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The Transformation of Interdependence between Japanese and Taiwanese TFT-LCD Industry: The Strength of Japanese Component and Equipment Industry in the East Asian Production Linkage

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ABSTRACT.
The rise of the global economy has transformed the competitive and interdependent relationships in the East Asian production linkage. As the development of globalization, Japanese downstream industry such as manufacturing industry, especially the consumer electronics industry is facing fierce catch up phenomena of South Korean, Taiwanese and Chinese manufactures. Many factories of Japanese consumer electronics firms were automatically forced to shut down and on the other hand, their suppliers: Japanese upstream firms such as electronic component and equipment suppliers have lost their business in Japanese domestic market, and they were under pressure to enter global markets. In the case of the relations between Japanese upstream industry and Taiwanese TFT-LCD downstream firms, responding to this transformation of competitive relationships in global TFT-LCD (Thin Film Transistor Liquid Crystal Display) markets, Japanese electronic component and equipment suppliers have been integrated into the strategic production linkage in East Asian countries. This is increasingly leading them to abandon the clients in Japan, and to become main electronic component and equipment suppliers for TFT-LCD manufacturers in Taiwan. In spite of the long term recession of Japanese economy and the decaying of downstream industry, under the Japanese regulatory regime, Japanese upstream industry has thus maintained their technological advantage in the global TFT-LCD markets, and still has dominated electronic component and equipment business for TFT-LCD manufacturers in Taiwan..
Keywords: TFT-LCD industry, regulatory regime, component and equipment industry, production linkage, East Asia.

INTRODUCTION

Taiwanese electronics firms began to outpace their competitors from Japan in TFT-LCD (Thin Film Transistor Liquid Crystal Display) industry's competition from about the year 2000(Tabata. 2012, 2014). However, this situation is just only in the manufacturing process of TFT-LCD industry. Taiwanese manufactures still rely on Japanese upstream industry in the field of electronic components, key materials and manufacturing equipment. Japanese upstream firms have extended their business activities in East Asian production linkage, and have considerable control of the catch up phenomenon of South Korean, Taiwanese and Chinese firms.

I re-focus the analysis to the diversity of East Asian capitalisms (Boyer ,Uemura & Isogai: 2012) using concepts from the literature on regulation theory (Boyer: 1986) to track the transformation of interdependence between Japanese and Taiwanese TFT-LCD industry. Using data from depth interview of senior engineers, business managers and national government bureaucrats in Japan and Taiwan and secondary analysis, I try to explore the coordinate mechanism of interdependence between Japanese and Taiwanese TFT-LCD industry, and the impact of the catch up phenomenon of Taiwanese and South Korean firms on the firms of strategies and the system of innovation in Japanese firms. In the manufacturing process of TFT-LCD, Taiwanese manufacturers have become no longer learning technology from Japanese firms. However, in terms of component, materials and TFT-LCD manufacturing equipment, Taiwanese firms still rely on the technology of Japanese counterparts. What is the main problem of the systems of innovation in Taiwanese TFT-LCD industry? How does the strength of Japanese upstream industry fight back the catch up of South Korean, Taiwanese and Chinese firms in the East Asian production linkage? These are the main research problem of my article. Finally, I try to integrate the historical process of transformation of interdependence between Japanese and Taiwanese TFT-LCD industry and elaborate on the regulation mode (Lipietz: 1987) in the diversity of East Asian capitalisms.

The Collapse of Japanese Companyist Regulation and Consumer Electronics Industry

In the early 1960s and the late 1990s, Japanese consumer electronics industry has kept on evolving its competitiveness and dominated East Asian markets. From the growth of TV set, to the development of semiconductor and mass production of TFT-LCD, Japanese consumer electronics giants, such as Hitachi, Toshiba, Mitsubishi, Sharp, Fujitsu, Panasonic, Sony, NEC: large nine companies in Japanese consumer electronics, have taken a leadership in this global field for over thirty years. However, due to the wave of globalization and financial liberalization, the Japanese mode of regulation changed drastically in the last decade of the twentieth century, Japanese electronics industry has lost its competitiveness, and played second fiddle to South Korean big business . Japanese regulation scholars who were enlightened by Fordism in the French regulation theory proposed a hypothesis of "companyist regulation" as a mode of regulation in post-1970s Japan (Yamada and Hirano, 2012). My field study in Japanese TFT-LCD industry and Taiwanese counterparts demonstrated the significant impact of the drastic change of Japanese mode of regulation as represented by companyist regulation over the collapse of Japanese consumer electronics industry.

