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The Risk of Upgrading Strategy: Lessons from the Strategic Coupling between the Taiwanese FPD Industry and its Japanese Counterpart

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This paper aims to understand the risk of upgrading strategy by analyzing the strategic coupling between the Taiwanese flat panel display (FPD) industry and its Japanese counterpart. Strategic coupling between the Taiwanese FPD industry and Japanese firms gave a critical advantage to the Taiwanese FPD industry, yet simultaneously, Taiwanese firms were forced to become technologically dependent on Japanese firms. Cost performance production strategy, global collaboration network, and adjusting Japanese technologies in the Taiwanese FPD industry are the main development mechanism of strategic coupling between Taiwanese FPD manufacturers and Japanese firms. However, this strategic coupling also has negative effects on the Taiwanese FPD industry. Namely, it has had negative effects on industrial upgrading due to the lack of long-term human resource development and in-house technology accumulation. These findings serve as an opportunity to develop a more profound theoretical framework of the industrial upgrading strategy of local firms embedded in global value chains.

Keywords: *strategic coupling, global value chain, upgrading strategy, FPD industry, comparative study of Taiwan and Japan*

Introduction

This study tries to explore a global value chain (GVC) strategy of the FPD industry from a "strategic coupling" (Yeung 2014, 2016) point of view and seeks to uncover the main reason that Taiwanese manufacturers cannot rise to the stage of industrial upgrading and independent development. The view of strategic coupling holds that in the transformation process of East Asian capitalism from the developmental state (1950s to 1980s) to the post-developmental state (1980s to present) due to fierce global competition and the increasing demand for vertical division of labor, companies from East Asian periphery countries have actively participated in global supply chains to link their resources with the needs of foreign multinational companies. These East Asian companies strengthened their bargaining power in economic transactions through this strategic coupling strategy, and even attempted to reverse the unequal power relationship with foreign multinational companies (Kleibert 2014).

The view of strategic coupling sheds light on the industrial development process of East Asian periphery countries from the early development stage accelerated by a strong developmental state to the stage of firm specific initiatives since the 2000s and emphasizes the agency and initiative of periphery companies which actively participate in the global supply chain. However, strategic coupling ignores the dark side of this strategy; supposing that firms in periphery countries did not have sufficient knowledge and resources to establish equal business relationship with foreign multinational companies, strategic coupling would result in adverse outcomes. For example, issues such as unequal value capture, labor exploitation, and class conflict (Coe and Hess 2011; MacKinnon 2012). Strategic coupling focuses on the dynamic process through which companies in periphery countries join and articulate into global production networks and upgrade their competitiveness. However, strategic coupling does not pay much attention to the power relationships between lead firms and subordinate firms in this competitive global field. Strategic coupling is a theoretical framework that originated from global production network (GPN) research as a means to analyze the causal relationship between the dynamics of these networks and their territories. Specifically, strategic coupling explores how geographical relationships in the global production network affect regional industrial upgrading and working conditions (Coe and Yeung 2019). However, since strategic coupling does not focus on the industry architecture, it does not give

consideration to the analysis of the power relationship between lead firms and subordinate firms, as does GVC analysis.

In this sense, I shed light on the power relationships between the Taiwanese FPD industry and Japanese firms and try to identify the unequal development in the global FPD value chain. Although Taiwan and Korea similarly share a background as developmental states, there are significant differences between Taiwanese high-tech industries and their Korean counterparts in terms of innovation management. As Hemmert (2008) pointed out, Korean firms, such as Samsung, are notable for their aggressive and challenging strategies in their innovative activities. They tend to adopt risk-taking strategic behavior in order to advance cutting-edge technology and break into unexplored fields (Hemmert 2008, pp. 9-10). Taiwanese firms, on the other hand, are content in the second mover position, and generally tend to adopt passive and inactive strategic behaviors. Korean firms have produced some distinguished global brands, supported by aggressive strategies and the state's national champion policy, however, despite being deeply articulated into the global production chain, Taiwanese firms have not yet caught up with Western lead firms in terms of the level of technology and branding (Chu 2009).

This study attempts to explore the central reason that the Taiwanese FPD industry cannot achieve industrial upgrade in the global supply chain by examining it from the perspective of the adverse, or dark side of strategic coupling. The Taiwanese FPD industry introduced key manufacturing technologies and talents from the United States and Japan through the social network of the global technological community and high-tech talents, and captured the global LCD market share from their Japanese counterparts. However, Taiwanese manufacturers are still dependent on Japanese manufacturers' technology in the field of FPD manufacturing equipment and upstream key electronic materials.

Research Method

This research explores the relationships between Taiwanese FPD manufacturers and Japanese firms through documentary analysis, including industrial development analyses and press reports, as well as in-depth interviews with a total of 11 executives of Taiwanese FPD manufacturers, FPD production equipment manufacturers, electronic material manufacturers, industrial associations, and headhunting companies. Regarding data collection in

Japan, a total of 10 interviews were conducted with major electronics manufacturers, FPD production equipment manufacturers, electronic material manufacturers, and other relevant supervisors. In Korea, six interviews were conducted with executives in FPD industry associations, chief executives of *chaebol* electronics firms, and professors in department of electronics to acquire an in-depth understanding of the problems faced by Taiwanese manufacturers in the global FPD supply chain and the power relationships in the high-tech industry in East Asia (see Table 1).

