiveness of the Taiwanese TFT-LCD industry as medium to high (M-H) and as high (H) for South Korea.

5.3 Evaluation of Demand Conditions

The analysis of this dimension of the diamond framework has revealed that both nations' demand derives mainly from outside the country. Due to the lack of data concerning domestic sales and international sales of Korean TFT-LCD manufacturers the exact size of home demand and international demand cannot be compared. However, the analysis disclosed that both domestic as well as international demand for Taiwanese and Korean TFT-LCD panels is declining since the entrance of China in the TFT-LCD market. Taiwan's market growth rate from 2014 to 2017 was negative 2.4 percent. Besides, TFT-LCD export sales declined during this period from 22.6 billion USD to 16.6 billion USD. Korean LCD export rates have also been declining over the past few years. While in 2014 the global export of Korean LCDs stood at 28 billion USD, in 2018 the number has been cut in half. Evidently, international demand as well as domestic demand for Korean and Taiwanese LCD products has declined in the past years, although the global TFT-LCD demand is still growing.

In 2010, the majority of demand for Taiwanese TFT-LCD panels derived from Taiwan as there was a large demand from the backward industry, such as the PC industry (Han, Oh, and Yoo 2012, 26). However, a few years later in 2015, most of the panels were exported to China and Hong Kong (88.5 percent). The same applies to Korea as most of their panels are exported to China (47 percent) and Vietnam (34 percent), since these nations house many global TV and IT production plants. China has become the number one importer of Taiwanese and Korean TFT-LCD panels, since many OEMs, ODMs and EMS are located in the country. Moon et al. also suggest that if a nation's exports depend on a limited amount of foreign countries, its export markets are not diversified, which in turn means they are not sophisticated (Moon, Rugman, and Verbeke 1998, 143). This dependence on Chinese downstream channels thus causes issues for Taiwanese and Korean manufacturers especially if China will continue to boost its own TFT-LCD industry.

The final category of demand conditions, the segment structure of demand, indicates the "quality" of TFT-LCD demand. Concerning Taiwan's segment structure, the nation has a higher capacity of large-size panels than small and medium-size panels. Taiwan's output value of large-size TFT-LCDs from 2012 to 2015 was around three times higher than the output value of small and medium-size panels. However, in the small and medium-size panel segment, Taiwan captured a higher share than their Korean counterparts in 2013. Korean TFT-LCD manufacturers on the other hand, gained a higher share in the large-size segment than their Taiwanese counterpart in 2015 and 2016. Generally, both nations are active manufacturers in the large- and small and medium-size segments.

It is evident that much of Taiwan's and Korea's loss in both segments has been captured by Chinese manufacturers, which have increased their share over the years, especially in the large-size segment. In 2020, Chinese panel manufacturers are expected to seize the largest market share in unit and area shipments of large-size TFT-LCDs displays, which will be the first time that Chinese companies become market leaders in that segment ("The Recovery Begins in the Large-Sized TFT Display Market" 2020).

When comparing the size of segments in the global TFT-LCD industry, the market is dominated by large-size TFT-LCDs, followed by medium to small-size panels. In terms of applications, the TV industry and the mobile phone industry made up the largest share for the global TFT-LCD market ("TFT LCD Panel Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2020-2025" n.d.). Porter states, that firms should invest in large, profitable segments to stay competitive, which is the case for Taiwan and Korea. Taiwanese and Korean manufacturers focus on the large-size panel segment, where demand is particularly high. Additionally, both nations pursue a high-end quality strategy for their TFT-LCD products, focusing on advanced technologies and specialized products. The exception is made by Taiwanese manufacturers in the small and medium-size segment, where manufacturers follow a low-end strategy for panels applied in smartphones and tablet PCs.

In conclusion, demand conditions are becoming weaker in both countries. Due to China's entrance in the TFT-LCD market, Taiwan and Korea are suffering from declining demand. Domestic demand as well as international demand is decreasing. In addition, both nations export most of their panels primarily to China, which makes them dependent on the nation, especially in the case of Taiwan. However, both nations upgraded to high-end products in their segments, which increases their competitive advantage. Overall, both countries' demand conditions are assessed as low (L).

