From Founding Company to Global Company: The Case of Taiwan Semiconductor Manufacturing Company

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Abstract--**In this paper, we argued that latecomer firms' attachment to the global outsourcing network is the result of interplay between institutions, technologies and firms' strategies with a co-evolution nature. Previous researchers on latecomer firms tended to focus on the upgrading of manufacturing technologies. In this paper, we argued that servitization is also an important strategic behavior in this process, and use TSMC as an illustrative case study to support our arguments.**

I. INTRODUCTION

We are living in a globalised word. Friedman [13] argued that 'the world is flat'. In his view, one of the driving forces the globalization phenomenon is the development of offshoring activities around the world. Starting from 1970s, a global production network (GPN) was forming in the manufacturing industries, followed by the service sectors in the 1990s. Nowadays, firms may cooperate with their partners around the world in providing the products and services.

Attaching into offshoring or production networks is crucial for nations and firms. National governments, especially in the developing world, have to ensure their firms could successfully be part of the GPN to create economic growth and new jobs. As technological gap exist [37], government also have to make their firms more innovative in order to narrow the gap. The nature of industry also matters. The organization form of industries is usually influenced by the nature of technologies [30]. Hence, firms have to be more innovative so that they can attach into the GPN. Their strategies and decision also matters, but their abilities to maneuver in the industries are affected by the institutional and industrial environment. While technologies constantly evolve and institutional environments change over time, a co-evolutionary perspective can help us explain the dynamic nature of the global production network [28], [29], [32].

Previous researchers have studied on how firms in the less-advanced regions attach into GPNs [7], [8], [9], and/or even challenge the market positions of incumbents from the more advanced regions [6], [17]. In their view, the success of attaching to GPN usually involves government's policies, industrial structure and firms' effort on improving their product and processing technologies. Although these precedent researchers have generated considerable fruit of the exploration the secrets behind latecomer firms, they tended to focus on how latecomer firms overcome the deficit of their manufacturing and R&D capabilities.

However, the supporting service behind the scene is also crucial for manufacturing firms [38]. In this study, we will use Taiwan Semiconductor Manufacturing Corporation (TSMC) as a descriptive case to explore how a manufacturing firm enhanced their position in the global production network with servitization.

II. LITERATURE REVIEW

A. The co-evolution between firms and environment

One of the major contributions from the evolutionary economists is to explain the dynamics of industries. A firm's innovative activities may cause the birth of a new industry or create turbulence within the industry through "selection" and "variation" mechanism [34], [35], [36]. In their view, the structure of industry is basically a result of the interplay between technologies, institutions and firms' behaviors [32], [39]. While the evolutionary economists tend to adopt a more neutral view to examine the changing structure of industry, business researchers have an interest looking for the explanation of firms' responses and corresponding strategies. Based on the historical analysis of the U.S. mutual fund industry, reference [27] suggested that firms are not just spectators watching the changes within the industry. In order to main their competitive positions in the market, they also react to changes in order to survive. Firms' capabilities evolve with the industry through the mechanisms of feedback, feedforward and focusing forces. Although some may contend that firms' capabilities to response to market is somewhat limited due to the effect of path-dependence [39], but it was generally accepted that co-evolution patterns do exist. However, to what extent a firm can alter their capabilities, and what factors influences a firm's abilities were still missing in the formalized models in business studies.

Reference [28] further expanded the idea of [27], and developed a comprehensive explanation, which emphasizes the interplay between institutional environment, industrial dynamics, and firms' strategic behaviors. This model is basically a meso-level model, which could further explain the forces which drive and limit the change of industry and the limitation of a firm's strategic moves. As new technologies constantly hit the market and institutional environment changes over time, firms have to adjust their organization forms and strategic activities in order to survive in the market.

B. Latecomer firms in the global production network

The forming of GPN may be traced back to 1970s and was a result of the change of institutions technologies and

firms' strategic moves. After the world war two, the international trade soon intensified. Through the observation of the trading patterns, Reference [37] noticed that the labour division between advanced and less-advanced countries do not simply follow the comparative advantage of cost. Advanced regions specialize in the technological intensive industries although they do not have the advantage of production cost. He suggested that technological gap exists between countries. Firms in different regions differ with their capabilities to innovate. As a result, advanced regions specialize in the new industries, while less advanced regions perform better in the mature industries. However, the trading patterns change over time. Reference [41] developed an international product life cycle (IPLC) model. In his prediction, trading pattern would reverse eventually. Firms in the less-advanced regions would be induced into the new industry, and overcome their technological disadvantage through imitation. Cost advantage would take effect once the technological gap disappears.