Table 1
Full List of Interviewees

Code*	Job title	Division	Industry	Location	Nationality	Date of interview
O-J1	Section Leader	Global Marketing Division	Japanese Optoelectronics Materials Manufacturer	Japan	Japanese (Interview was conducted in Japanese)	2015/02/04
O-J2	General Manager	Media Marketing Division	Japanese Optoelectronics Materials Manufacturer	Japan	Japanese (Interview was conducted in Japanese)	2015/02/06
O-J3	Team Manager	Material Solution Division	Japanese Optoelectronics Materials Manufacturer	Japan	Japanese (Interview was conducted in Japanese)	2015/02/09
O-J4	Manager	Marketing Division	Japanese Optoelectronics Materials Manufacturer	Japan	Japanese (Interview was conducted in Japanese)	2018/02/09
O-J5	Manager	Marketing Department	Japanese Major Optoelectronics Equipment Suppliers	Japan	Japanese (Interview was conducted in Japanese)	2018/02/20
F-J1	Manager	R&D & Marketing	Japanese FPD Manufacturer	Japan	Japanese (Interview was conducted in Japanese)	2018/02/7
F-J2	Manager	FPD Planning Division	Japanese Major Electronics Company	Japan	Japanese (Interview was conducted in Japanese)	2018/02/8

E-J1	Manager	Technology Division	Japanese Manufacturing Equipment Association	Japan	Japanese (Interview was conducted in Japanese)	2016/02/01
E-J2	General Manager	Marketing Department	Japanese FPD Manufacturing Equipment Suppliers	Japan	Japanese (Interview was conducted in Japanese)	2018/02/13
E-J3	Manager	Marketing Department	Japanese FPD Manufacturing Equipment Suppliers	Japan	Japanese (Interview was conducted in Japanese)	2018/02/15
E-T1	Director	Electric Manufacturing Equipment Division	Industry Association	Taiwan	Taiwanese (Interview was conducted in Mandarin Chinese)	2017/08/14
E-T2	Secretary-General	FPD Materials and Equipment Division	Industry Association	Taiwan	Taiwanese (Interview was conducted in Mandarin Chinese)	2017/08/15
E-T3	General Manager	FPD Sales Division	Taiwanese FPD Manufacturing Equipment Suppliers	Taiwan	Taiwanese (Interview was conducted in Mandarin Chinese)	2017/08/20
E-T4	General Manager	FPD Sales Division	Taiwanese FPD Manufacturing Equipment Suppliers	Taiwan	Taiwanese (Interview was conducted in Mandarin Chinese)	2017/08/20
E-T5	Manager	R&D Division	Taiwanese FPD Manufacturing Equipment Suppliers	Taiwan	Taiwanese (Interview was conducted in Mandarin Chinese)	2017/08/22
E-T6	General Manager	R&D Department	Major Taiwanese FPD Manufacturing Equipment Suppliers	Taiwan	Taiwanese (Interview was conducted in Mandarin Chinese)	2017/12/02

ES-T1	General Manager	Sales Department	Taiwanese Electronic Manufacturing Service Company	Taiwan	Taiwanese (Interview was conducted in Mandarin Chinese)	2017/08/23
F-T1	Secretary-General	FPD Division	Industry Association	Taiwan	Taiwanese (Interview was conducted in Mandarin Chinese)	2017/08/15
F-T2	General Manager	Japan Branch	Major Taiwanese FPD Manufacturer	Taiwan	Japanese (Interview was conducted in Japanese)	2018/02/16
M-T1	Electrical engineering headhunter	Taiwan Branch	Singaporean Manpower company	Taiwan	Taiwanese (Interview was conducted in Mandarin Chinese)	2017/09/15
M-T2	Electrical engineering headhunter	Taiwan Branch	Japanese Manpower Company	Taiwan	Taiwanese (Interview was conducted in Mandarin Chinese)	2018/01/18
F-K1	Researcher	FPD division	Institute of Industry and Trade	Korea	Korean (Interview was conducted in Korean and translated into Japanese by Korean professional translator.)	2018/04/04
F-K2	President	FPD Marketing Division	Industry Association	Korea	Korean (Interview was conducted in Korean and translated into Japanese by Korean professional translator.)	2018/04/06

EL-K1	Professor	Department of Electronics	National University	Korea	Korean (Interview was conducted in Korean and translated into Japanese by Korean professional translator.)	2018/04/09
EL-K2	Professor	Department of Electronics	National University	Korea	Korean (Interview was conducted in Japanese)	2018/06/25
EL-K3	Researcher	Institute of Electronics	Research Institute	Korea	Korean (Interview was conducted in Japanese)	2018/06/27
EL-K4	Principal Consultant	Electronics & Manufacturing Team	Major Korean Electronics Company	Korea	Korean (Interview was conducted in English)	2018/06/28

*Each quotation from an interviewee in this paper was given a code to indicate the source of information. The first and second letter of the code refers to the main product grouping to which the company interviewee belongs. The following letters stand for the interviewee's country. The Arabic numbers refer to the serial number of the interviewee.

Risks of Strategic Coupling: The Dark Side of Global Production Network

Gereffi and other GVC scholars have focused on the structural aspects of leading firms that control value chain governance. They have attempted to analyze how local suppliers cooperate with focal companies through a cooperative network relationship in this structure. In particular, they have delved into the question of under what conditions local suppliers can increase the added value and achieve industry upgrading to affect the whole value chain governance (Sako and Zylberberg 2017). Manufacturers in core countries utilize the advantages of technological standards and brand name to control manufacturers in peripheral countries belonging to the global commodity chain (Gereffi 1994). Gereffi further pointed out that as long as suppliers in peripheral countries successfully participate in the global

commodity chain, they can achieve stable technology articulation, and it is easy to enhance their position in the value chain governance mode through organizational learning mechanisms. Suppliers from peripheral countries have developed from an export-oriented labor-intensive technology stage to a technology-intensive level of original equipment manufacturing (OEM) and original design manufacturing (ODM) and have reached a breakthrough technology stage with a relatively high gross profit margin: newly created goods, services, design, marketing, and financial systems (Gereffi 1999, p. 39).