5.4 Evaluation of Related and Supporting Industries

For the dimension related and supporting industries of the diamond framework, Taiwan's and Korea's domestic semiconductor industries as well as the supporting upstream display equipment, parts and materials industries were examined. Several conclusions can be drawn from the results.

Taiwan is one of the leading nations regarding semiconductors. The country houses the market leader in foundry, TSMC, which captured more than half of the global market share and ranked first in the world based on sales in 2017 and 2018. The semiconductor industry is also a leading industry in Taiwan in terms of industry output, export ratio and investment amount.

In 2018, total sales of semiconductors accounted for 10.1 billion USD. Around 300 companies with 230,000 employees were registered in 2019. The semiconductor industry helped spur the initial development of the Taiwanese TFT-LCD industry as it provided skilled labor and technology.

Similarly, the Korean semiconductor industry is also highly competitive, especially in the field of memory semiconductors. Korean semiconductor companies have a high amount of proactive investments and advanced process technologies. As of 2018, the Korean semiconductor industry comprised a workforce of 165,000 employees and 3700 companies, including the industry leaders for DRAM and NAND, Samsung Electronics and SK Hynix. In the same year, total sales of semiconductors amounted to 114.7 billion USD.

Both nations benefited greatly from spillovers from the semiconductor industry, especially in the initial phase. As the array production processes for TFT-LCD panels are 70 percent similar to semiconductor fabrication, the TFT-LCD industry was able to import technology as well as talent from the semiconductor industry (Hsiao et al. 2011, 125). In addition, spillovers from the semiconductor industry positively affected technology, human resources, organizational systems, network, production and quality management (T. Y. Park, Choung, and Min 2008, 2855).

While the semiconductor industries in Taiwan and Korea are highly competitive, the upstream supplying industries are less advanced. Even though the Korea and Taiwanese upstream display market had the largest market size in 2014, with 36.2 billion USD in Korea and 33 billion USD in Taiwan, the countries are still dependent on imports. Taiwan as well as Korea import their equipment and materials from Japan, the U.S. and Germany. However, the economies have improved their localization rate of the upstream supplying industry over the past few years. In 2016, more than 40 upstream display suppliers were registered in Taiwan. Korea housed around 70 upstream display suppliers in 2014.

In order to be competitive, upstream suppliers should preferably be located nearby manufacturing bases to save time and transportation costs as well as to provide easy access to components (Hsiao et al. 2011, 120). In case of Taiwan, a tendency of manufacturers to depend on imports of Japanese materials and components can be detected. Thus, the country should concentrate more on the development of its upstream equipment and material supply. In Korea, many of the suppliers for materials and components have production bases located in the country, which makes access fast and easy. In addition, key materials such as glass, target and backlight unit plastics are highly localized. This gives Korea an advantage of easy access to materials and decreases the chance of an unstable supply.

Overall, the conditions for related and supporting industries is favorable for Taiwanese manufacturers, but there is still space for improvement, especially concerning upstream material and equipment supply. Thus, this dimension is evaluated as medium in the case of Taiwan (M). Korea faces similar issues, concerning its semiconductor and upstream supplying industries. Yet, in the case of Korea, the level of localization has experienced an overall improvement over the years and the industry is less dependent on foreign exports than its Taiwanese counterpart. Hence, Korea's related and supporting industries is assessed with medium to high (M-H).

5.5 Evaluation of Firm Strategy, Structure and Rivalry

The section firm strategy, structure and rivalry analyzed the ownership structure of Taiwanese and Korean manufacturers and their strategies. In addition, the section examined the degree of rivalry based on the number, size and global market share of competitors and the global market growth.