In the 1970s, the prediction of IPLC started to loss its power of prediction. In the IPLC model, the production of location moves to less advanced regions only when the product enters the mature phase. However, in the 1970s, even the new products could be produced partly in the less advanced regions at the beginning of lifecycle. Reference [41] argued that some changes of institutional and technological environment had made his original assumptions obsolete. First, the loose of trading and investment regimes reduced the obstacles of the international flow of goods and investment. Second, facing intensified competition in the market place, moving production line to a lower cost place could help firms in the advanced regions to maintain their competitive advantage. The global network was not just about exchanging products between nations, but also including the internationalization of the production value chain.

Firms in the less-advanced regions were usually latecomers in the industries due to the effect of technological gap, and became much more active in the GPN under the above-mentioned institutional changes. Through the subcontracting activities, they could not just imitate foreign products, but could also transfer technologies from foreign firms or learn from subcontracting activities through the learn-by-doing mechanism. The structure of such a production network was usually centered around firms in the advanced regions, in which they complete the development and design activities, while latecomer firms focused on the manufacturing activities, as shown in various industrial case studies [6], [9]. However, it is still possible for latecomer firms to challenge the market positions of the incumbents. Reference [17] study on computer industry is a very good example to illustrate how latecomers firms improved their market position in a technological-intensive industry.

The abilities of latecomer firms to attach into such a global production network are highly influenced by the institutional and technological environment. Many researches in the fields of development studies and innovation management have already drawn considerable accounts on this matter. For instance, Freeman's [10], [11], [12] studies on Japan and Germany demonstrated the importance of national innovation system in such a catch-up process. Johnson's [24] in particular analyzed the role of MITI in the Japanese experience. In the example of Taiwan, many researchers put particular attention of the role of government policy and the public research institutes [19], [20], [21]. Such a view echoes the co-evolution perspective [28], in which the influences of institutional factors on the change of a firm's capability has been specifically singled out.

In the meantime, the GPN was also changing. In the 1970s and 1980s, researchers tended to focus on the manufacturing industries. The rise of India's software industry provided an interesting implication, that is, the forming of global offshoring software network [1], [3], [16], [25].

The global production network of manufacturing goods and services may have different features and implications to subcontracting firms [23]. For instance, manufacturing products are more standardized and codified. Hence, the factors to support firms co-evolve with industry and environment may differ between manufacturing and service firms. However, this view over-simplifies the intrinsic nature of manufacturing industry. Reference [14] argued that collaboration and information sharing are key factors to drive the success of global production network. In other words, some business services still played an important role on firms' ability to compete in the manufacturing factors.

C. Servitization – a neglected area of global production network

The term servitization is firstly coincided by [38]. In their view, the added-value services could be used as a source of competitive advantages. Through bundling goods, service, support and knowledge, a firm can build up its unique advantage. Although the customer in the manufacturing industry purchases goods from suppliers, their satisfaction is highly determined by the hidden services complementary to their product-using experience [15]. These bundled services could be the best way to 'enter customers' door' [42].

Furthermore, customers, by and large, require somewhat "tailored' solutions"; this is particular true in the subcontracting business [31]. For instance, reference [22] argued that the add-on service is crucial for subcontractors to establish a 'virtual factory' for their customers. Reference [22] also contended that subcontractor firms also have to take account of the services related to supply chain management.

However, the existing researches on latecomer firms in the global production network in the manufacturing industries tend to neglect the service side of the business. For instance, many studies, in the context of Taiwan, have disclosed many underlying factors supporting Taiwanese manufacturing firms attaching into the GPN, such as the ability to innovate and to scale-up [2], unique business network [5], or focused on the interplay between the institutional environment and firms'

innovative capabilities [6]. These factors are only applicable in the manufacturing side of business. The role of servitization in the attaching to global production network is still under-investigated.

III. RESEARCH DESIGN AND METHODOLOGY

This study is a qualitative research. We use a single case study as a descriptive case to explain how institutional and industrial environment affect a firm's ability to attach into the GPN and how servitization become a crucial source of advantage on the course of this co-evolution process. As [33] argued, historical analysis is a suitable approach to study the co-evolutionary process between industries, technologies and institutions. In this paper, we use TSMC as an example to conduct history analysis. Our data is secondary, by collecting information from case books, research papers, industrial reports and company reports; we reconstruct the historical patterns and study how TSMC responded to institution and technologies.