Unlike GVC's corporate strategy analysis, the well-known strategic coupling perspective in the field of economic geography tries to integrate various structural factors—technological talent communities, collaboration relationships between suppliers in peripheral countries and MNCs, and the cross-national outsourcing business model—in order to analyze the process through which suppliers in peripheral countries actively establish cross-border cooperation networks with firms in core countries (Yeung 2016: 59-194). As opposed to the developmental state view that focuses on the country-led development model, both GVC and strategic coupling viewpoints explore the strategic aspects of suppliers. However, while GVC only focuses on how a supplier's strategy affects the value chain governance structure, the notion of strategic coupling attempts to analyze a supplier's agency and initiative in establishing cooperative network relationships with firms in core countries through institutional advantage and social network structure. In other words, the analysis of strategic coupling is aimed at how global commodity chains, countries, society, and societal/communitarian forces[1] interact and coordinate to support regional suppliers in peripheral countries to become the powerful focal enterprise in global market. In this way, unlike the GVC approach, strategic coupling points out that in the developmental trajectory of the global commodity-chain, the role played by governments in Asian leading suppliers has shifted from the early leading roles of "demiurge" and "husbandry" to the supportive role of "catalyst (Evans 1995)." After graduating from the developmental state stage, leading Asian manufacturers have gradually broken their dependence on governmental support and have worked as the global partners of branded companies in US and Europe to become core suppliers in the global production chain.

Strategic coupling of regional suppliers in peripheral countries is closely

[1] Taiwan has entered the stage of the post-developmental state, and the government's role in the process of economic development has become supplementary. Yang et al (2009) argues that, as a result, explaining the role of the transnational community in the interaction between government and economic competitiveness from strategic coupling perspective is an important issue.

related to the institution of each country, the collaboration model of the firm organization, social networks, and the establishment of collaboration network relationships with firms in core countries. For example, cross-national collaboration networks between Silicon Valley in California and Hsinchu Science Park in Taiwan have accelerated the technological learning system of the Taiwanese high-tech industry (Saxenian 1994; Hsu 2001; Yang et al. 2009). As will be discussed further, the cross-national production network between Japanese firms and their Taiwanese counterparts also made significant contributions to the development of the FPD industry in Taiwan (Tabata, 2014). Hsinchu Science Park was established by the Taiwanese government in 1980, and it built an intensive production linkage with Silicon Valley through a social network which was organized by Taiwanese engineers returning from the United States. It constructed the semi-conductor industrial cluster in northern Taiwan (Saxenian 1994; Hsu 2001; Yang et al. 2009). In the late 1990s, under pressure due to the Asian financial crisis and Korean firms catching up, major Japanese electronics firms were forced to build collaborative relations with Taiwanese FPD manufactures to strengthen their cost competitiveness. Tainan Science Park was established by the Taiwanese government in 1995 and shaped the high-tech industrial cluster in southern Taiwan. Subsequently, Japanese electronics firms situated their factories in Tainan Science Park and transferred FPD manufacturing technology to Taiwanese firms. Retired senior engineers and technology consultants who had worked at major Japanese electronics firms were hired by Taiwanese firms to provide technical guidance for Taiwanese engineers (Tabata 2012).

However, strategic coupling is not always the best strategy for all the suppliers in the peripheral regions. As the development process of suppliers is affected by its structural and institutional environments, endogenous and exogenous factors, suppliers in some regions are not only unable to join the global commodity chain (Yang et al. 2009) but even strategic coupling poses challenges to suppliers' development (Kaplinsky, 2000). For example, while suppliers in some regions actively participated in global commodity chains, they failed to gain benefits in the process of global integration, and they suffered from declining commodity prices and low labor wages and income levels. Kaplinsky (2000) also pointed out that the fundamental conditions to take advantage of global commodity chain are barrier to entry and economic rents, governance, and systemic efficiency.[2] If suppliers in peripheral

[2] "Economic rent" means that firms can raise their entry barriers through the level of technology

countries lack these three conditions, it inevitably may play a marginal role in the process of global integration, and the level of wages and incomes in these peripheral countries also might have a negative influence.

Global commodity chain (GCC) and GNP theoretical approaches focus on the process by which local companies successfully join global production networks. However, they underestimate how and why local companies could or could not participate in the network from a geographical position as well as a cross-national production arrangement point of view. To address this problem, Bair and Werner (2011) conducted research showed that despite active attempts to participate in global commodity chains, due to the decrease in customers' orders, suppliers in peripheral countries could not maintain added value and were kicked out of their respective global commodity chains. For example, in the 1990s, thanks to the North American Free Trade Agreement (NAFTA) and the advantages of regional agricultural development, regional suppliers in La Laguna quickly became global suppliers and established an industrial cluster of large-scale cowboy clothes manufacturers locally with major clients such as GAP and Calvin Klein. However, from 2004 to 2008, due to the drastic decrease in orders from United States, regional suppliers in La Laguna were kicked out of this global commodity chain. In the regional institutional system organized by the Brazilian government, industrial communities and corporate organizations were unable to adjust their added value and competitiveness, resulting in the inability to join new markets and supply chains, demonstrating the failure of the strategic coupling strategy. As for the dark side of strategic coupling or "disarticulation" in these global supply chains, Bair and Werner emphasize that analysis of the main reason for the disarticulation of local manufacturers from global commodity chains makes it easier for us to understand the strategy of local firms regarding how to choose and join specific global commodity chains and accumulate their capital. The analysis of the dark side of strategic coupling and disarticulation shows that the processes and mechanisms of the long-term involvement of suppliers in the global commodity chain are closely related to the social, institutional, and cultural contexts of the suppliers themselves (Bair and Werner: 16).