Regarding the Taiwan's TFT-LCD industry, most manufacturers are public companies that are listed on Taiwan's stock exchange. Shareholders of these manufacturers usually hold only a small percentage, and most shares are in private domestic and foreign hands. In the TFT-LCD industry, the government generally holds a very small percentage of shares with less than one percent.

The ownership structure of Korean TFT-LCD manufacturers is quite different. The Korean industry is dominated by big business groups. The two chaebols, LG Display and Samsung Display, lead Korea's TFT-LCD market. LG Display is a publicly listed company, which belongs to the LG Group, whereas Samsung Display is a privately-owned subsidiary of Samsung Electronics. Even though the ownership structures of these chaebols differ they have in common a chaebol-typical method, which involves cross holdings through affiliated enterprises and subsidiaries.

While there are no indications about whether the public or private form of ownership offers more competitive advantages (Trostel and Nichols 1982, 61), some authors argue that companies, which are not under the control of the state, have a better performance than state-owned enterprises (SOEs) (Goldeng, Grünfeld, and Benito 2008, 1266). SOEs maintain inferiority due to their weak incentives for managers to perform and their less efficient means of monitoring (Goldeng, Grünfeld, and Benito 2008, 1265). Since Taiwanese and Korean manufacturers are all not under the control of the state, they may be more successful in attracting managerial talents, and operate with a more efficiently allocated capital base (Goldeng, Grünfeld,

and Benito 2008, 1264). Additionally, TFT-LCD manufacturers in Taiwan and Korea are considered large businesses, which come with several advantages. Large-sized firms can take risky investments, gain economies of scale in manufacturing and in R&D, and can shift their production lines to others in order to avoid temporary fluctuations in demand (Ashoka 1990, 296, 299). Small-sized firms on the other hand are more dependent of government support (Ashoka 1990, 299). Hence, both Taiwanese and Korean TFT-LCD manufacturers' ownership are fairly well adapted to the industry' needs and can overcome potential issues.

Concerning strategies, Taiwanese and Korean TFT-LCD manufacturers changed their approaches over time, especially after China emerged as a new competitor. Among Taiwanese manufacturers a trend towards differentiation and focus can be detected. Many of the manufacturers abandoned the low-cost strategy as they cannot compete with cheap production costs in China. Thus, companies either upgrade to higher quality products as is the case in the large-size segment, or focus on specific segments, such as vehicle panels or wearable devices.

The same trend is apparent in Korea. LG Display and Samsung Display began focusing on differentiated products and upgraded to OLEDs. Both companies are slowly exiting the LCD market to focus on more advanced technologies.

The final part of this section, rivalry, measured the level of competition among domestic Taiwanese and Korean TFT-LCD manufacturers. Porter argued that fierce competition in the home market as well as intense rivalry among companies can pressure firms to improve product quality and productivity in order to maintain a competitive edge. The analysis of rivalry among Taiwanese manufacturers is considered relatively high. Taiwan houses around eight TFT-LCD manufacturers, which are roughly of same size and market share, except for the two market leaders, AUO and Innolux. They captured a much larger market share than the remaining manufacturers. Another factor contributing to rivalry, is slow market growth and exit barriers. Over the past years, Taiwanese manufacturers were confronted with a slow or even negative market growth as market demand has become saturated and other competitors such as China flood the market with new low-cost products. Additionally, exit barriers in the TFT-LCD industry are relatively high, since companies can expect high sunk costs if they are to exit from the industry.

The Korean chaebols face an even higher degree of rivalry, as the Korean market is consolidated and rivalry between the two chaebols is fierce. LG Display and Samsung Display are similar in size and market share. The companies have been rivals for many years. Moreover, they are challenged with a stagnating market growth and high exit barriers. Thus, the degree of rivalry is relatively high.