IV. CASE STUDY – TAIWAN SEMICONDUCTOR MANUFACTURING CORPORATION

TSMC was founded in 1987, as a spin-off company from VLSI (Very-Large-Scale Integration) project of Industrial Technology Research Institute. In 1970s, Taiwanese government was looking for new momentum to support Taiwan's economic growth. At the time, some Taiwanese firms started to produce electronic components for foreign electronic firms. Local electronic appliance firms emerged in domestic market. Informed by overseas Chinese advisors, the premier realized the market potential of the electronic industry, and established a public research institute, ITRI, to develop relevant technologies for domestic firms.

In 1976, ITRI signed a technology transfer agreement with Radio Corporation of America (RCA) for its foundry processing and CMOS technologies. In 1977, a demonstration factory was established. In 1979, this factory spun off from ITRI and formed a new company – United Microelectronics Corporation (UMC). Despite suffering from loss in the first two years, UMC soon turned profit.

In 1982, U.S. government deregulated the telecommunication market. This policy induced new competition and created new demand of the dial-up chips. After upgrading its testing facility, UMC soon grasped this market and turned profit.

At the same time, ITRI launched a new project to develop the VLSI technology. Witnessing the success of UMC, government decided to spin off this project from ITRI and form a new company – TSMC. Morris Chang, the former head of semiconductor business of Texas Instrument, was invited to lead this new company. The initial capital of TSMC was USD$1.4 billion, in which 27.5% came from Philip, 48.3% came from the Development Fund of Taiwan's government, and 24.2% came from private sector.

As a veteran in the semiconductor industry, Morris understood how big the challenge is. First, despite with government's backing; TSMC was just a small firm, compared to the incumbents. Second, although TSMC obtained technologies from ITRI, it was still far behind the technological leaders for at least two to three generations. Third, the landscape of semiconductor industry was changing. In 1960s, the global semiconductor industry was dominated by U.S. firms. In the mid-1970s, Japanese firms entered this industry and challenged the dominant positions of these incumbents. In 1978, the market share of IC of U.S. and Japanese firms were 74% and 20% respectively. Japanese firms were famous with high quality and low cost. They soon became powerful players in the marketplace. In 1988, Japanese firms had surpassed their U.S. competitors with 47% of the global market. New entrants in the market meant the fierce of competition, especially in some 'standard application' areas. For instance, Intel was one of the leading DRAM producers in the 1970s, but retreated in this market in 1985. Many IDMs became conservative on establishing new foundries in order to fully exploit their existing capacity.

In the mean time, a new breed of firms started to emerge – IC design house. The production of ICs had to experience three phases. Firstly, engineers had to design the layout of the IC based on the specification from the customers. A tapeout file would be produced. Then, it would go into the fabrication process, in which the layout would be imprinted on the silicon wafer. Finally, these wafers would be tested and cut into dice.

Traditionally, the design and fabrication activities were usually carried out in a single firm. These firms could be called the integrated design manufacturers (IDM). However, the design and the fabrication were actually two different tasks and require different knowledge bases. In 1975, Carver Mead and Lynn Conway, two microelectronic experts, suggested that design and fabrication activities could be carried out by different specialized firms in order to deal with the more and more complicated design and manufacturing needs. Comparatively, the design activities were far less capital-intensive than manufacturing activities. The booming of electronic appliances and the emergence of personal computers (PCs) also induced many new entrepreneurs entered the market. Some entrepreneurs started to adopt a new business model – fabless design house. In this model, IC design house only got involved in the design activities, which were less capital-intensive, and rented the capacity from IDMs to complete the fabrication process. However, as IDMs also had their own products, those IC design houses could only use the spared capacity. As many IDMs reduced investment on new foundries, these IC design houses were struggling to control the production schedule. Moreover, those IDMs also had their own products in the market. Hence, IC design houses had to risk the possibility of secret leaks to potential rivals.