The strategic coupling approach originated from GCC and GNP theoretical and empirical research accumulation attempts to analyze the

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and other advantages to avoid attacks from competitors. "Governance" is a mechanism to adjust and arrange economic rents to enhance their value, "systemic efficiency" refers to the improvement of business efficiency (Kaplinsky 2000, pp. 122-126).

autonomous agency of suppliers in peripheral countries to establish collaborative relationships with lead firms in core countries from institutional structure and organizational network relationship perspectives. In the view of strategic coupling, it is not easy for suppliers to promote industrial upgrading when they are unable to gain advantages through cross-border firm relationships, industrial policy, and the local cluster economy. However, as mentioned above, strategic coupling pays little attention to the adverse effects of this strategy and power relationships between lead firms and local suppliers in peripheral countries (see Table 2). Lack of advanced technologies and management resources in local suppliers made them less likely to succeed in establishing an equal business relationship with foreign lead firms. Unequal value creation relationships, technological dependence, labor exploitation, and serious class conflict are inevitably caused by this negative impact of strategic coupling.

GVC's view mainly discusses the strategic orientation of suppliers in peripheral countries to promote industrial upgrading in value chain governance structure. The GVC view argues that if suppliers in peripheral countries make a strategic blunder in their choice of supply chains, adopting technology-innovative strategies and diversifying buyer portfolio, they cannot achieve industrial upgrading (Humphrey and Schmitz, 2002; Sturgeon, Humphrey, and Gruber, 2011). GVC also analyzes the situation in which local firms are integrated or not integrated into cross-border business networks as governance by the power relations of the respective actors. In addition, recent GVC research has expanded from the governance of linkages between lead firms and suppliers to a wider range of governance, including institutions and norms, including governments, certification authorities, and international NGOs, in a mode of participation of value chain. In this wide range of governance, GVC examines the power relationships between lead firms and suppliers in terms of price competitiveness, technology standards, technology upgrading, government regulation, buyer power, and tacit information (Ponte, Sturgeon et al. 2019).

Therefore, this study focuses on the process and condition of the so-called dark side of strategic coupling and the power relationships between lead firms and local suppliers in peripheral countries, and tries to explore the main reason for Taiwanese firms' technological dependence on Japanese firms from the GVC strategic governance perspective. By analyzing the details of the Taiwanese FPD industry's technological dependence on Japanese FPD manufacturing equipment and upstream key electronic materials, this study shows how the risk of upgrading strategy is closely related with the dark

side effect of strategic coupling.

Table 2
The differences between GVC and strategic coupling

GVC	Strategy of suppliers to promote industrial upgrading in value chain governance. Focusing on the relational dynamics of specific industry and firm. The power relationships between lead firms and suppliers in terms of price competitiveness, technology standards, technology upgrading, buyer power, government regulation, and tacit information.
Strategic Coupling	Autonomous "agency" of suppliers in peripheral countries. Collaboration relationship with lead firms in core countries through the institutional structure and organizational network. Undervaluation of "dark side" of strategic coupling, disarticulations in the uneven geographies of commodity chains.

The Transformation of Strategic Coupling in the Japanese FPD Industry: from "Downstream Control" to "Upstream Control"

During Japan's post-war economic growth, the development of cutting-edge technology was the main objective of the Japanese government and major firms. From the early to late 1990s, the Japanese FPD manufacturing business dominated the global market. However, after nearly two decades of recession with the liberalization of financial regulation, the Japanese development model fell into crisis and Japanese society also faced unprecedented economic stagnation. The FPD manufacturing divisions of Japanese electronics giants were facing a crisis due to a shortage of funds, the outflow of technology and talent, and the trend of Korean electronics giants quickly catching up. During this period, Korean and Taiwanese FPD manufacturers were rapidly catching up with Japanese electronics giants in the FPD industry's supply chain, and these Japanese electronics giants were forced to withdraw from the global large-scale FPD market. Since the early 2000s, FPD manufacturers in Korea and Taiwan have quickly caught up with the Japanese electronics giants in the FPD industry's supply chain. As a result, Japanese FPD manufacturing equipment and opt electronics materials manufacturers (upstream suppliers)

lost Japanese customers (downstream manufacturers). Therefore, Japanese upstream suppliers shifted their target customers to Taiwanese and Korean manufacturers from Japanese firms. Consequently, the transformation of strategic coupling from "downstream control" to "upstream control" became the major global strategy in the Japanese FPD industry (Tabata 2016).

In downstream control, Japanese electronics giants (downstream manufactures) play central roles in coordinating manufacturing networks through their brand and technology in the East Asian FPD global supply chain. On the contrary, in upstream control, Japanese optoelectronics materials and manufacturing equipment firms (upstream suppliers) play the pivotal role of supplying key materials and production equipment for Korean, Taiwanese, and Chinese FPD manufacturers. In this upstream control structure, major optoelectronics firms (upstream suppliers) in Japan are as follows: Hitachi, Nikon, Canon and JX Nippon Mining & Metals. Leading manufacturing equipment firms in Japan include ULVAC, Nikon, Canon, and TEL (Tabata 2016, pp. 156-158).