On the whole, while there are notable differences in the firm structure of Taiwanese and Korean TFT-LCD manufacturers, they follow similar strategies and are facing a high degree of rivalry as the market growth has decelerated and new competitors emerged. The author detected no correlation between private and public forms of ownership structure and competitiveness but found that large-size companies that are not under the control of the state can provide a more efficient performance. The strategies of Taiwanese and Korean TFT-LCD manufacturers are also considered as effective, as companies upgraded to more sophisticated technologies to become more competitive. With regard to this dimension of the diamond model, Taiwan as well as Korea are assessed with high (H).

5.6 Evaluation of Government Policies and Multinational Activity

The final dimension of the diamond model examined government policies towards the TFT-LCD industry as well as multinational activity in the industry. From the results of the analysis several conclusions can be drawn.

In the initial stage, during the 1990s, the Taiwanese government provided a multitude of positive policies for the liquid crystal industry. It created an environment that supports technological development, creates new, skilled human resources and provided financial support. In the 2000s government support was still strong as can be seen from plans, such as the “Two Trillion and Twin Star Development Program”. However, by the 2010s a lack of governmental support can be recognized. There are only few supportive acts in place that assist in the development of the TFT-LCD industry.

The situation in Korea is similar. Government support was particularly strong in the initial phase, especially since Korean companies had no technological exchange with Japanese TFT-LCD manufacturers. Governmental support led to the development of regional clusters in the TFT-LCD industry under the leadership of LG and Samsung. It also increased the number of trained professionals and technicians, and cooperation between firms and the government. The Korean authorities further reinforced the creation of the industry by financing chaebols, developing human resources and encouraging the upstream material and component industry. However, in later years, especially since the introduction of OLED technologies, governmental support shifted towards newer technologies away from TFT-LCD manufacturing.

Concerning FDI, the Taiwanese as well as the Korean government provided much support. Taiwan’s government focuses on the provision of incoming FDI in science parks and the upgrading of new information technology industries. Policies aim at simplifying procedures for foreign investors, including easier access to the domestic market, tax incentives and the attrac-

tion of foreign skilled workforce. There are however some impediments targeting foreign investments deriving from China.

In Korea, the government focuses on improving its opaque regulatory system to increase foreign investments. Agencies, such as Invest Korea or the Foreign Investment Ombudsman facilitate foreign investments. Additionally, the government provides tax incentives for industrial zones and parks. Generally, Korea is very attractive to foreign investors, however, foreign investors are still facing numerous impediments, including limited regulatory transparency, regulatory revisions, high cost of labor, and antiquated governance structures, amongst others. New info

Regarding FDI, there is much inbound FDI in the upstream level of Taiwan's TFT-LCD industry, while the midstream level experiences more outbound FDI. Much of the material and equipment comes from Japan, although Taiwan has increased its domestic share over the years. The outbound FDI mainly concerns the module manufacturing, which is labor intensive and thus often transferred to lower cost countries such as China or Vietnam. Outsourcing the module process offers several advantages for manufacturers: first, the fixed cost of the module process manufacturing system can be reduced; second, the amount of manufacturing can be operated with more flexibility; and finally, logistics and inventory costs are reduced as panels and not the final products are carried (S. H. Lee, Yun, and Jeon 2020, 177).

Korean TFT-LCD manufacturers follow a similar strategy. LG Display and Samsung Display opened several manufacturing bases in China and Vietnam to save on labor cost. Also, inbound FDI is more common in the upstream level, where many foreign material and equipment companies opened subsidiaries near or in industrial clusters. Korea's chaebols LG and Samsung attract many foreign investments and its infrastructure allows for easy access. In both cases, inbound FDI creates access to equipment and materials, while outbound FDI provides access to cheap labor.

In conclusion, the dimension government and multinational activity concerning Taiwan's TFT-LCD industry is rated as medium (M). Multinational activity, such as governmental policies towards FDI in the TFT-LCD industry and inbound and outbound FDI, is strong, but governmental policies have been deteriorating over the years in Taiwan. Similarly, the Korean TFT-LCD industry needs more governmental support in order to spur development, yet the government shifts policies towards newer technologies. In addition, the regulatory system in Korea is opaque and there is room for improvement. Thus, this dimension is rated as medium (M) in the case of Korea.

