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The Development of Industrial Cluster and Firm-Level Strategy: A Case Study of the Taiwanese IC Industry

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The Development of Industrial Cluster and Firm-Level Strategy:
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Abstract

The main purpose of this paper is to shed light on interaction between inter-firm relationship in an industrial cluster and firm-level strategy. Existing cluster studies mention various merits of clustering and try to examine the existence and impact of these merits through case studies of various industries in various regions. However, they rarely pay attention to firm-level strategic intents. Although some of cluster merits may be realized passively, the principal suggestion of this paper is that the full potential of clustering is brought out only when many of local firms intentionally adopt an appropriate strategy to enhance and mobilize local business resources for their growth. Conversely, a specific set of local resources may promote a particular type of firm-level strategy which is advantageous in a certain industrial sector. The mere presence of a cluster and the textbook-like examination of cluster merits do not fully explain why firms of a specific region are especially competitive in a certain industry. Local business resources consist of relational as well as physical ones, and the former is critical for continuous regional development. Therefore, in this paper, based on a detailed analysis of the Taiwanese IC industry which is one of the most successful cases of the latecomer development relying on a cluster, I will examine how inter-firm relationship (including both cooperative and competitive aspects) in the cluster facilitates firm-level strategic efforts and vice versa, and how a favorable interaction between these two elements brings the growth of Taiwanese firms and the regional development dynamism.

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Introduction

The beginning of the Taiwanese integrated circuit (IC) industry[2] goes back to the mid-1970s when the first IC pilot plant project in Taiwan started following the instruction from the chief of Executive Yuan (equivalent to the Prime Minister), Jiang Jing-Guo, as a part of the upgrading of industrial structure in Taiwan. Although the government and public research institutes played the leading role in the beginning, the establishment of TSMC as the first pure-play foundry manufacturer in the world marked a new epoch. Since then, local enterprises including small-scale fabless design firms have actively entered into the IC business and it has promoted the unique industrial structure of vertical disintegration in which each of the production stages and related sectors is shouldered by independent specialized firms. Despite starting as a latecomer in the IC industry, recently, Taiwan has become a world top class player in many of IC-related sectors and has shown a strong presence as the "Silicon Island" of the world. It is also often mentioned that the substantial agglomeration of local specialized firms in/around Hsinchu Science Park has generated cluster merits. This paper tries to investigate the key to success of Taiwan through examining interaction between inter-firm relationship in the cluster and firm-level strategic efforts.

This paper consists of five sections. Section 1 shows the analytical approach and purposes of this paper. Section 2 introduces the overview of the Taiwanese IC industry as the background knowledge of the following sections. Section 3 is devoted to the analysis of some important features of firm-level strategy in the Taiwanese IC industry. Section 4 aims to clarify the details of inter-firm relationship in the IC cluster. Section 5 provides the summary and concluding remarks.

1. Approach and Purposes

Many scholars and experts have examined the economic advantages derived from industrial clusters from various viewpoints. Among them, Porter's work is seen as a representative one, in which he mentions the enhancement of productivity, the stimulation of innovation and the promotion of new business as the main effects of clusters (Porter, 1998). Similarly, according to Schmitz (1995, 1999) who tries to

[2] The IC is nearly the same meaning as the semiconductor. Strictly speaking, the IC is one segment of the semiconductor. The semiconductor also includes discrete semiconductors (diodes, transistors, etc.), optoelectronic devices (LEDs, etc.), and sensors/actuators. But, nowadays, the IC occupies the majority of the total output of the semiconductor industry. For example, the total output of the Taiwanese semiconductor industry was US$ 42.4 billion in 2006, in which the share of ICs was 93% (Electronic Journal, 2007).

apply the cluster approach to developing economies as well as developed ones, clustering may (or may not) lead to efficiency and flexibility gains which individual producers can rarely attain, as is captured in the concept of “collective efficiency”. Collective efficiency consists of local external economies and joint action. Local external economies include the emergence of a pool of sector-specific skilled labor/experts, the easy and rapid availability of local suppliers of specialized machinery and inputs, the emergence of traders and other ancillary agents, technological and market knowledge flows, technology diffusion and human capital formation via labor mobility, and technology diffusion and innovation through user-producer interaction. Joint action involves more active and consciously pursued inter-firm relations that go beyond anonymous market driven contracts such as sharing equipment, joint research and development (R&D), collective actions by way of business associations and other cluster-wide institutions. Based on these or similar definitions, substantial amounts of case studies have been produced (e.g. Bersnahan and Gambardella eds., 2004; Yusuf et al. eds., 2008), which shed light on some of these cluster advantages.

Although we can get many insights from these existing studies, especially on linkages and synergy among local actors, one important problem should be pointed out. That is to say, in many of the previous case studies, the analysis is often conducted from a general and statistical viewpoint without making a vivid picture of dealings and interactions among local actors and of their strategies and peculiar behavioral patterns, through which an analyst can bring the feature of a specific industry in a specific region into sharp relief and can enable us to understand how the potential advantages of clustering are realized. In connection with it, in a cluster, various actors play the role of supplies and customers/users at the same time, and you can get quite different pictures about the reality of partnership and knowledge exchange depending on which part of such multiple levels of supplier-customer interactions you focus. In regard to the Taiwanese IC industry (or the information technology (IT) industry in a broad sense) which I see as one of the most successful cases of latecomer development, existing studies have already made some mentions on the development of vertical division of labor among local IC/IT-related firms mainly located in/around Hsinchu Science-based Industrial Park (HSIP) and on the important role of government policy and public research institutes such as Industrial Technology Research Institute (ITRI) (see Chen, 2008; Shih et al., 2007). However, more detailed examination must be conducted on the dynamism of local inter-firm relationship, firm-level strategic efforts peculiar to the Taiwanese IC industry, and on interaction between these two factors in order to clarify how clustering facilitates the competitiveness of Taiwanese firms in the global IC industry. The main purpose of this paper is to make some contributions on this matter.

In regard to this, although clustering has possibility to bring various kinds of economic efficiency, the realization of the possibility depends on how firms located there adopt and carry out an adequate strategy in order to make good use of the potentially advantageous environment and to construct effective linkages with other local actors (Ishikura, 2003). The mere presence of a cluster and the general mention of cluster advantages do not explain fully why firms in a specific region are competitive in the real business world. In this paper, substantial attention will be paid to firm-level strategy [3] including various issues of marketing, technology development, core competence, alliances and so on. However, the main concern of the cluster study is the relationship among local firms/organizations and the generation of efficiency and flexibility in a region as a whole which goes beyond the simple sum of individual efforts. Therefore, I will restrict my task to showing some important common strategic features of Taiwanese IC firms rather than conducting a detailed analysis of individual corporate cases.

Even providing an easily understandable summary of the general feature of firm-level strategy in a specific region/country is not an easy task. In this regard, recently, we can find a lively discussion on the success and failure of several different types of strategy (or often called "business models") in the IC (or IT) industry. Especially, in the IC device industry, analysts often contrast the rise of Taiwanese IC firms which tend to specialize in a limited number of products/activities through constructing a minute division of labor among local firms on the one hand with the long-term decline of Japanese major integrated device manufacturers (IDMs) which tend to undertake all or most of the production stages from basic product planning/design to final testing basically by themselves (or within their own corporate groups) and have a too wide product line-up in each company on the other hand (Shimizu, 2006; Miyazaki, 2008; Izumiya, 2006). Besides, some specialists suggest that difference between integrated and disintegrated strategies is not critical. It is pointed out that the key factors for

[3] According to a textbook-like explanation, the firm-level strategy consists of three parts, namely, corporate strategy, business strategy and functional strategy. The corporate strategy is relevant to the entire company which has two or more business units. It specifies a basic line of corporate growth and the target business domains. The business strategy expresses more concrete plans to obtain an advantageous status against competitors in a specific business domain. Finally, the functional strategy deals with each component of the business strategy such as marketing, R&D, finance, personnel affairs, and so on. In this paper which focuses on the IC industry, the words of "firm-level strategy" are roughly equivalent to the business strategy. However, as mentioned afterwards, because one of the main features of firm-level strategy in Taiwan is concentration on core business, it is relevant to the corporate strategy too. In addition, I will also mention some elements of the functional strategy such as marketing, R&D, and so on. So, in order to imply such subtle distinction, I use the words of "firm-level strategy".

success in the IC business include to get hold of growing markets, to attain a dominant share in a specific important product, to control state-of-the-art technology, to conduct bold and timely investment in plant and equipment, and to have the strategic definition of the scope of in-house activities (Hamada, 2008). This paper does not try to offer a comprehensive introduction of such discussion and a full-scale international comparative study between two or more countries/regions. My task in this matter is limited to selecting some important strategic features of Taiwanese firms through consulting these existing studies and my own field research and to examining these strategic features in detail in terms of the cluster approach.