Companyist regulation has two institutional character: employment security and management security. Life time employment has been a social norm between the management and workers since the postwar years of spectacular economic growth, main bank system where firms could fully enjoy the benefit of additional finance, favorable interest rates, and dispatched executives from banks through the stable finance collaboration relationships with particular banks supported employment security. The cross-shareholdings and keiretsu system: web of corporate alliances and collaboration relationships between the banks and government also enhanced and protected the sustainable development of management security in Japan. (Yamada and Hirano,

2012: 16-17).

Due to the pressure for financial deregulation by the USA and serious economic slump since the 1990s, management security in Japan has become destructed. Companyist regulation as a social adjustment principle suffered catastrophic damage, caused the collapse of job security, seniority-based promotion and employee welfare program (Yamada, 2008: 178-208). Drastic transformation in mode of regulation made an enormous impact on the development of Japanese consumer electronics industry. In the period of postwar growth, Japanese leading consumer-electronics giants has been operating in-house divisions of various manufacturing business. However, in addition to the transformation of Japanese companyist regime, Japanese consumer electronics giants were hard hit by the bursting of the information technology bubble in 2000, and suffered a huge deficit. Due to the South Korean business groups' fast-paced catch-up and serious recession, Japanese consumer-electronics giants liquidated in-house large-size TFT-LCD manufacturing division, and spun off them into separate companies. TFT-LCD manufacturing division which was spun off from main office downsized their operations, and were forced to focus on the R&D and manufacture of small-size TFT-LCD. In consequence of the restructuring and workforce cut, Japanese senior engineers specialized in manufacturing large size TFT-LCD lost their jobs or were forced to transfer to another business divisions and could not take advantage of their expertise in Japanese consumer electronics firms. Some of them left consumer electronics giants and started their own business, however, almost all Japanese senior engineers were headhunted by South Korean and Taiwanese firms in contract base, this brain drain of Japanese senior engineers has continued until 2002(Tabata, 2012).

The Rise of Taiwanese TFT-LCD Industry: the Collapse of Innovation Regime in Japan

Since 1990s, South Korean major electronics firms have started to play a central role in the global high-tech industry. South Korean electronics firms through financial support by business groups and South Korean government has invested lavishly in manufacturing plants, sold decent quality consumer electronics at a low price to the world market. Japanese consumer electronics giants has injected a sizable amount of funds into research and development, produced high-quality products over the whole postwar period. However, due to the catch up of South Korean firms, such innovation regime in Japan: technology-centric strategy which sticks to the inexhaustible upgrade of technological level and quality has lost its competitiveness.

Since the 1970s, under favor of strategic industrial policy by the government, Taiwan as well as Singapore and South Korea have become the world's major exporters of information technology-related producers. Taiwanese government established Hsinchu Science-based Industry Park and research institutes such as Industrial Technology Research Institute (ITRI) and Electronics Research Service Organization (ERSO), and incubated technology capital-intensive semiconductor start-ups: TSMC and UMC. ITRI and ERSO mediated the collaboration relationships between domestic firms and foreign high-technology companies, recruited returning Taiwanese engineers who have gained work experience and technological knowledge in Silicon Valley (Yeung, 2009:334).

Taiwanese LCD industry has started since the late 1970s, Taiwanese engineers returned from the United States passed on the experimental manufacturing technology of LCD in Taiwan. Japanese consumer-electronics giants refused transferring mass production technology to Taiwanese manufactures, Taiwanese manufacturers on the basis of experimental technology introduced from the United States, through trial and error, accumulated their experience and know-how. As a result, the rise of South Korean firms and long-term depression in Japan gave a big breakthrough for a take-off of Taiwanese TFT-LCD industry.

In 1998, Japanese consumer-electronics giants suffered from South Korean firms' fast-paced catch-up, started to transfer mass production technology to Taiwanese manufacturers. The purpose was outsourcing production process to Taiwanese manufacturers to reduce production

cost. From 1997 to 2000, Taiwan's major TFT-LCD manufactures such as CPT, Unipac, Acer Display Technology, Hannstar successfully introduced key technology from Japanese companies.