Inspired by Mead and Conway and informed by the changing of the landscape in the semiconductor industry,

Morris Chang made a bold move. He decided to position TSMC as a professional fabrication service firms. As mentioned earlier, IC design houses were struggling to get hold of spare capacity. Additionally, a professional foundry, who did not sell their own products in the market, could reduce the risk of secret leaks. This position also gained support from Taiwan's government as domestic IC design firms, who also had difficulties to find a reliable fabrication capacity. This strategy paid off very soon. The initial project of TSMC was 30% of capacity for domestic market, and 70% for foreign customers. As there were just a few IC design houses in the industry, TSMC's main target customers were those IDMs, who did not have enough capacity to cope with the fluctuation of market demand. However, many orders came for North America based IC design houses. The existence of professional fabrication service was influential because it provided an alternative way to produce IC. In 1981, all of the top ten semiconductor firms, leading by TI, were IDMs. In 2013, Qualcomm and Broadcom occupied the fourth and tenth place, respectively, in the league table. Both firms are fabless design houses.

Professional foundry was not just to manufacture ICs for customers, but also provided various added-value services to customers. In order to make TSMC's foundry as customers' own factories, TSMC had to provide different services to support this business model.

First, TSMC provided many different ancillary design aids and support service. Staring from late 1980s, TSMC provided their customers with third-party design libraries, which could accelerate the design process and reduce the possible issues in the manufacturing process. TSMC also had its own design libraries. Additionally, TSMC collaborated with EDA (Electronic Design Automation) providers to ensure the compatibility of their products and the manufacturing process in TSMC. These efforts were to reduce the possible issues between the design and manufacturing phases.

Second, with the advance of information technology (IT), TSMC established complicated IT system for realizing the e-Foundry concept. In 1996, TSMC developed a total order management system to enable customers checking the production and delivery scheduling. In 1999, TSMC further launched a TSMC online service. Customers could assess all the technical documents. Many IT services were introduced subsequently, such as TSMC direct, TSMC Yes, TSMC internet layout viewer and TSMC jobview. The main purpose of the development of these IT services is to enable customers to view TSMC's foundry as their own factories.

V. FINDINGS AND DISCUSSION

TSMC's case study demonstrated how institution and technologies affect the way latecomer firms attached to the GPN overtime. The birth of the TSMC was actually a result of Taiwan's industrial policy. In order to overcome the technological gap [37], Taiwanese government created public research institutes and to assimilate technologies in electronics industry. TSMC was a spun-off unit of a research project. The national institution also had an impact on how TSMC obtained capital as the developmental fund of the government was the major source of capital of TSMC at the early stage.

In the meantime, national institution's influences were limited. Even with government's backing, TSMC was still small in scale and technological behind. However, the nature of semiconductor industries shed a new light. The semiconductor industry was under transformation in the 1980s. Historically, almost all firms were IDMs who operated vertically. However, the IC design and manufacturing process required different knowledge base and different capital conditions. Similar to the history in the computer industry, hardware and software could be produced separately, so did IC design and manufacturing. Innovative entrepreneurs with IC design abilities started to open IC houses, and created the demand of professional foundry subcontractors. This provided an alternative way for TSMC to enter the market. The booming of IC design houses was stimulated by the booming of electronic appliances and personal computer industry. This, in turn, made professional foundry a working business model.

However, in order to compete with the incumbent IDM, IC design houses had to ensure they could had their products as the same quality as their IDM rivals. Moreover, new firms also entered the subcontracting market. In order to satisfy the needs of IC design houses and to differentiate with rivals, in the 1990s, TSMC started to enhance their supporting business service. Based on the idea of virtual foundry, TSMC had to develop various IT systems for collaboration and knowledge sharing.

TSMC's case demonstrates how institution, technologies, technologies and firms' stragegies co-evolved over time, as [28] suggested. The industrieal development policy, lauched in 1970s, created a favorite insitutional enviornment for TSMC. In the meantime, the technologcial change, and the new applications of IC, also provided an alternative route for firms to operate in the industry. Although the environment was favour to a new form of labour division, TSMC's strategy was also crucial to trigger the industiral change. A proffessional foundry manafacturing service was unheard of. As a latecomer, TSMC demostrated it was a new way to produce IC chips and could meet the raising demands of independent IC design houses.

However, the idea of professional foundry was not just about the imporvement or upgrading of manufacturing service. As discussed in the case, clients wanted the the foundry like their own facotries. In order to meet such an expectation, TSMC had to develop different kinds of services, such as design libraries and information systems. Hence, servitization is crucial for latecomer firms tapping into the GPN.

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