Finally, I should mention another important, but secondary, task of this paper. Recently, people are taking an increasing interest in the significance of (sub-national) regions (or region states) as the platform based on which local firms build dynamic business linkages in the globalizing economy (Ohmae, 2006). In the cluster study too, it was pointed out long ago that a cluster with closed structure easily dried up the development dynamism (Bell and Albu, 1999). In recent studies, it is suggested as essential for local corporate managers and policy makers to consider the strategic positioning of their region in a global value chain and to manage to promote upgrading in the chain through supplementing local resources (i.e. talents, markets, technology, high-end parts/materials and equipment, and so on) with external linkages (Schmitz ed., 2004; Pietrobelli and Rabellotti eds., 2006). Although the full-scale analysis of this issue is too much, at the least I will show that the development of local close partnership is consistent with the active construction of external linkages in successful cases such as Taiwan.

2. Overview of the Taiwanese IC Industry

In this section, I offer the overview of the Taiwanese IC industry in order to let the readers know the background of the following sections. There are three aspects to be mentioned for this purpose, namely, vertical disintegration, intensive enterprise agglomeration, and aggressive exploration of overseas markets.

2.1. Vertical Disintegration

The most obvious feature of the Taiwanese IC industry is vertical disintegration among five main production stages of ICs, namely, IC design, manufacturing of photo masks, wafer process, packaging and (final) testing, each of which stages is basically undertaken by specialized firms. In addition, Taiwan has a considerably large share in

Table 1: The Output of the Taiwanese IC Industry（Unit: hundred million NT$)

	2003	2004	2005	2006	2007	2007 World Share
Total output of the IC industry	8,188	10,990	11,179	13,933	14,667	—
IC design sector	1,902	2,608	2,850	3,234	3,997	26.5%
IC manufacturing sector	4,701	6,239	5,874	7,667	7,367	—
Foundry	3,089	3,985	3,735	4,378	4,518	67.8%
Excluding foundry	1,612	2,254	2,139	3,289	2,849	—
IC packaging sector	1,176	1,566	1,780	2,108	2,280	47.6%
IC testing sector	409	577	675	924	1,023	67.7%

Note: The data in this table include overseas production. In 2007, the share of overseas production is 10.0% in IC design, 2.2% in foundry, 6.7% in packaging, and 6.9% in testing.

Source: Made by the author based on ITRI-IEK (2008, p.1-15, p.1-21, p.1-23).

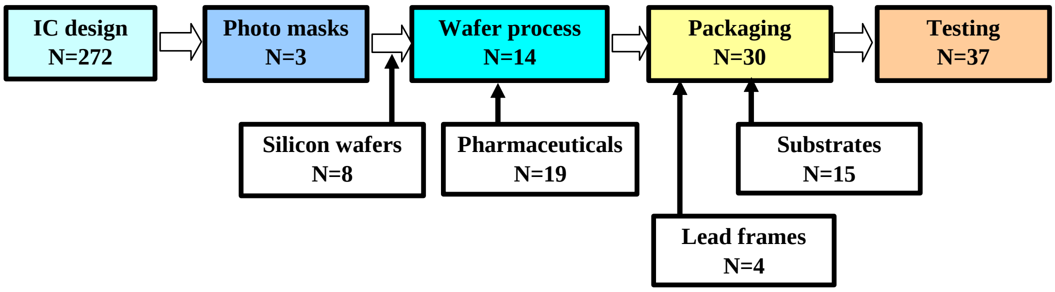
the total world output in each of main IC-related sectors (see Table 1). "Foundry" means a business model which undertakes wafer process in behalf of the other IC firms. Taiwan is well-known for pioneer specialized foundry manufacturers (called "pure-play foundry") such as TSMC and UMC, which offer manufacturing services without having their own brand products. Because wafer process is a highly capital intensive stage which possibly need the investment in plant and equipment of several billion US dollars every year, by outsourcing this stage to specialized makers, even a small scale firm without its own plant (so-called "fabless") is able to concentrate on the design and development stage and attain considerable profits, as long as its design technology is fine and market focus is appropriate. There are also several foundry manufacturers in the other countries including Japan and Korea, they are not necessarily specialized in this business, which means that they have their own brand products and may become competitors of their customers and/or give a lower priority to customers during a busy season.

Strictly speaking, Taiwan has several IDMs, which have their own manufacturing plants for their own brand products (mainly DRAMs). The share of these firms in the total output of the IC manufacturing sector has tended to increase in these days (see "Excluding foundry" in Table 1). However, unlike Japanese and Korean counterparts which basically internalize all (or most) of the production stages, they usually undertake only design, wafer process and testing stages among the above-mentioned five main stages by themselves (Ou, 2006). In addition, they often outsource a part of wafer process to specialized foundry manufacturers and offer foundry services to the other IC firms at the same time.

2.2. Intensive Enterprise Agglomeration

Another main feature of the Taiwanese IC industry is the highly developed agglomeration of specialized local IC-related firms, most of which are located in a relatively small area from Hsinchu to Taipei. Figure 1 shows the structure of the Taiwanese IC industry including the above-mentioned five main stages and several other sectors providing IC-related materials. Besides the sectors and stages in this figure, there are sectors which provide the various types of manufacturing machines, tools and other materials. Despite the considerable agglomeration of local IC-related firms, Taiwan still depends on foreign suppliers on the supply of many of these highly technology-intensive machines, tools and materials, although local suppliers have gradually developed.

Figure 1: The Structure of the Taiwanese IC Industry in 2007



Note: N=the number of firms.

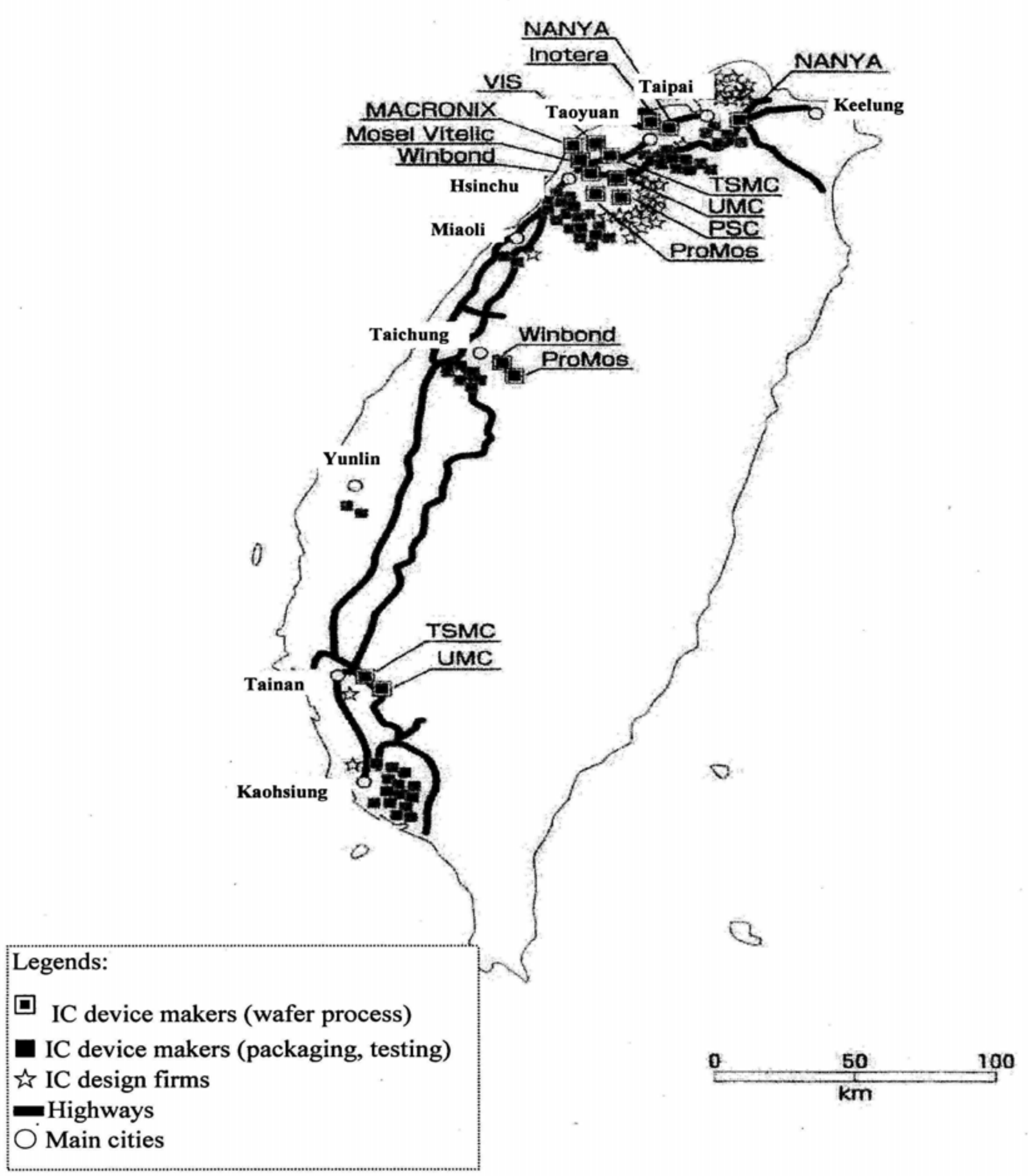
Source: Made by the author through modifying Figure 3-32 in ITRI-IEK (2008, p.3-103).