Fig. 1.—Technological dependence on Japanese firms in Taiwanese FPD industry

In the global FPD industry, TFT-LCD (thin film transistor liquid crystal display) manufacturing technology has led to many applications: television, flexible displays, electronic paper, electronic books, smartphones, and tablet PCs. TFT-LCD consists of around 25 key materials and components, which account for more than 75% of the cost structure of LCD TV panels. The major suppliers for the five most expensive components including optoelectronics materials are dominated by Japanese firms (Jurichich 2009, p. 1). As will be described below, until now, Taiwanese firms have been conservative regarding investing in OLED (Organic Light-emitting Diodes) which is notable for its next generation technology display. However, in recent years, Korean FPD manufacturers have actively invested in the

development of OLED displays and started to dominate the global market. Korean manufacturers also had dominated the global DRAM (dynamic random-access memory) market since the late 1990s; they took initiative in this business field and collaborated with various domestic and foreign equipment manufactures to innovate cutting edge technologies, and they have overall relied less on specific equipment manufacturers from Japan than their Taiwanese counterparts (Yoshioka 2006). If the case of the DRAM industry is any indication, the dependency on Japanese firms in the Korean FPD industry, which is developing with a singular focus on OLED manufacturing technology, may be diminishing at an even faster rate than Taiwanese firms.

One manager in an FPD industry association in Taiwan mentioned that manufacturing equipment and optoelectronics materials need to be certified for quality and service when they are on the market. However, almost all Taiwanese manufacturing equipment and optoelectronics materials firms are small in scale and cannot invest huge amounts of money in long-term research and development to obtain product certification. This is the main reason why Taiwanese manufacturing equipment and optoelectronics materials firms are not able to surpass the competitive advantage of their Japanese counterparts in the global market (E-T1). The general manager of a major Taiwanese manufacturing equipment firm explained the development trend of manufacturing equipment industry in Taiwan as follows.

> In Taiwan, due to government policy, the Industrial Development Bureau of the Ministry of Economic Affairs is encouraging domestic firms to increase the domestic production ratio. The current (2016-2017) domestic production ratio is about 40-60% for manufacturing equipment, but at that time, process equipment is about 80%. Basically, process equipment is array equipment. Array equipment in Taiwan is still focused on automation handling systems, cleaner equipment, and inspection equipment. This is the current situation in Taiwan. It seems that it has not changed much since five or six years ago. Because Taiwanese firms have not invested much in this field. For example, Japanese equipment manufacturers such as Nikon and Canon produce exposure equipment, but no one else is doing it in Taiwan (E-T6).

From the viewpoint of product architecture and product technology positioning, Taiwanese manufacturers transformed the *tacit* knowledge of Japanese large-size FPD manufacturing technology into *explicit* knowledge

during their long-term collaborative relationships with Japanese firms. Therefore, for Taiwanese manufacturers, the manufacturing technology of large-size FPD panels has become *standardized* knowledge, meaning that it is easy for them to handle this technology without any guidance from Japanese partners. However, with respect to the manufacturing equipment and optoelectronics materials, their technological characteristics and product architecture are vastly different from FPD manufacturing technology. It requires a long trial and error process to develop technologies, and technological knowledge, experience, and know-how accumulated over a long period of time are embedded in engineers' teamwork and business organizations. It is not easy for this tacit knowledge embedded in Japanese engineering teams and firms to outflow and diffuse across other countries. The general manager of the marketing department at one Japanese FPD manufacturing equipment firm explained the firms' measures to prevent technology outflow:

> Though there are a few cases that Japanese senior engineers of manufacturing equipment firms who moved to Taiwanese and Korean counterparts, the technology of manufacturing equipment firms is not easy to outflow to foreign countries. Because manufacturing equipment is not produced by just only one or two engineers but produced by a technological team which are organized by many engineers, so it is extremely hard to outflow to foreign firms (E-J2).

"Trial and error" and "learning by doing" solution methods in Japanese firms require the investment of large amount of R&D expenses and long-term accumulated experience. Taiwanese FPD manufacturers have been taking a more passive stand against investing huge funds into the research and development of FPD manufacturing equipment, and thus they are still under the control of their Japanese counterparts. The Taiwanese FPD industry combines two types of commodity chain management governance: "process upgrading"[3] and "inter-sectoral upgrading"[4] strategies. The Taiwanese

[3] Process upgrading is a cost reduction strategy adopted by suppliers during the production process, such as adjusting labor costs, improving logistics efficiency, and strengthening the operating environment (Blazek 2016: 853-855).

[4] Humphrey and Scmitze (2002) and Kawakami (2018) pointed out that the Taiwanese high-tech industry's suppliers have established a close cooperative relationship with customers through the "inter-sectoral upgrading" strategy to introduce core technical knowledge in order to shift from low-end technology value chain governance into advanced technology value chain governance model. Taiwanese computer giants such as ASUS are representative examples.