Table 28: Source of Taiwan's competitiveness in the TFT-LCD industry

Taiwan					
Determinants	Factor Conditions	Demand Conditions	Related and Supporting Industries	Firm Strategy, Structure and Rivalry	Government and Multinational Activity
Assessment	MEDIUM TO HIGH	LOW	MEDIUM TO HIGH	HIGH	MEDIUM
Source of competitiveness	- Lower labor costs - Skilled workforce - High R&D expenditures - Favorable conditions for FDI - Strong stock market growth - Highly developed hard infrastructure - High quality and specialized educational infrastructure	- Focus on large and profitable segments	- Spillovers from semiconductor industry in human resources and technology - Second largest upstream supplying industry - Increasing localization of upstream industries	- Large and private businesses - Differentiation and focus strategy - Relatively high level of rivalry	- Government support - Existence of supportive measures for FDI - Inbound FDI provides materials and technology - Outward FDI provides cheap labor

Source: Author's own compilation.

Table 29: Source of South Korea's competitiveness in the TFT-LCD industry

South Korea					
Determinants	Factor Conditions	Demand Conditions	Related and Supporting Industries	Firm Strategy, Structure and Rivalry	Government and Multinational Activity
Assessment	HIGH	LOW	HIGH	HIGH	MEDIUM
Source of competitiveness	- Attractiveness of the TFT-LCD industry - Skilled workforce - High R&D expenditures - Favorable conditions for FDI - Highly developed hard infrastructure - High quality and specialized educational infrastructure - Highest amounts of registered patents	- Focus on large and profitable segments	- Spillovers from semiconductor industry in human resources and technology - Largest upstream supplying industry - Fast increase in localization of upstream industries	- Large and private businesses - Differentiation strategy - High level of rivalry	- Existence of supportive measures for FDI - Inbound FDI provides materials and technology - Outward FDI provides cheap labor

Source: Author's own compilation.

6 Conclusion

6.1 Summary and Results

The final chapter of this study provides a summary of the results derived from the analysis and answers the research question. Furthermore, the second part of this chapter includes the limitations and relevance of this study, as well as suggestions for future research.

This study was set out to compare the competitiveness of Taiwan and Korea concerning their TFT-LCD industry. The time frame chosen comprised the years following the 2008 financial crisis. The research question of this study sought to understand the key success factors for competitiveness of the TFT-LCD industries in Taiwan and Korea. In order to answer the research question, a modified version based on Michael Porter's diamond model was applied.

The results of the analysis suggest that both nations are still competitive. Taiwanese and Korean manufacturers enjoy similar advantageous factor conditions for their industry success. Both nations provide a skilled workforce, have plenty of capital resources and support FDI. Additionally, their educational systems offer specialized programs for the training of the TFT-LCD workforce, and the hard infrastructure of display clusters is highly developed and well connected. In contrast to Taiwan, Korea also excels in the amount of registered TFT-LCD patents, which provides independent access to technologies.

The other determinants of the diamond model show similar favorable conditions. Both East Asian economies have strong related and supporting industries. Taiwan and Korea house several of the market leaders in semiconductors. The semiconductor industry allowed spillovers in human resources and technology, which spurred the initial TFT-LCD industry growth. In addition, the nations are home to the very well-developed display material and equipment industries which are increasingly localized. Their TFT-LCD manufacturers have integrated strategies that are well-adapted to the changing environment and to the degree of rivalry in the TFT-LCD industry. Furthermore, the ownership structure of TFT-LCD-related firms supports competitiveness in the industry.