In regard to geographical distribution, HSIP which was established in 1980 is the core location[4], which is usually seen as "the Taiwanese IC industry cluster". According to *The Taiwanese Semiconductor Industry Year Book 2008* (ITRI-IEK, 2008, p.5-45), more than 90% of the Taiwanese IC-related firms are located in the region from Hsinchu to Taipei. However, this figure is calculated by only considering the address of firms' headquarters and a firm may have several branch factories in different sites. So, if you consider these branches too, you find the gradually growing number of business units located in other regions, especially in central and southern parts of Taiwan of which center is Taichung and Tainan/Kaohsiung respectively (see Figure 2). The emergence of these new regional centers is largely attributed to the establishment of Southern Taiwan Science Park (STSP) in 1995 and Central Taiwan Science Park (CTSP) in 2003[5].

[4] HSIP consists of the original base in Hsinchu and five additional bases (Jhunan, Longtan, Tunglo, Yilan and Biomedical park), of which gross area is 1,400ha. The overall sales of the park in 2007 was NT$ 1,146.2 billion. ICs, optoelectronics (mainly, TFT-LCDs) and computers & peripherals were three major products, of which shares in the total sales were 72%, 16% and 8% respectively (http://www.sipa.gov.tw).

[5] CTSP consists of three bases (Taichung, Huwei, and Houli), of which gross area is 765 ha. In 2007, the overall sales reached NT$ 265.7 billion. Optoelectronics and ICs accounted for the most of it (http://www.ctsp.gov.tw). STSP consists of two bases (Tainan and Kaohsiung), of which gross area is 1,608 ha. In 2007, the overall sales was NT$ 558.9 billion. The two major products, optoelectronics

Figure 2: Locations of Taiwanese IC-related Firms and Plants



Source: Made by the Author.

In this paper, I consider the region from Hsinchu to Taipei to be the IC industry cluster, but its boundary is not so clear-cut and the cluster may include the central and southern parts in a broad sense in these days.

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and ICs, combined together, occupied more than 90 % of the total (http://www.stsipa.gov.tw).

2.3. Aggressive Exploration of Overseas Markets

The third important feature of the Taiwanese IC industry is that the share of overseas sales is substantially large in all of the IC-related sectors (see Table 2). Among them, North America (mainly the USA) shows a large share in foundry, packaging and testing. In IC design, mainland China is the main market for Taiwan, which reflects not only growing importance of mainland China as a production site of electronic and other goods but also the fact that Taiwanese manufacturers of electronic goods including PCs & peripherals, communication equipment and digital household appliances request IC makers to deliver IC chips to their overseas factories in China (ITRI-IEK, 2008, p.3-111). These figures seem to suggest that the Taiwanese IC industry has developed through being incorporated into the IC industry global value chain, in which Taiwan has developed mainly as a manufacturing site and as a design center to a certain extent. Leading firms located mainly in the USA (and Europe and Japan) still have core functions such as the development of innovative IC chips and the supply of highly technology intensive machines/tools and materials.

Table 2: Main Markets of Taiwanese IC-related Sectors in 2007 (Unit: %)

IC design	Taiwan	Mainland China	Korea	Other
	32.9	56.7	2.8	7.4
Foundry	Taiwan	North America	Western Europe	Other
	20.5	67.0	6.0	6.4
Packaging	Taiwan	North America	Japan	Other
	42.6	41.1	7.1	9.2
Testing	Taiwan	North America	Japan	Other
	57.5	28.7	5.6	8.2
IC manufacturing (excluding foundry)	Taiwan	Japan	Mainland China	Other
	44.6	16.9	14.1	24.4

Source: Made by the author based on data derived from ITRI-IEK (2008, p.3-111, p.3-122, p.3-123, p.3-131, p.3-139).

3. Features of Firm-Level Strategy of the Taiwanese IC Industry

This section analyzes the feature of firm-level strategy in the Taiwanese IC industry paying attention to three important factors including concentration on core business, thoroughgoing cost management, and active utilization of external knowledge sources. The analysis of this and next sections is mainly based on information and data attained from my own fieldwork (interviews and a questionnaire survey with IC firms) mainly conducted in the region from Hsinchu to Taipei[6].

[6] The fieldwork consists of a questionnaire survey and interviews with IC firms. The questionnaire survey was conducted in July to October 2007 in Taiwan and 36 firms replied in total. Interviews were

3.1. Concentration on Core Business

As I mentioned in the previous section, the most conspicuous feature of Taiwan is well-developed vertical division of labor and substantial accumulation of local specialized firms in each of main production stages and sectors. This is partly because many of Taiwanese IC-related firms used to be small-sized and not resourceful at least in their early stage and could not avoid concentrating their company resources on one or a few products and/or services. Table 3 offers a list of main firms in each of main sectors.

Table 3: Main Firms in the Taiwanese IC Industry in 2007 (Unit: hundred million NT$)

IC Design			IC Manufacturing (Wafer Process)		
Ranking	Company Name	Sales	Ranking	Company Name	Sales
1	MediaTek	804	1	TSMC	3,226
2	Novatek	361	2	UMC	1,068
3	Himax	301	3	PSC	775
4	Phison	203	4	NANYA	529
5	Realtek	157	5	ProMos	476
6	VIA	147	6	Inotera	459
7	Etron	132	7	Winbond	321
8	Sunplus Technology	92	8	MACRONIX	243
9	Global Unichip	70	9	VIS	160
10	ESMT	69	10	Episil	50
IC Packaging			IC Testing		
Ranking	Company Name	Sales	Ranking	Company Name	Sales
1	ASE	785	1	ASE	200
2	SPIL	565	2	KYEC	124
3	Powertech	139	3	ChipMOS	116
4	ChipMOS	80	4	Powertech	107
5	Greatek	72	5	SPIL	57

Source: Made by the author based on ITRI-IEK (2008, p.1-17, p1-18, p.1-19).