FPD industry saves on manufacturing costs by adjusting personnel costs, improving logistics efficiency, and utilizing foreign production bases in what can be called a "process upgrading" strategy. In the meantime, Taiwanese FPD manufacturers establish close collaborative relationships with Japanese manufacturing equipment firms and optoelectronics materials suppliers and set up a manufacturing base quickly to save time for doing long-term in-house "trial and error" solution method: "inter-sectoral upgrading." In the process of this "inter-sectoral upgrading" strategy, Taiwanese FPD manufacturers need to strengthen their collaborative relationships with Japanese manufacturing equipment and optoelectronics material firms and, at the same time, it is necessary for them to improve their ability to coordinate and adjust Japanese technology. For example, purchasing manufacturing equipment from Japanese firms is also a process of technological learning. The reason is that Taiwanese FPD manufacturers that purchase manufacturing equipment need to learn about the concept of manufacturing technology and arrange the overall formula of display design. After purchasing manufacturing equipment, due to the situated cognition, each manufacturing equipment has different characteristics, thus Taiwanese FPD manufacturers need to communicate closely with Japanese equipment manufacturers to establish the best conditions for producing displays. Especially in the production network of the FPD industry, manufacturing equipment is the key machine equipment. As for the Taiwanese FPD industry, establishing a close collaborative relationship with Japanese manufacturing equipment firms is an important step in controlling the global supply chain and managing strategic coupling.

Strategic Coupling in the Taiwanese FPD Industry: the Limit of "Process Upgrading"

As I mentioned in the previous section, Taiwanese FPD manufacturers introduced Japanese core technology and tech talents, replaced the position of the Japanese consumer electronics giants, and procured the global FPD market. Japanese optoelectronics material and production equipment manufacturers changed their strategy, shifted their major customers from Japanese consumer electronics giants to FPD manufacturers in Taiwan and Korea.

At the beginning of the development of the FPD industry in Taiwan, the Taiwanese government provided strong support for this industry. The

Industrial Technology Research Institute (ITRI), the most recognized public research institute in Taiwan, promoted the development of key industries in response to such government policies. In 2002, ITRI established the Color Imaging Industry Promotion Office (CIPO) in the Industrial Development Bureau of the Ministry of Economic Affairs. CIPO integrated the synergy effect of industry, government, universities, and research institutes to assist with the investment and expansion of the Taiwanese FPD industry. In 2006, the Taiwanese FPD industry performed very well in the field of large-size TFT-LCD, with its shipments reaching approximately 140 million units. This volume was equivalent to 50% of market share in the global TFT-LCD industry, and surpassed Korean electronics manufacturers, which are ranked first in the world (iKnow Room, December 12th, 2006). However, after the late 2000s, the Taiwanese FPD industry missed opportunities to upgrade and was quickly overtaken by Korean and Chinese manufacturers. Compared with its Korean, Chinese, and Japanese counterparts, the Taiwanese FPD industry is quite conservative regarding investment in OLED display technologies. In response to Chinese manufactures catching up with them, Korean FPD manufacturers actively invested in the development of OLED display. OLED display is thinner and more energy-efficient than TFT-LCD, the color contrast is quite vivid, and it is also possible to produce curved screens. However, it is quite technologically complex, the materials and chemical handling procedures are extremely complicated, and credible yield control is required. Korean and Japanese manufacturers invested in OLED production capacity aggressively and obtained a considerable number of OLED display related patents. Chinese manufacturers also began to invest in the OLED display industry (Taiwan Business TOPICS February 10, 2017). In March 2017, AUO[5] failed to keep up with the OLED production trend and was excluded from Apple's 200 major suppliers. Thus, Taiwanese FPD firms completely withdrew from Apple's global supply chain (CNA, March 29, 2017). In 2019, Apple decided to equip the new model of the iPhone with an OLED display. Taiwanese integrated device manufacturers (IDMs) Pegatron[6] and Wistron[7] received a small number of assembly orders for the new iPhone, and Foxconn[8] received assembly orders for the new iPhone model as well

[5] Major FPD manufacturer in Taiwan

[6] Taiwanese major electronics manufacturing company. Subsidiary of ASUS: Taiwanese leading notebook PC firm.

[7] Taiwanese major ODM (original design manufacturer) firms for information and communication technology (ICT) products.

[8] Foxconn Group is the world's largest EMS (electronics manufacturing service) firm from

(UDN.Com May 30, 2018). Although Innolux[9] did not invest in OLED display itself, Sharp,[10] an affiliated firm of Innolux, started to produce OLED display for mobile phones in the spring of 2018. The iPhone X OLED display is currently exclusively supplied by Samsung. Therefore, Foxconn tried to acquire iPhone display orders through Sharp's mass production technology (Yin and Hsiao 2018).

As discussed, the mainstream product in the FPD industry has changed from TFT-LCD to OLED display. The Taiwanese FPD industry was unable to join the global commodity chain of Apple, and with the exception of Foxconn, FPD manufacturers are facing a disarticulation crisis. The Taiwanese FPD industry has been struggling, especially since 2010, falling behind Korea and China. In 2018, Taiwan's Innolux increased the number of units shipped by gaining Chinese customers such as Huawei (see Figure 2). However, as seen in Figure 3, the revenue of Taiwanese companies is far below that of Korean companies due to the lower value added of their products. The future situation of Foxconn is far from optimistic. In terms of OLED display technology, Foxconn is completely dependent on Sharp in Japan. Foxconn is reluctant to conduct long term human resource and technology development in Taiwan. It only relies on FPD factories and technological talents from Japan to fight Korean firms' high technological level and Chinese firms' vast economic scale.