Another great benefactor for the industry success of Taiwan and Korea was government support. Governmental agencies helped spur initial TFT-LCD development through financial funding, the generation of human resources, tax reductions and FDI support, amongst others. The Taiwanese and Korean governments also announced the TFT-LCD industry as strategic industry to foster growth. However, it is evident that from 2010 onwards, governmental support has slowly decreased. While in the initial phase many supportive measures stipulated TFT-LCD growth, in recent years policies began to focus on newer technologies, such as

OLED. Concerning multinational activity, both nations set up strategic inbound and outbound actions, such as the outsourcing of labor-intensive processes to countries with low-labor costs. The study further revealed that while both nations are successful in many determinants of the diamond framework, they are lacking in demand conditions. As market demand for TFT-LCD products is saturated, global market growth has slowed down after the financial crisis. In addition, China increased its production capacity and captured much of the demand. Thus, Taiwanese and Korean TFT-LCD manufacturers have lost much of their share over the past ten years.

The key success factors identified in this study are similar to the ones found in other analyses. Researchers suggested that Taiwan's main key success factors for its competitiveness in the TFT-LCD industry are strong governmental support, technology transfer from Japan, and R&D talent accumulation. Chang's (2005) study on the competitiveness of the Taiwanese TFT-LCD industry further recommended that Taiwan should increase their domestic supply of key components, TFT-LCD manufacturers should emphasize on patents, and should pay attention to other new technologies (S. C. Chang 2005, 213–14). Although Taiwan has improved its domestic supply of key components, some suggestions are still relevant, as Taiwan is still lacking in IPRs and has neglected to support other technologies such as OLED.

In the case of Korea, scholars argue that industry success is based on governmental support and knowledge spillovers from other industries such as the semiconductor industry. In contrast to Taiwan, Korea's advanced level of IPRs and strong governmental support has strengthened the market leadership of Korean display manufacturers. Yet, it is evident that Korean manufacturers are slowly withdrawing from LCD technologies to focus on more promising display segments, including OLED, where competition is less fierce.

In conclusion, the study revealed that both nations have favorable conditions in most determinants of the diamond model, however, with China's presence in the TFT-LCD industry, the countries have lost much of their market share of international demand to Chinese competitors. Taiwan and Korea, although competitive, are currently facing a major threat.

6.2 Relevance, Limitations and Future Research

The results of this study are relevant for several reason. Firstly, the results disclose what constitutes competitive edge in the TFT-LCD industry. The results are relevant for potential entrants who want to improve and adapt strategies and expand their market share in the industry. Potential new entrants such as Vietnam, Cambodia or India can learn from Taiwanese and Korean TFT-LCD manufacturers and their governments and strategize accordingly. Not only

are the key success factors relevant for players in the TFT-LCD industry, but they are also relevant for other display industries, including different LCD types, OLED and Micro-displays, since they share many resemblances in their industry-structure.

Second, this thesis not only revealed the key success factors but also highlighted weaknesses of Taiwan's and Korea's TFT-LCD industry. The economies can adjust their strategies to improve their overall competitiveness.

Third, the study indicates how changes in demand and the entrance of new competitors affects the industry dynamics. The TFT-LCD industry has surpassed its growth stage and entered a mature stage with saturated market demand. Slow demand intensifies competition and only the most competitive manufacturers can survive. The results show that TFT-LCD manufacturers need to pay more attention to market demand trends and how other competitors' strategies influence the market.

However, this research has also several limitations. The study focuses on only two players of the TFT-LCD industry. To gain more information on the key success factors for competitiveness in the TFT-LCD market, future research may include other players, such as Japan and China. Japan has entered the display many years before its competitors. Even though the nation has lost its leadership with the entrance of Korea, it has maintained a dominant position in the small and medium-size segment. Additionally, China has risen as a new competitor and has increased its TFT-LCD production capacity in the years. Further research on competitiveness might include these players to obtain more detailed information on what constitute success in the industry.

Another limitation is level of focus. This work analyzed competitiveness on a national level and has thus not concentrated on regional or segment-specific criteria. Competitiveness may vary in among regions and companies as well as segments. The study attempts to include some factors that discuss the regional, segment and company level, however, the general focus lays on the national level. Therefore, further studies might emphasize these sections.