Recently, firms tend to expand their product line-ups and/or services. However, if you observe carefully, you can find that successful firms still keep well-selected business focuses. In many cases, they aim at one or a few volume market zones,

held with 13 Taiwanese IC firms including 6 IC design firms (fabless), 4 IC manufacturing firms (foundry and IDMs), 3 packaging and testing firms in July/August 2007. I received a great support from Mr. Eric Jain, Mr. Meng Shien Hsieh, and Ms. Naomi Yu, who were experts of Industrial Economics & Knowledge Center (IEK)/Industrial Technology Research Institute (ITRI, Hsinchu). They supported me by implementing the questionnaire survey, arranging interviews with business people, and offering related data. Besides, Dr. Hsien-Yang Su and the staff of Japan Center of Chung-Hua Institution for Economic Research (CIER, Taipei) kindly helped me. I have also conducted more than ten sessions of complementary interviews with IC-related firms and organizations in Japan since then. I would like to express my sincere gratitude to all of these people who cooperated with me.

which leads to the realization of economy of scale. Otherwise, they divide an overgrown company with too many product categories into several subsidiaries, each of which concentrates on one or a few niche markets. These niche markets are often too small-sized to be taken care of seriously in a relatively large firm, and the firm may miss potentially promising markets which are trivial at this stage.

For example, MediaTek, the largest fabless IC design firm in Taiwan, has four or five main product categories, but they have not run all of them at the same time. Roughly speaking, the company has shifted an application target in the sequence of CD-related devices, DVD-related devices, mobile phones, digital TVs, and global positioning system (GPS). In this manner, MediaTek has successfully realized technological synergy and attained a substantial share in the volume market zone of important consumer electronic products in those days. On the other hand, Sunplus Technology which is also one of the major IC design firms in Taiwan used to have the exceptionally large number of product categories. Since 2005, the company has conducted reorganization in which several subsidiaries were separated and took charge of some product categories of the original company. For example, Orise Technology took over the business of LCD controller/driver ICs, while Sunplus Innovation Technology started to handle ICs for controllers/peripherals. Similarly, Sunplus mMobile has focused on personal entertainment and communication business, while Sunplus Technology, as the head company, has devotedly dealt with the platform for home entertainment business and R&D of core intellectual properties (IPs).

How can they properly understand a market trend and find a promising product? I heard in my fieldwork in Taiwan that, in the case of IC design firms, one of the main knowledge sources in this regard was close interactions with their main customers, namely, final product makers (i.e. manufacturers of final products such as PCs, digital TVs, mobile phones, and so on). It is also important to point out that their precise focus is enabled by the capability of quick adjustment. That is to say, they can get a good aim through accelerating the cycle of releasing a new product to the market, receiving feedback from main customers, then offering an improved version to the market. In addition, they are also very prompt in adjusting their target through benchmarking technological and cost advantages against competitors and, if necessary, readily modifying a plan. In contrast, I heard in my interviews in Taiwan and Japan that Japanese major IC firms tended to be slow in market research and decision making, which prevented them to catch variable market trends. It is also often pointed out that Japanese firms in general are too strict on quality guarantee to quickly release a new product. In addition, because they used to deal with too many product categories (namely, lack of concentration on core business), they had exhaustive competition among domestic major players of which product line-ups overlap each other, although the increasingly severe world-wide competition in these days has forced them to carry out the extensive reshuffle of their business.

3.2. Thoroughgoing Cost Management

Thoroughgoing cost management of Taiwanese IC firms is substantially attributed to the realization of economy of scale through keeping well-selected business targets, as I mentioned above. Aggressive exploration of overseas markets is also relevant to this point. In addition, you may mention some other factors in this regard such as relatively low cost of engineers, strict cost accounting, economizing on R&D through actively utilizing external resources, and so on. In this subsection, I will shed light on an important factor which is especially relevant to the economy of scale, namely, standardization of design and production process (see Miyake and Kimura, 2005 as a comprehensive analysis of cost management in the IC industry).

It is widely observed in Taiwan that IC firms try to construct a common fundamental (often called "platform") of product design and/or production process which is applicable to many kinds of products with small modifications. It enables them to offer some customization without large cost rising. I will explain it in detail by showing examples in IC design and manufacturing firms respectively.

In the design of system LSI, largely speaking, there are two product categories, namely, application specific integrated circuit (ASIC) and application specific standard product (ASSP)[7]. Both of them are designed for a specific application such as cellar phones, digital steel cameras, digital TVs and so on. The difference is that ASIC is designed for a specific customer, while ASSP is applicable to many customers by modifying software embedded in an IC chip without changing the design of hardware (electronic circuits)[8]. In other words, ASIC is a more customized product category and ASSP is a relatively standardized one. ASIC is designed to meet a specific customer's specific needs most suitably and it is also advantageous in terms of cost as long as the

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[7] The definitions of ASIC and ASSP are not uniform among documents. According to a textbook, ASIC means semi-customized ICs of which design tasks are allotted to both IC firms and customers. That is to say, in the design flow of ASIC, a customer undertakes the high-level design stages (i.e. specification design, RTL design, logic synthesis, logic verification), while an IC firm takes charge of the low-level design stages (i.e. layout design). In the design of ASSP, IC firms undertake all of these stages and develop an IC chip for a specific purpose of various users.

[8] The development and design of an IC chip consists of two segments, namely, the design of hardware (electronic circuits) and that of software embedded in the IC chip. In these days, the design of software tends to require considerably large amount of time and human resource and it often demands more human resource than that needed for hardware design.

output is large enough. However, in these days, because the development and design cost of an IC chip has substantially increased (e.g. several hundred thousands US dollars or more in many cases) and the lifespan of a specific product has become too short to attain a substantially large amount of sales, ASSP is often more advantageous by distributing the total design and development cost over various products of various customers. In the IC design sector of Taiwan, the share of ASSP is predominant, namely, the proportion of ASIC: ASSP is 10.5: 89.5 in 2007 (ITRI-IEK, 2008, p.3-109).

In Japan, although I could not get hard data, it is generally said that ASIC has been more important. It is partly because many of major Japanese IC chip makers were established as one business unit of a huge electronic company (e.g. Panasonic, Hitachi, NEC, Toshiba, and so on) and they mainly deal with final product makers of their own company group (or other major company groups) which tend to prefer customized key parts (Kojima, 2006). This is also the reason why the growth of independent fabless IC design firms is very difficult in Japan and, if any, in most cases, they must reconcile themselves to a status of minor subcontractor of established electronic companies. In addition, in my own interviews in Japan, I often head that the technological capability of these Japanese major final product makers is very high and they undertake substantial parts of IC design process by themselves for their novel final products, so, IC chip makers play a passive part and have weaken their own product planning capability. In Taiwan, partly because there are not many indigenous final product makers with globally well-known brands and Taiwanese final product makers as contract manufacturers tend to adopt standardized key parts to oppress costs, Taiwanese IC chip makers also tend to concentrate on a more standardized category.

According to information from my fieldwork in Taiwan, in the design of ASIC, a customer generally shoulders the design cost and the price in a contract is guaranteed, but the chip is exclusively provided for the specific customer. In the design of ASSP, an IC maker may discuss a specification with a main customer, but the design cost is shouldered by the IC chip maker. It is often observed that an IC maker supplies a new IC chip to a major customer first, then, showing off the trading achievement, tries to open up many other minor customers. In the IC design sector, it seems a key factor for business success to understand appropriately the common needs of various customers and to promptly supply a product of good cost performance without falling into excessive specification.

We can observe a similar effort to establish a basic common production process in IC manufacturing firms in Taiwan. Taiwanese major foundry manufacturers such as TSMC and UMC must have a wide range of wafer process technology to handle various products of various customers. They must meet various demands in a production line without establishing a factory specializing in a specific product. According to my interview with one of the major foundry manufacturers, for this purpose, they have made a painful effort to flexibly adjust a machine, tool and recipe[9] for various products, which is so thoroughgoing that it has finally become a company culture. They emphasized that the trial was painful at the early stage, but that it led to great flexibility and substantially profited the company at the later stage. It is because that machines for wafer process are extremely expensive (e.g. several dozens million US dollars for a stepper) and that about 60 percent of the wafer process cost is relevant to depreciation expenses of these machines. They prepare a limited number of technology platforms and meet each customer's special demands through a modification and/or combination of them[10]. In connection with it, it is pointed out that Taiwanese IC manufacturers tend to make much of technology development for the purpose of cost down (for example, having a good command of standard machines, eliminating unnecessary production steps, enhancing throughput and operating rate of machines, improving yield rate, and so on), while Japanese counterparts tend to attach great importance to R&D aiming at high quality and state-of-the-art technology, which leads to expensive products with excessive functions (Yunogami, 2005).