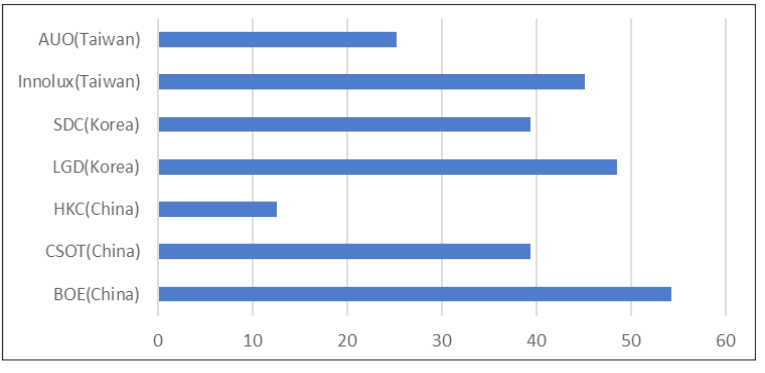

Fig. 2.—2018 Global FPD Shipment (million pieces)

Source: New Fortune, September 9th, 2019.

Taiwan.

[9] Innolux is a major FPD manufacture in Taiwan. Subsidiary of Foxconn Group.

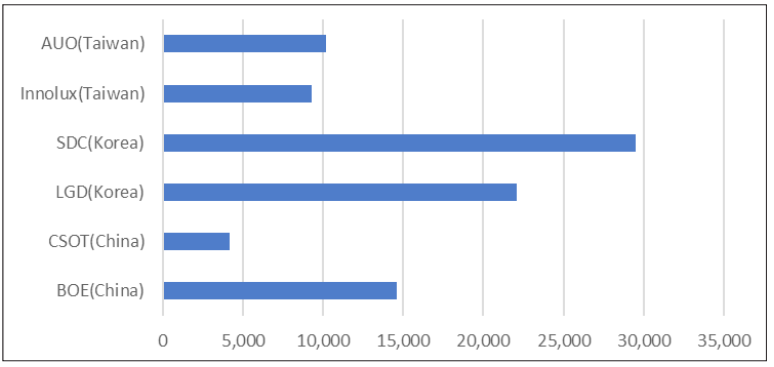

Fig. 3.—Global Top Six FPD Companies' FY2018 Revenues (US$ millions)

Source: New Fortune, September 9th, 2019.

The Taiwanese high-tech industry has utilized a "process upgrading" strategy to strengthen its international competitiveness, such as by reducing production costs by cutting personnel costs, improving logistical efficiency, and using foreign production bases for many years. In particular, the reduction of labor cost is desperately serious. The average workday for technological talents in Taiwan does not finish even well after 9 o'clock in the evening. The main business of Taiwan's high-tech industry is outsourcing manufacturing such as OEM, ODM, and foundry, and delivery term and lead time are inevitably controlled by foreign customers. In other words, the "making out" game in sweatshops (Burawoy 1979) has become somewhat of a norm in the Taiwanese high-tech industry workplace. The salary of Taiwanese technology talents is generally lower than that of their foreign counterparts, and engineers are forced to work overtime (M-T1).

Compared to Japanese FPD manufacturers, Taiwanese manufacturers made strategic decisions more quickly, such as introducing automation systems to reduce personnel costs. However, regarding the working conditions of engineers and the accumulation of technology, there is a possibility that the introduction of such automation systems diminishes opportunities for long-term human resource development and the accumulation of technologies. The general manager of the marketing division in a Japanese FPD manufacturing equipment firm pointed out the problems and limitations

[10] Sharp is former renowned FPD manufacturer in Japan. In 2016, Taiwan's Foxconn Group merged Sharp.

of the process upgrading strategy, which focuses on cutting costs in the following way.

> Taiwanese customers (FPD manufacturers: author's note) are not willing to pay the "development experiment fee." Our Japanese manufacturing equipment firm cooperates with customers to develop new product technologies. Customers usually spend money to ask us to conduct basic experiments. Through this experiment, we can try new technologies and develop new functions of manufacturing equipment. However, Taiwanese customers are unwilling to pay experiment fees. They do not pay experiment fees, so they cannot carry out new innovative technology's experiments... If they cannot expect to profit immediately, Taiwanese manufacturers are not interested in investing on this business (E-J2).

As Japanese manufacturers pointed out, Taiwanese manufacturers are not interested in the long-term "trial and error" technology improving system that requires massive funding. Taiwanese manufacturers lower and reduce the specifications and prices of their products at any time according to customers need, and quickly provide products with high cost-performance ratios. The problem is that Chinese manufacturers have also imitated their Taiwanese counterparts' marketing strategy that prioritizes cost-performance ratio and have competed with Taiwanese manufacturers through the power of huge cheap labor. Sooner or later, the advantages Taiwanese manufacturers currently have will be replaced by those of Chinese manufacturers (E-J2).

Conclusion

As shown in results of the field research, the Taiwanese FPD industry successfully began to play a leading role in the global FPD commodity chain through strategic coupling. However, Taiwanese manufacturers joined the global supply chain through a cost-effective development strategy to reduce personnel costs and spur the trend of high-tech talent moving overseas. As a result of this cost-effective development strategy, Taiwanese FPD firms could not upgrade their technological competitiveness, and were obliged to receive their supply of key materials and manufacturing equipment from Japanese firms. The context of strategic coupling departed from the developmental state notion and the state's earlier role as husbandry or demiurge, however this concept focuses on the firm-specific initiatives and explored the process

of East Asian firms' participation in global production networks since the late 1990s (Yeung 2016). Originally, subordinated firms such as Taiwanese high-tech firms acquired cutting edge technology and knowhow from lead firms succeeded to expand their global market through such strategic coupling. However, this success story has also negative aspects; the inconvenient truth is that Taiwanese high-tech firms are forced to be dependent on the Japanese electronics material and manufacturing equipment manufacturers in this global production network. In other words, the process of Taiwanese high-tech firms' articulation into global production network is a sort of double-edged sword; in articulating they could utilize the resources of the global production network and upgraded their competitive advantage, however, simultaneously, they have been trapped in technological dependence on upstream Japanese manufacturers for a long time.