As mentioned above, owning to the collapse of employment security in Japan, Taiwanese TFT-LCD manufacturer headhunted a large number of senior engineers from Japan, Taiwanese TFT-LCD manufacturers learned and mastered Japanese key technology and tacit knowledge. In the early 2000, Taiwanese TFT-LCD manufacturers through the accumulation of experience and know-how, introduction of Japanese senior engineers, technology transfer from Japanese companies, they had already learned and mastered key technology of TFT-LCD. Under the influence of internal factors in Taiwan (accumulation of experience and knowhow, social embeddedness), technology blockade policy (black-box strategy) adopted by Sharp (Japanese largest TFT-LCD manufacturer) since 2004 was minimally effective. Taiwanese TFT-LCD industry still increased in the size of operation, in contrast, Japanese consumer electronics giants completed their withdrawal from large size TFT-LCD manufacturing process. Sharp which solely continued manufacturing large size TFT-LCD in Japanese consumer electronics giants suffered from a heavy debt load, President Kozo Takahashi met with executives of the creditor banks to seek financial support for the firm's rehabilitation in early March 2015. Sharp also is considering 5,000 job cuts, or downsizing about 10 percent of its global workforce(Japan Times, March 19, 2015).

The Survival of the Japanese Component and Equipment Sector: Developing Global Markets

TFT-LCD is an extremely important electronics device in consumer electronics industry. Success in the development of TFT-LCD manufacturing technology has led to many applications for flat-panel displays (FDP), including television, flexible displays, electronic paper, electronic books, smartphones, tablet PC and advertising signs (Hilsum, 2010: 1027). TFT-LCD is composed by about 25 key materials and components, they are expected to contribute more than 75% to the cost structure of 40-42" LCD TV panels. Five most expensive components' major suppliers are as in Table 1 (Jurichich, 2009: 1):

Table 1. Five most expensive TFT-LCD components' major suppliers

Key Components for TFT-LCD	Percentage of Total Costs of TFT-LCD	Major Supplier
Backlight units	33%	Radiant(Taiwan) Coretronic(Taiwan) Taesan(South Korea) Heesung(South Korea) Sharp(in house)[1] AUO and CMO(in house)
Color filter	19%	Toppan Printing(Japan) TORAY(Japan) DNP(Japan)
Polarizer	9%	Fuji Photo Film(Japan) Kuraray(Japan)

[1] The capacity of Sharp's backlight units is dedicated to in-house production. AUO and CMO (major TFT-LCD manufacturers in Taiwan) are gradually expanding their operation of in-house backlight assembly for LCD TV backlights (Jurichich, 2009: 5).

		Fuji Photo Film(Japan) Konica(Japan) Nitto Denko(Japan)
Array glass substrate	8%	Asahi Glass(Japan) Corning(U.S. firm) NH Techno Glass(Japan) Nippon Electro Glass(Japan)
Backlight inverter	7%	Darfon (Taiwan) Foxconn(Taiwan) Logah(Taiwan) Sharp(Japan) Taiyo Yuden(Japan)

Source: (Jurichich, 2009)

As indicated Table 1, global market of TFT-LCD components is dominated by Japanese firms, in the late 1990s and the late 2000s, almost all Japanese TFT-LCD component manufacturers' share of world market have exceeded 60% (Wu, 2014:101). Global market of TFT-LCD manufacturing equipment is also an exclusively territory of Japanese firms, and their technology level is still top class in the global market (see Table 2).

Table 2. Major TFT-LCD manufacturing equipment maker

	Sputtering equipment	CVC equipment	Exposure equipment	Coater/ Developer	Dry etching equipment
Japanese firm	ULVAC Canon-anelva Hitachi Zosen	ULVAC Hitachi Zosen	Nikon Canon Hitachi-hightech Screen holdings Vtec Ushio	Screen holdings Toray engineering Tokyo ohka kogyo/Tazmo[2] Tokyo electron Shibaura mechatronics Micro engineering	Tokyo electron Y.A.C.
Non-	AKT(AMAT	AKT(AMAT		SEMES(South	WONIK

[2] Tokyo ohka kogyo and Tazmo established collaboration relationship in Coater/ Developer business(Masuko, 2014: 2).