3.3. Active Utilization of External Knowledge Sources

In these days, it has become more and more important to actively utilize external knowledge sources in order to speed up the rate of new product development and/or to save cost and human resource for R&D. It is often said that the recent downfall of Japanese IC device makers is partly attributed to their obdurate attachment to in-house R&D. It is the so-called "Not Invented Here (NIH)" syndrome (Hamada, 2007). Contrastively, I often heard that Taiwanese IC firms tended to readily utilize external knowledge sources. In regard to this, in my questionnaire survey in Taiwan, I asked questions about means to get necessary technologies. It revealed that many Taiwanese firms were introducing technologies from external sources as well as conducting in-house R&D at the same time. The questionnaire survey got replies from 36 firms in

[9] A recipe is a program for controlling wafer process. It instructs the process sequence and control parameters (i.e. setting values on temperature, pressure, the kind of gas and its flow rate, etc.) of a specific process machine.
[10] For example, TSMC prepares two platforms, namely, advanced technology platform and mainstream technology platform, depending on the degree of coordination with customers. The former includes wireless SoC platform, consumer technology platform, PC and network technology platform, while the latter covers five applications such as power ICs, display driver ICs, CMOS image sensors, microcontrollers and RFID (Ishihara, 2005; http://www.tsmc.com).

total, among which 28 firms (78%) replied that "In-house R&D" was a main means for getting technologies. At the same time, other means such as "Technology transfer/licensing", "Cooperative R&D" and "Headhunting" are conducted by 44%, 39% and 33% of the respondents respectively. As for "M&A" and "Investment to start-ups", only the small number of firms is relevant (11% and 6%, respectively).

Table 4: Partners for Technology and Product Development and Their Locations (Unit: Firm)

Types of Partners	Relevant firms	the USA	Europe	Japan	Korea	China	Taiwan	Other
Suppliers of materials and parts	13(36%)	6	0	4	1	1	10	0
Suppliers of machines and tools	12(33%)	9	2	2	0	1	6	0
Contract manufacturers (Foundry, etc.)	19(53%)	0	0	2	1	5	19	1
Customers and users	24(67%)	16	10	17	10	13	22	2
Firms in the same trade	10(28%)	5	2	4	1	3	6	0
Firms in different trades	2(6%)	1	1	2	0	0	0	0
Universities and research institutions	16(44%)	1	0	0	0	1	16	0
Other	1(3%)	1	0	0	0	0	0	0

Note: "Relevant firms" means the number of respondents who acknowledged cooperation with each type of partners. The figures in parentheses mean the share in the total respondents (36 firms). The respondents were also requested to tell countries/regions in which their partners were located. Because a respondent may point out two or more countries/regions in this regard, the sum of figures in the cells of countries/regions in each line may exceed the number of respondents in the cell of "relevant firms".

Source: The international questionnaire survey on business environment of the East Asian semiconductor industry.

In my questionnaire survey, I also asked about partnership in technology and product development. The result is summarized in Table 4. According to the table, in regard to the types of partners, about 30% or more of the total 36 respondents reply that they have a cooperation and/or alliance with all the types of actors except "Firms in different trades" and "Other". Among these, the shares of "Customers and users" and "Contract manufacturers" record more than 50% respectively.

This table also shows the location of partners. Taiwan is the most important location in all the types of partners except "Firms in different trades" and "Other". However, all the foreign countries listed in the table, especially the USA and Japan, are also substantially important as the location of "Customers and users" in cooperation. This is consistent with the fact that the share of overseas sales reaches a substantially high level in all of the sectors of the Taiwanese IC industry (see Table 2). In addition, the shares of the USA and Japan are relatively large in "Suppliers of materials and parts", "Suppliers of machines and tools" and "Firms in the same trade". Especially, the importance of the USA as the location of partners is conspicuous in "Suppliers of machines and tools". Finally, in "Contract manufacturers", the share of Mainland China is not small. All these figures tell us that overseas linkages have considerably developed in knowledge exchange.

4. Inter-firm Relationship in the Taiwanese IC Industry Cluster

This section examines in detail inter-firm relationship in the Taiwanese IC industry cluster of which core location is HSIP. In each of the following subsections, I will focus on division of labor between IC design and manufacturing firms, relationship between IC design firms and final product makers, and local competitive environment respectively.

4.1. Division of Labor between IC Design and Manufacturing Firms

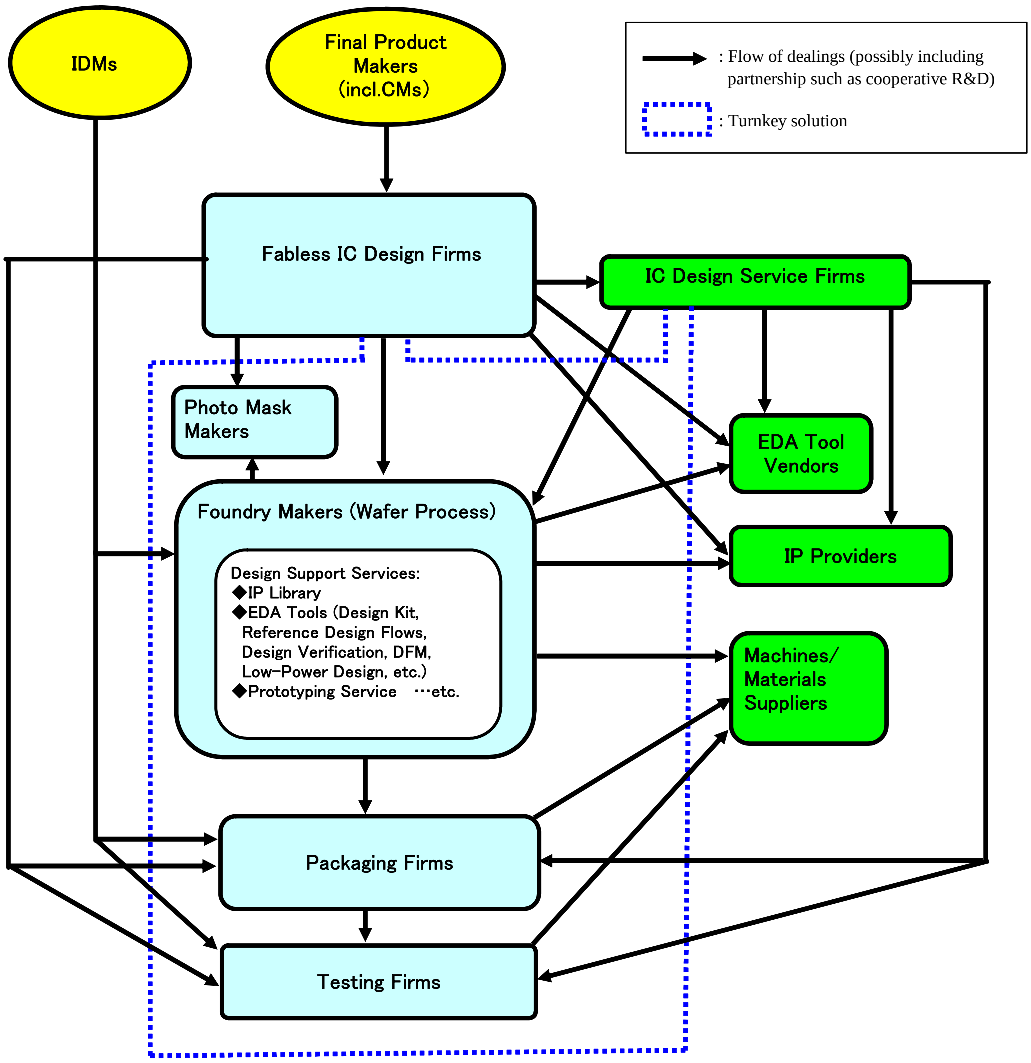
As mentioned above, the most conspicuous feature of Taiwan is the development of vertical disintegration among five main production stages. Five stages are divided roughly into two stages, namely, IC design and manufacturing. Here, I will focus on partnership between IC design firms and manufacturing firms (especially, foundry manufacturers).