FPD production equipment and the electronic materials industry requires teamwork-based research and development, so there are few opportunities for an outflow of technology overseas. Japanese firms have maintained their advantage in brand and technology for several decades. Therefore, the Taiwanese FPD industry was forced to adopt a passive and inactive innovation strategy, whereby they reduced R&D investment and human resource development costs. In addition, the Taiwanese FPD industry adopted a "process upgrading" strategy; through the international logistics network, automation system and reduction of labor costs improved production cost effectiveness. In this global supply chain, Taiwanese manufacturers must purchase FPD production equipment and electronic materials from Japan. As a result, breaking their technological dependence on Japanese firms is not easy.

Thus, the Taiwanese FPD industry does not pay special attention to the establishment of Taiwanese brands, long-term human resources, or technology development. As interviewees mentioned, Taiwanese manufacturers must strengthen their cost-effectiveness and global marketing strategies, which are Japanese firms' weak points, to keep up with the drastically changing high-tech industry's life cycle. Specifically, Taiwanese manufacturers are devoted to playing the role of assisting Japanese companies in opening global marketing channels, and leave brand building, human resource development, and technology development to Japanese manufacturers. In brief, the main reason for the emergence of dark side of strategic coupling between Taiwanese firms and Japanese counterparts in the global FPD market is the less targeted and passive technology strategy in the Taiwanese FPD industry. Their short sighted technology strategy, a lack of

the long-term human resource development, and sticking to the process upgrading strategy focusing on the cost effectiveness may have cost them bigger opportunities.

In terms of the contract manufacturing-based development, for example, Foxconn and TSMC, the industrial community in Taiwan expects the division of labor development model in Taiwan and Japan to be promising in the future. This development model implies that Taiwan's high-tech industry is responsible for global marketing strategy and cost control while their Japanese counterpart handles brand building. However, we cannot ignore that Taiwan's high-tech industry is hyperfocused on cost-saving. Though the cost-effectiveness strategy is useful for the development of a global market, it requires lowering personnel costs and a low-wage labor market. Under this development model, Taiwanese high-tech industry is prone to exploit the surplus value of its technological talents, and the talent drain—senior engineers who cannot endure the working conditions in Taiwan seeking employment outside of Taiwan—is becoming increasingly serious. In addition, from a long-term perspective, although Taiwanese manufacturers can assist the Japanese FPD industry in developing overseas markets, the problem of the Taiwanese FPD industry's technological dependence on Japanese counterparts has no easy solution. To strengthen the local capability of Taiwan's high-tech industry, Taiwanese firms need to focus on social upgrading, and invest in long-term human resource development, employment security, and technology research and development.

Regarding the role of the state in Taiwan, investing in technology and the workforce should become extremely urgent priority for the Taiwanese government. As Yeung (2016) pointed out, by the early 1980s, under the rule of Kuomingtang (KMT) authoritarian government, Taiwan's industrial officials strongly supported large scale industrial firms in heavy industries such as petroleum and chemical products; the developmental state has played an important role in the growth of Taiwanese economy. However, Taiwan achieved swift democratization and market liberalization during the late 1980s, and the first opposition party, the Democratic Progressive Party (DPP) was established in 1986. Due to the rapid development of private companies under the rule of the KMT, in the 1990s and the 2000s, technocrats in government bureaucracy have lost their powerful role and private firms and social groups have supplanted the position of state autonomy. Around that time in the 1980s, Taiwanese private firms became integrated into global production networks in high-tech industries and accelerated to reduce the importance of sector-specific industrial policy in the developmental state.

Thus, the development of democracy in Taiwan succeeded to undermine the authoritarian state initiatives, the articulation of Taiwanese high-tech firms and global production networks also boosted to weaken the state autonomy and industrial policy (Yeung 2016: 28-189). In the integration process of Taiwanese high-tech firms into global production networks, Taiwanese firms utilized their technological talent pool, collaborative relationships with buyers, and cross-national outsourcing business model to upgrade their technological level and marketing strategy. However, it is vital to note that articulation into global production networks not only brought about various advantages for Taiwanese FPD manufacturers, but also generated a negative development structure: long term technological dependency on Japanese material and manufacturing equipment firms. In terms of the relationship between democracy and state autonomy, since the late 1980s, Taiwanese society succeeded in breaking up the authoritarian developmental state economy; private sectors were integrated into global production network and began to grow their power in the development of high-tech industries. Though these Taiwanese high-tech firms upgraded their competitiveness through their global outsourcing business model as well as collaboration with lead firms and high-tech industrial clusters, they are still stuck being dependent on Japanese material and manufacturing equipment firms. In this unequal power relationship with lead firms, a new state role that differs from the authoritarian regime of the past is required. This new state role would consist of a supportive and active government as well as plans to promote social upgrading and a sustainable society. For example, government support for a program for long term technological upgrading and human resource development. This new state role is expected to revise and correct the private sectors' short sighted strategy and the harmful influence of global capitalism.

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