Finally, future research may focus on how newer display technologies, such as OLED, affect the TFT-LCD industry. OLED is often said to become the next major display technology, driving out LCD technologies. Thus, it would be interesting to gain a better perspective on the dynamics between different display industries. This study established that there remains much to be explored that further research can shed light on.

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Appendix

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Abstract

The liquid crystal display (LCD) industry has witnessed an extraordinary growth in the past twenty years, especially in the East Asian Region, with market leaders situated across Japan, Taiwan, South Korea and Mainland China. Among them, Taiwan and South Korea became the largest provider of thin film transistor LCDs (TFT-LCDs) at the turn of the century. However, with the entrance of China as a competitor, both nations are facing an unprecedented threat. It is uncertain if Taiwan and Korea can maintain their leadership in the TFT-LCD industry. Against this backdrop, this study is set out to examine the competitiveness of the Taiwanese and Korean TFT-LCD industry. For this purpose, Porter's Diamond Model of national competitiveness and its extensions are utilized to develop a greater understanding of Taiwan's and South Korea's unique competitive advantages.

As the results of the analysis show, the key success factors of Taiwan and Korea are their favorable factor conditions, particularly their skilled workforce, their specialized educational system and hard infrastructure. Furthermore, spillovers from related semiconductor industry and the increasingly localized display part and material industries, both stimulated TFT-LCD industry growth. Taiwan and Korea also benefited from supportive governmental measures and strategic multinational activities of TFT-LCD manufacturers. Yet, as the study revealed, both nations are suffering from China's expansion plans since much of the demand is captured by Chinese manufacturers.

Zusammenfassung

Diese Arbeit untersucht die Wettbewerbsfähigkeit der zwei ostasiatischen Staaten Taiwan und Südkorea bezüglich ihrer Dünnschichttransistor-Flüssigkristallbildschirm (engl. TFT-LCD) Industrie. Während der letzten 20 Jahre hat die TFT-LCD Industrie ein außerordentliches Wachstum erlebt, insbesondere in der ostasiatischen Region. Die weltweite Nachfrage von TFT-LCD Paneelen entsteht durch den Gebrauch von Fernsehbildschirme, Laptops, Computer und Smartphones.

Seit Beginn des 20. Jahrhunderts konkurrierten Taiwan und Südkorea um den ersten Rang in der TFT-LCD Industrie. Mit dem Eintritt Chinas als Mitstreiter, stehen beide Nationen jedoch vor einer noch nie dagewesenen Bedrohung und es ist ungewiss, ob Taiwan und Korea ihre Führungsposition in der TFT-LCD-Industrie erhalten können.

Die vorliegende Studie untersucht die Wettbewerbsfähigkeit der taiwanesischen und koreanischen TFT-LCD-Industrie mit Hilfe eines Modells, dass auf Porters Diamond Modell basiert. Dieses hat den Zweck Faktoren zu ergründen, welche es Taiwan und Korea ermöglichen ihre Wettbewerbsfähigkeit zu erhalten.

Wie die Ergebnisse der Analyse zeigen, sind die wichtigsten Erfolgsfaktoren Taiwans und Koreas ihre günstigen Faktorbedingungen, insbesondere die qualifizierten Arbeitskräfte, das spezialisiertes Bildungssystem und die gut ausgebaute Infrastruktur von Bildschirm-Clustern. Darüber hinaus stimulierten Spill-Overs aus der verwandten Halbleiterindustrie und die zunehmend lokalisierten Bildschirmteile- und Materialindustrien das Wachstum der TFT-LCD-Industrie. Taiwan und Korea profitieren ebenfalls von fördernden staatlichen Maßnahmen und den strategischen multinationalen Aktivitäten ihrer TFT-LCD Produzenten. Allerdings wies die Studie auch auf, dass beide Länder durch Chinas Expansionsplänen unter Druck leiden, da in den letzten Jahren ein Großteil der Nachfrage von TFT-LCDs von chinesischen Herstellern vereinnahmt wurde.