One of the fundamental driving forces for evolution of the IC industry is micro-fabrication technology. The development of micro-fabrication technology enables IC manufacturers to place more transistors and wires on a specific chip area, which means the realization of higher performance ICs if the chip size is constant. In other words, they can get the increasing number of chips from a specific area of silicon wafer and it leads to lower unit cost because the cost of an IC chip is generally proportionate to the size of it. The marvelous speed of technological development is usually expressed as “Moore’s law”, which is the empirical observation advocated by G. Moore of Intel that the transistor density of an IC chip doubles every 24 months. The progress of micro-fabrication technology has made it possible to materialize the entire (or most) functions of an electronic apparatus by only one IC chip, which is called a “system LSI” (or “system-on-a-chip, SoC”). Recently, as the transistor density has extremely increased and wafer process technology has become highly complicated, it has become difficult to prevent anomalies. So, nowadays, it is indispensable to take account of how to keep a good yield rate and reliability of products not only at the manufacturing stage but also at the design stage in advance (called “design for manufacturability, DFM”), the trend which enhances the importance of close coordination between the IC design and manufacturing stages. It seems that Taiwan IC firms used to focus on the volume zone product category by taking advantage of their cost competitiveness rather than on the state-of-the-art technology realm. However, in these days, customers have requested Taiwanese foundry manufacturers to advance into more technologically complicated products such as SoC, in which close coordination is needed between the design and manufacturing stages.

In addition, in the design of SoC, it has become common to utilize silicon intellectual properties (IPs). An IP is a design data of functional block of SoC, which is developed in advance and is reusable as a module in the design of various SoC. Nowadays, there are many vendors which specialize in the design and supply of IPs in the world. In order to eliminate the cost and time-to-market for the development of ICs, it is indispensable for IC designers to combine in-house IPs and IPs purchased from external sources, not making all the necessary IPs by themselves from the scratch every time. Recently, foundry manufacturers have prepared an "IP library" for their customers which is a database of common and/or widely applicable IPs. Because IPs purchased (licensed) from third-party vendors sometimes do not work at the trial or mass production stages and that causes a large loss, foundry manufacturers have already verified the affinity of IPs in the library for their production process. By utilizing the IP library, even IC design firms with limited in-house resources are able to concentrate on the development of a core IP and to accelerate new product development. In the same way, foundry manufacturers have provided their customers with electronic design automation (EDA) tools (software) which are indispensable for the development of complicated and large-scale ICs. There are various kinds of EDA tools needed at various design stages, and EDA tools provided by foundry manufacturers are developed in cooperation with specialized EDA tool vendors in order to make the tools suitable for their production process. In this context, in Taiwan, the relationship between IC design firms and foundry manufacturers has been transformed from simple division of labor to close partnership in which foundry manufacturers offer wide-raging design support services (Shimizu, 2006). In the following part, I will examine the details mainly based on information from my own fieldwork (see Figure 3 as the overall image of vertical disintegration partnership).

In Taiwan, there are several types of foundry manufacturers. They are roughly divided into two groups, specialized foundry manufacturers ("pure-play foundry") and non-specialized foundry manufacturers which produce their own brand IC chips at the same time. The examples of former are TSMC, UMC, VIS, Inotera, Episil and so on. The latter includes PSC, ProMos, NANYA, Winbond, Mosel Viteric and so on. In terms of main product categories, they are roughly classified into two groups, logic-centered foundry (e.g. TSMC and UMC) and memory-centered foundry (e.g. PSC, ProMos, NANYA). Among them, TSMC and UMC are top two companies, of which

Figure 3: Vertical Disintegration Partnership in the Taiwanese IC Industry



Note: CMs=contract manufacturers.
Source: Made by the author.

outputs combined together reach more than 50% of the total output of the Taiwanese IC manufacturing sector including both foundry and IDMs[11].

TSMC and UMC are also leading companies in providing their customers (namely, fabless IC design firms and IDMs which outsource some parts of their manufacturing process) with design support services (called "SoC Solutions"). As I mentioned above,

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[11] The total output of pure-play foundry manufacturers in the world reached US$ 193 billion in 2006, of which the shares of TSMC and UMC were 50% and 17% respectively. In addition, Chartered Semiconductor Manufacturing (CSM, Singapore) and Semiconductor Manufacturing International Corp. (SMIC, China) accounted for 8% respectively. Remaining 17% were occupied by several other firms (http://www.tsmc.com).

in these days, foundry manufacturers offer various services including the provision of an IP library, EDA tools and reference design flows which enable IC design engineers to easily conduct design verification, DFM, low-power design and so on. In addition, foundry manufacturers provide a low-cost trial production service. These services and tools are developed in cooperation with various partners including major overseas EDA tool venders (e.g. Synopsys, Cadence, Mentor Graphics, Magma and so on) and IP providers (ARM, Virage Logic, MIPS, Rambus and so on) (On, 2006).

In Taiwan, I found "IC design service firms" which kept a special connection with a specific foundry manufacturer. For example, as TSMC-related design service firms, we can mention Global Unichip, SOTA, Innochip, Goyatek, PGC, Socle and so on[12]. As an UMC-related design service firm, Faraday is famous (Xu et al., 2005). These design service firms undertake some parts of IC design process and IP development for their customers, and play the role of windows through which a foundry manufacturer provide above-mentioned design support services. I heard that a foundry manufacturer kept a direct connection with major and/or technologically important customers, and that design service firms dealt with other minor customers. In addition, fabless IC design firms usually deal with third-party IP providers by themselves, but, design service firms sometimes conduct licensing negotiations with major foreign IP providers in behalf of them, through which even small-scale IC design firms may attain more favorable terms (Xu et al., 2005).

Foundry manufacturers primarily focus on wafer process, but they may offer a "turnkey solution" for their customers, which means that a foundry manufacturer undertakes coordination of the total manufacturing process. For this purpose, they go into partnership with specialized suppliers of photo masks[13], packaging and testing services, and in some cases, they conduct technological exchange. In the provision of turnkey solution too, above-mentioned IC design service firms may play the role of liaison counter (Xu et al., 2005). Because the turnkey solution is often expensive, substantially large-sized design firms try to directly deal with packaging and testing firms, which leads to cost reduction and close communication. But, if the company-scale is small and/or the order size is small, design firms may attain more favorable terms through the turnkey solution which brings collectively larger bargaining

[12] TSMC-related design service firms are organized as "TSMC Design Center Partner (DCP)". There are DCP firms in foreign countries as well as in Taiwan. Among overseas partners, 8 firms are in Asia (including Taiwan, but excluding Japan), 4 firms are in Japan, 2 firms are in Europe, and 10 firms are in the USA (http://www.tsmc.com).

[13] TSMC have the in-house photo mask manufacturing section, of which output is a highest class in the world (http://www.tsmc.com). On the other hand, UMC does not have its own photo mask manufacturing section.

power. By the way, in these days, the division of labor between packaging and testing stages has changed, namely, these two stages are often handled together in one company. It means some modification of the vertical disintegration among main five production stages.

Finally, it is often observed that foundry and manufacturing companies invest in fabless design firms and/or design service firms. That is to say, they get information about promising niche markets through their foundry business, and establish (or facilitate spin-off of) fabless and/or design service firms as their group companies. Then, these design (service) firms are offered favorable term by group manufacturing companies and easily boost sales, which may lead to the rise of stock price. In this regard, the case of UMC is conspicuous. Design firms which spun off from UMC include MediaTek, SiS, ITE Tech, Novatek, Holtek, PixArt and so on (Cai-xun Publisher ed., 2007). Besides these, there are other examples such as eMemory, Silicon Optronics and Syntronix which are connected with PSC, and Gateway Silicon which was set up by MACRONIX.

4.2. Relationship between IC Design Firms and Final Product Makers

In Taiwan, there are a lot of electronic final product makers which manufacture final products such as PCs and peripherals, cell phones, digital TVs and so on, although many of them are contract manufacturers without own brand products. Their manufacturing plants are mainly located in mainland China, but headquarters still stay in Taiwan in many cases. This subsection sheds light on the relationship between IC design firms and these final product makers, and examines the process of new product planning and development by IC design firms in detail.