Japanese firm	group)(U.S. firm)	group)(U.S. firm) Jusung Engineering(South Korean firm)		Korean firm) Systems technology (South Korean firm)	IPS(South Korean firm)

Source: (Masuko, 2014)

Due to the withdrawal of Japanese consumer-electronics giants from large size TFT-LCD global market, major customer of TFT-LCD component and manufacturing equipment has shifted from Japan to Taiwan. In other words, TFT-LCD component and manufacturing equipment's mainstream market has become Taiwan, South Korea and China. Japanese component and manufacturing equipment makers were pushed in the developing global market strategy to survive in the competitive relationship with Taiwanese, South Korean and Chinese followers (MF-J3). Japan YAC company (TFT-LCD manufacturing equipment maker)'s cadre commented the expansion of bargaining power of Taiwanese customers:

Now, we are talking business relationships with Taiwanese customers, such as TV set, smart phones, mobile device or touch panel manufacturers. If we'd like to sell LCD manufacturing equipment to these Taiwanese customers, we are always asked by them "Have you ever had business dealings with Samsung or LG? ". It just looks like that we are tested by Taiwanese manufacturers. But, we are not asked by them whether we have had business dealings with Sharp. Recently, Samsung and LG LCDs' manufacturing technology have become a mainstream technology in this global competitive field. So, relationship between Taiwanese TFT-LCD manufacturers and Japanese LCD manufacturing equipment makers has been changing drastically. Anyway, South Korean manufacturers received much more attention than Japanese counterparts(MF-J3) .

The product of Samsung Electronics has become mainstream LCD TV in European and emerging markets. If Japanese component and manufacturing equipment makers established customer and supplier relationship with South Korean TFT-LCD manufacturers, Japanese firms are able to gain good reputation and trust, and easy to get another customers in East Asian TFT-LCD market. For example, Japanese LCD equipment manufacturers are trying to do business with Taiwanese customers, they inevitably are asked by Taiwanese customers whether they have had business relationships with South Korean manufacturers or not. The business experience with South Korean manufacturers has become the important trust for signing a business contract. Taiwanese manufacturers do not care about that whether Japanese LCD equipment manufacturers have signed a contract with Japanese major consumer electronics giants such as Sharp.

A senior business manager in Canon (Japanese major electronics company whose product portfolio includes TFT-LCD manufacturing equipment) pointed out, the rise of South Korean and Taiwanese TFT-LCD industry started at the beginning of 2000s, however, due to the global business downturn, Japanese consumer electronics giants were extremely conservative to do large-scale investment on the TFT-LCD industry. Japanese LCD component and equipment manufacturers which lost major customers in Japan began to develop new market in Taiwan and South Korea to sell TFT-LCD component and manufacturing equipment to Taiwanese and Korean TFT-LCD manufacturers:

In terms of the protection of Japanese technology, Japan's leading businesses, for example Japanese consumer electronics giants just like Sharp, NEC and Hitachi (major TFT-LCD manufactures in Japan) should block leaks of their corporate secrets. But, we are not this kind of vendor, just only standing at the position to supply TFT-LCD manufacturing equipment to the varieties of customers in the global TFT-LCD market. As long as customers meet certain benchmarks, regardless of which countries in the world, we will sell our products to them. Any countries, Taiwan, Korea or China, we will sell our TFT-LCD manufacturing equipment to them. It would be a pleasure for

us to accept their orders. I think that Japanese equipment manufacturers could not receive orders from Japanese consumer electronics giants, finally with no other choice, they started to sell their products to Taiwanese TFT-LCD manufactures around 2000(MF-J4).