Partly because their business resources are often limited, partly because a product planning based on long-term R&D is evaded in the case of listed companies (i.e. individual stockholders prefer a short-term result), the primary stage of R&D is usually put in the hands of public research institutes such as ITRI. On the other hand, Taiwanese IC design firms actively try to get a correct understanding of customers' needs at the present time and try to quickly supply appropriate products and services. For this purpose, many of Taiwanese IC design firms have a product manager (PM), who shoulders the responsibility for coordinating the total process of a new product development from product definition to design and mass production (outsourcing to manufacturing companies). According to an IC design firm, a PM with technological knowledge makes a primary specification through exactly understanding customers' needs and, then, a detailed specification is made by R&D staff, through which they quickly develop a product which has just enough quality and functions at a reasonable price. On the other hand, I heard that, in the case of negotiation between Japanese companies, the definition of specification is often not very strict and modified afterwards, which brings cost rise and delay. In addition, according to another respondent, it is normal in Taiwan for IC design firms to make their engineers reside at customers' sites, through which quickly respond to problems. They said that such "on-site-support" was one of the competitive advantages of Taiwanese firms.

As I mentioned above, in the Taiwanese IC design sector, the share of more standard product category (i.e. ASSP) is predominant. While it is critical to exactly and fully meet the needs of a specific customer through close communication in the case of more customized product category (i.e. ASIC), it is indispensable to understand important common factors of various customers' needs and to quickly offer a product with a reasonable price in the case of ASSP. So, IC design firms must make substantial effort to learn knowledge about final products in which IC chips are incorporated (Shindou, 2006). For this purpose, Taiwanese IC design firms have a lot of application engineers, part of which moved from final product makers, and try to get detailed understanding about the development and manufacturing process of customers.

In regard to this, in Taiwan, it is often for IC design firms to provide customers with a module which integrates IC chips, software and other electronic parts rather than a single IC chip. In the case of a relatively simple final product, IC chip firms possibly offer a "total system solution" which realizes all or most functions of the final product and a reference design of the entire final product which may be easily adopted by customers. I heard that, in the provision of a total system solution or module, it was usual to concentrate on the development of core IC chips/IPs and outsource or cooperatively develop other parts. The manufacturing of modules is also outsourced to contract manufacturers.

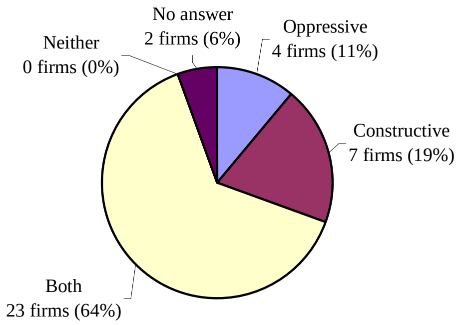
4.3. Local Competitive Environment

Local competitive pressure is supposed to facilitate the improvement of skills and products of local firms, which is often mentioned as one of the merits of clustering. In this subsection, I will examine local competitive environment of the IC cluster in Taiwan mainly based on the result of our questionnaire survey.

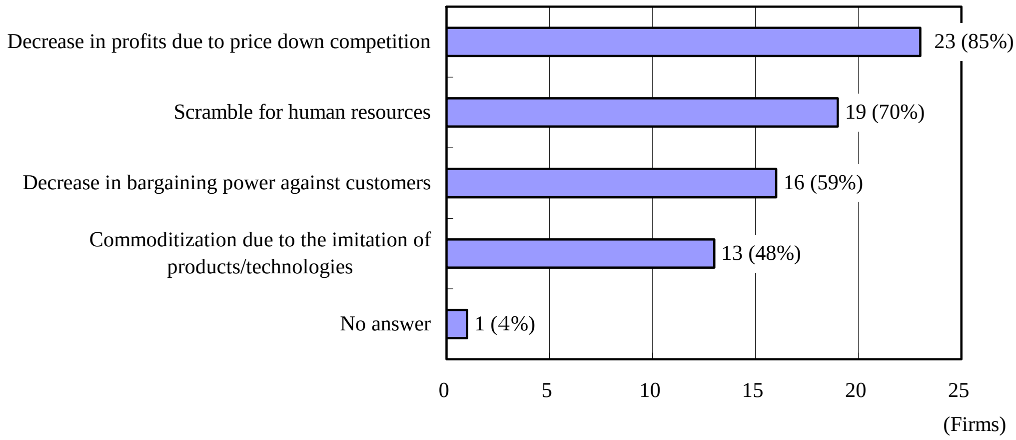
First, we asked about the location of main competitors. Among all the respondents (36 firms), 27 firms (75 percent) replied that competitors were in the local area, while 31 firms (86 percent) said that they were outside the local area. This result means that many of the respondents have their competitors both in and outside the local area. As

Figure 4: Local Competitive Pressure

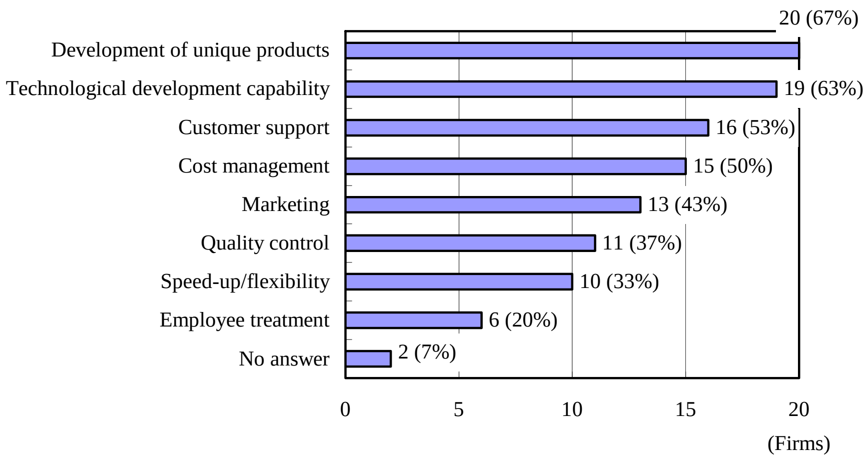
4-1: How Do You Feel Local Competitive Pressure? (Among 36 Respondents)



4-2: The Detail of "Oppressive" and "Both" (Among 27 Respondents)



4-3: The Detail of "Constructive" and "Both" (Among 30 Respondents)



Source: The international questionnaire survey on business environment of the East Asian semiconductor industry.

the locations outside the local area, respondents mentioned the following countries/regions: the USA (55 percent), mainland China (48 percent), Japan (36 percent), Korea (32 percent), Europe (26 percent), Taiwan excluding the local area (23 percent), and other and no answer (6 percent).

Then, we asked the question: "Which do you think the local competitive pressure is oppressive or constructive for your company management?" Among all the respondents (36 firms), 4 firms (11 percent) replied "oppressive", while 7 firms (19 percent) replied "constructive". 23 firms (64 percent) said, "It is both oppressive and constructive". The remaining 2 firms (6 percent) gave no answer (see Figure 4-1). 27 firms (75 percent) replied "oppressive" or "both oppressive and constructive". The breakdown is as the following: "Decrease in profits due to price down competition" (23 firms, 85 percent), "Scramble for human resources" (19 firms, 70 percent), "Decrease in bargaining power against customers" (16 firms, 59 percent), and "Commoditization due to the imitation of products/technologies" (13 firms, 48 percent) (see Figure 4-2). On the other hand, 30 firms (83 percent) replied "constructive" or "both oppressive and constructive". We asked them in which aspects they attained improvement. Important items include "Development of unique products" (20 firms, 67 percent), "Technological development capability" (19 firms, 63 percent), "Customer support" (16 firms, 53 percent), and "Cost management" (15 firms, 50 percent) (see Figure 4-3).

In sum, it is observed that the local competitive pressure in the Taiwanese IC cluster has the aspect of constructive competition which contributes to innovation and better management techniques as well as the aspect of excessive one which leads to the devastation of management. In the both aspects, its influence covers a wide range of items. Based on Porter (1990), it is often said that strong competition in a home base strengthens the international competitive advantage of firms rooted in the region. However, I suggest that it is important to examine both of destructive and constructive aspects and to clarify the details of the impacts.

5. Conclusion: Interaction between Inter-firm Relationship in the Cluster and Firm-Level Strategy

In the previous sections, I examined important features of firm-level strategy and inter-firm relationship in the Taiwanese IC cluster. The main factors of firm-level strategy lead to the creation of customer value, namely, the appropriate understanding of customers' needs and the offer of solution[14], reasonable prices, and rapid product

[14] The word of solution in the IT industry usually means (the proposal and/or construction of) the information communication technology (ICT) system in order to solve daily operation problems. In a

development. I often heard from Taiwanese business people that their technology was not necessarily state-of-the-art and very unique, and that the main source of their competitive advantage is persistent effort to offer customers solution promptly at a reasonable price, the practice which is seen as increasingly important in the IC (and IT) industry. Although many experts in the world understand it, I believe that Taiwan is able to go thoroughly because the firm-level strategy is appropriate and the inter-firm relationship in the cluster facilitates it in the background. In other words, the firm-level strategy is compatible with the inter-firm relationship in the cluster, and vice versa, which realizes potential merits of clustering and creates development dynamism in this region. The mere presence of a cluster and the textbook-like reference of cluster advantages do not fully explain why firms of a specific region are competitive in a specific industry.

Figure 5 shows the interaction as a summary. Concentration on core business is closely connected with the minute division of labor and cooperation, because a specialized firm alone can not get through. In the Taiwanese IC industry, it resulted in the development the unique vertical disintegration structure. The substantial agglomeration of various specialized firms in the relatively narrow area in/around HSIP facilitates close partnership. At the same time, it enhances competitive pressure in each of the production stages and IC-related sectors, which has constructive impact for the improvement of management techniques in various fields including the development of unique products, better customer support, technological development, cost management, and so on. In addition, we can find linkages between the factors of firm-level strategy. That is to say, concentration on core business probably leads to the realization of the economy of scale, which is fundamental to thoroughgoing cost management. Similarly, the concentration of corporate resources on well-selected targets normally promotes active utilization of external knowledge sources to supplement in-house R&D. Furthermore, it brings the economization of R&D expenses, then, finally contributes to thoroughgoing cost management. However, such favorable linkages between factors do not necessarily happen in an automatic manner. Or rather, as examined in detail, it is critical to have firm-level strategic efforts and local business environment which is facilitative to the efforts.

In these days, it is observed that some Taiwanese IC firms pursue the diversification of product categories and activities and the provision of solution (for example, modules, turnkey solution, and so on), which seems contrary to concentration on core business.

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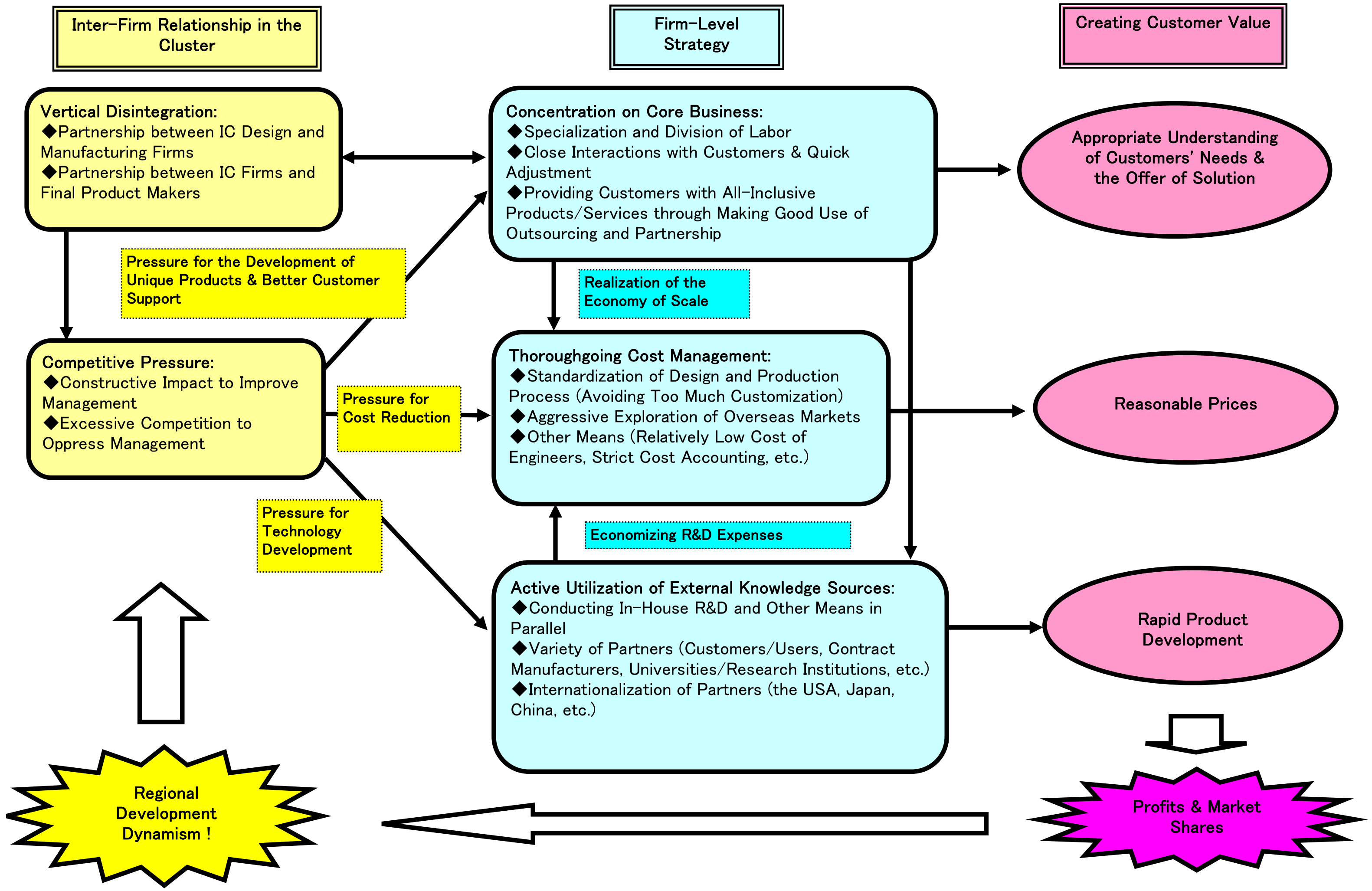
broad sense, it means (the offer of) customized products/services or a package of products/services to comprehensively solve a customer's problems. In this paper, the word is used as the latter meaning.

Figure 5: Interaction between Inter-firm Relationship in the Cluster and Business Strategy in the Taiwanese IC Industry



Source: Made by the author.

However, a more detailed examination reveals that they try to gradually expand a product line-up considering technological synergy, and/or try to divide an overgrown company into several affiliates which focus on a limited number of targets, and/or try to actively rely on outsourcing and alliances in the product development except for the development of core technology. All these practices are not necessarily inconsistent with the original strategy. Or rather, these can be seen as the evolution of it. A similar explanation also seems the case in the development of close partnership between IC design firms and foundry manufacturers, or between foundry manufacturers and packaging/testing firms. Namely, it is considered that such close partnership should be seen as effort to upgrade their specialties rather than intention to become an IDM.

The other important finding in this paper is that external linkages with foreign actors play an important role in the development of the Taiwanese IC industry and cluster. As mentioned above, Taiwanese IC firms have substantial connections with foreign partners in both of trading and knowledge exchange. Similarly, while Taiwan has a substantial number of local specialized firms and close partnership among them which covers most related sectors of the IC industry as a whole, they still rely on foreign actors as the supplier of critical machines/tools and materials and as the source of state-of-the-art technology. However, the dependence is no longer unilateral in these days. For example, as Taiwanese foundry makers (especially, TSMC and UMC) have become world top-class IC manufacturers, it is indispensable for overseas major suppliers of equipment, EDA tools, IPs and materials to have strategic partnership with them in order to verify their new trial products by using the process lines of these major foundry makers. It is a remarkable example of successful latecomer development that they entered into the IC business as middle-/low-technology manufactures focusing on the volume market zone, then, relying on the unique business model and cost advantage, they have gradually enhanced their presence in the sphere of technological development as well as mass production in the world.

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