When Sharp promoted research and development of sixth-generation TFT-LCD manufacturing technology in order to maintain technological advantages, Taiwanese TFT-LCD manufacturers have started to set up the fifth-generation plant which was a mainstream technology in global TFT-LCD market trend on that time. Taiwanese TFT-LCD manufactures started to buy a large amount of fifth-generation lithography equipment from Canon. Canon Business Manager said:

In terms of the list of customers, Asian customers (Taiwanese, Korean customers and so on) have overwhelmingly surpassed Japanese customers. This is because Japanese customers no longer to invest in TFT-LCD production capacity. Global TFT-LCD market is under this kind of situation. Japanese customers focus on the technology development of the extremely details in TFT-LCD's internal structure. Otherwise, Japanese consumer electronics giants are reluctant to make a large scale investment. In fact, I was working at Canon Marketing Japan Inc, and was taking care of Japanese customers. Canon Marketing Japan just focused on customers in Japan. However, later Japanese domestic market shrank drastically, Canon Marketing Japan reduced redundant personnel, and I got laid off and transferred here (optical equipment division in Canon head office). Due to a severe economic slump, in 1997, Yamaichi Securities Company (one of the major financial institutions in Japan) went into bankrupt, Japanese consumer electronics giants have lost their hospitable investment climate in Japan. So, they abandoned their large-scale investment in TFT-LCD industry. During this period, Korean and Taiwanese TFT-LCD manufacturers desperately continued to make large-scale investment. But, as for Japanese consumer electronics giants, they once gave up their investment in TFT-LCD industry, it would be really hard to go back and started to invest again(MF-J4).

Until the late 1990s, there have been frequent business dealings between Japanese major consumer electronics (Sharp, etc.) and Japanese TFT-LCD component and equipment manufacturers. From the beginning of 2000s, Japanese major consumer electronics started to withdraw from large-size TFT-LCD market, in the past several years, major customers of Japanese TFT-LCD equipment manufacturers became Taiwanese and Korean TFT-LCD manufactures. Compared to Korean manufacturers, Taiwanese TFT-LCD equipment manufacturers tend to be reluctant to promote high cost research and development, they purchase many more components and production equipment from Japanese upstream firms than Korean counterparts. Statistical data from Japanese government can track this trend of transformation. In terms of domestic and external demand, in 1996, 78% of Japanese TFT-LCD production equipment was sold in Japanese domestic market, just only 22% was sold in foreign market. However, after 1999, the ratio of foreign markets started to increase. In 2005, the ratio of domestic market reduced to only 19%, the ratio of foreign markets grew to 81 percent, and demand trend of domestic and international market became reversed. In terms of country of sale, in 2005, percentage of Japanese TFT-LCD production equipment export to Taiwan reached 63 percent of the total exports, the proportion of export volume to Korean market was 31%, and the proportion of exports to Chinese market was 4%. The main export market transformed from Japanese domestic market to other Asian market (METI statistical report,2013:38-39).

The Wider Implication

The approach of VOC (varieties of capitalism) by Hall and Soskice(2001) focuses on the agency or autonomy of the firms or other economic actors, mainly analyses the coordination mechanisms that firms establish and adjust the relationship with other firms, government, policy-makers, trade unions and employers to improve economic performance(Hall and Soskice, 2001:45; Yamada, 2008:112-127). Japan is the typical type of coordinated market economies (CMEs), as mentioned above, Companyist regulation has played an extremely important role as paradigm for

a society in postwar development of Japan's economy. Due to the fall of consumer electronics industry in Japan which was accelerated by brain drain from Japanese firms to Korean and Taiwanese firms in the collapse process of Companyst regulation such as employment security, Japanese TFT-LCD component and equipment manufacturers lost their domestic market, and started to develop global customers such as South Korean, Taiwanese TFT-LCD manufacturers. Developing global market is supposed to be a coordinate effort made by Japanese component and equipment manufacturers. However, most of these firms articulated their technological advantage through long-term job security and life time employment. For example, major TFT-LCD key component manufacturers such as Toppan Printing, TORAY, DNP and Fuji Photo Film are leading chemical industrial group in Japan (METI,2009), their engineers have articulated technological knowhow and experience in house under the stable employment security, and developed high quality electronic component such as high-performance materials. The collapse of employment security causes large-scale unemployment engineers and brain drain across the national border. In facing to a series of financial crisis and the catch up phenomenon of Korean, Taiwanese and Chinese counterparts, Companyst regulation is no longer sole coordination regime in Japan. It's time to consider the other coordination mechanism such as civic associations organized by group of employees beyond corporate boundaries to coordinate the relation between change in the global industrial structure and career path of employees.

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