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Science, Technology and the Economy Program (STE)
Working Papers Series STE-WP - 21 - 2004

Technion - Israel Institute of Technology

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STE-WP-21-2004

[1] Acknowledgment: This paper is part of a larger research project comparing the development of the IT industry in Taiwan, Israel, and Ireland. The author would like to thank Suzanne Berger and Richard Lester for without them the Taiwan part of the project would not have been; Richard Samuels and Michael Piore for their constant help; Andrew Schrank and Gary Herrigel for their comments on earlier drafts; the participants of the IPC globalization project for their advise, comments, and comradeship especially Douglass Fuller, Akintunde Akinwande, Charles Sodini, Edward Cuningham, Timothy Sturgeon, and Sara Jane McCaffrey; Wen-Yueh (James) Wang and Yu-Chen (Jesse) Lan supplied superb research assistantship; Alan Chen and Hsin Hsin Lin gave superb logistic support. The larger research project is supported by a Sloan Foundation graduate fellowship; the STE program of the Neaman Institute in the Technion in Israel; the SSRC program on the Corporation as a Social Institution through a grant given by the Sloan Foundation; the MacArthur Foundation, through two grants given by the Center for International Studies at MIT; MIT - Industrial Performance Center; and MediaLabEurope. This paper presents the author's own view and not that of the Samuel Neaman Institute for Advanced Studies in Science and Technology or any members of its staff. All mistakes are solely the Author's.

Abstract:

Of the East Asian Newly Industrialized Countries (NIC) Taiwan's story is one of the most inspiring. In almost all accounts of Taiwan, the state has been described as the major impetus of economic development and technological upgrading. The Taiwanese government's policy goal in the last decade has been to spur more new-products innovation capabilities. This paper explores the capabilities and limits of the Taiwanese state in achieving such objectives in two key sectors of the IT industry, software and IC design. This is done through mapping of the evolution of, and the changing roles of the state in, these two subsectors, looking specifically at capabilities, innovations, and business models employed by private firms. The main arguments are, first, the division of labor between state and private industry that successfully developed an industrial system utilizing OEM and ODM business strategies may now limit innovational capacity to second-generation innovations. Second, I argue that the public research institution-based industrial technology policy of Taiwan has been helping the growth of private industry when: (1) these research institutions created and expanded multiple and broad interactions with the private IT industry; (2) when the public research institute saw private IT firms as their final customers. On the other hand, the same policy approach has hampered the growth of the industry when the institute competed directly with the industry for its own customers.

Key Words: Science and Technology Industrial Policies, Technological Learning, Industrial Evolution, Research and Design capabilities, IC Design, Software.

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Introduction

Of the East Asian Newly Industrialized Countries (NIC) Taiwan's story is one of the most inspiring. In some important aspects, Taiwan is the only country in the region that has managed to eliminate the gap in innovational activities with the leading western industrial nations and Japan – the G7. [1] Taiwan seems also to have developed a vibrant industrial system of indigenous new small and medium size enterprises that is not dominated by a few huge conglomerates or subsidiaries of foreign MNCs. In almost all accounts of Taiwan, the state has been described as the major impetus of economic development and technological upgrading.

Today most Taiwanese companies specialize in producing systems and equipment for other companies. One may argue that in the "new global economy" this is not such a disadvantage. However, the fact that Taiwan has yet to develop a significant number of companies that can develop new products and not just improve and innovate on products developed elsewhere implies that the industry cannot capture the lucrative rents that come with skills that bring new products to market first. [2]

The Taiwanese government's policy goal in the last decade has been to spur more new-products innovation capabilities. This paper explores the capabilities and limits of the Taiwanese state in achieving such objectives in two key sectors of the IT industry, software and IC design. The paper presents the evolution of these two subsectors of the IT industry in Taiwan and looks specifically at capabilities, innovations, and business models employed by private firms. It maps the institutional system in which the industry is embedded and the changing roles of the state, giving a detailed micro-level

understanding of the industry's evolution as well as industry-financial industry, industry-universities, and industry-state, interactions.

Much of the literature that attempts to explain the Taiwanese economic growth depicts Taiwan as a society in which the state takes the lead in first forays into new economic activities, always, however, with the aim of spurring private entrepreneurs and always through interactions with private industry (Amsden 2001; Amsden and Chu 2003; Evans 1995; Fields 1997; Fuller 2002; Hong 1997; Mathews and Cho 2000; Wade 1990; WB 1993). In most accounts, Taiwan's industrial and innovation systems come through as a humming machine of industrial development with a smooth and well-functioning division of labor between government and industry. In this division of labor, the public research institutions do most of the research and early development, and then diffuse the results to the industry that concentrates on final development and integrated design. It is this division of labor that is considered responsible for Taiwan's leading role in the global information technology industry.

This division of labor may, however, limit Taiwan's' ability to excel in cutting-edge innovation activities. It creates a system that support technological absorption and excel in 2nd generation innovation, i.e., innovation that seeks to improve the production and reliability of products based on novel technologies developed elsewhere. But it is not certain whether this system can assist Taiwanese companies in developing their own innovative original IT products. Moreover, around this system, with its division of labor in R&D between public and private organizations and its very successful firms, an institutional system of rules, regulations, and service and financial industries evolved and

became the environment within which firms operate. The question today is whether this institutional environment can be as supportive to more original R&D-based companies.

Another gap in our understanding is that while studies of Taiwan's high technology industry, or for that matter most studies in the developmental state tradition, explain the great success of Taiwan's IT industrialization in both the macro and micro level, almost none of them utilized a micro-institutional industrial case-study method to understand not only the successes, but also the limits and even the failures of Taiwan's industrial technology policy.[3] If we seek to understand how state policy shapes industrial development this oversight is preventing us from seeing the full picture. In order to fully understand the ways in which policy and state action shapes industrial development it is not enough to look at them from the aggregate level, nor is it enough to look only at the successes. We must analyze the failures and understand why they fail, and we also need to analyze the limitation of the successes if we seek to continuously improve industrial growth. The use of the more inclusive levels of analysis biases the researchers to concentrate on the macro levels successes and does not enable them to fully explore the limits of those or pay attention to the failures. That focus colors most analysis of Taiwan in overly rosy predictions.

This paper aims to fill this gap. It will do so by looking at two subsectors that have been on the edge of the technological innovation of the global IT industry in the 1990s: software products, and fabless chip design, particularly for telecommunication and multimedia. The two sectors are especially interesting cases in which to examine government industry interactions, since both sectors have their own dedicated public research agency. The fabless chip design industry is considered to be the latest and most

innovative subsector of the semiconductor industry to emerge in Taiwan, in part as a result of the efforts of the Industrial Technology Research Institute (ITRI) and its two dedicated semiconductor labs, the Electronic Research Service Organization (ERSO) and the Computing and Communication Lab (CCL). In software the, role of the state agency, the Institute for Information Industry (III), is, however, not as clear, and we lack analysis of its approach to and interaction with the industry.[4]

This paper presents the evolution of these two subsectors of the IT industry in Taiwan and looks specifically at capabilities, innovations, and business models employed by private firms. It maps the institutional system in which the industry is embedded as well as the changing roles of the state. The data analyzed here come from a unique database of 582 interviews conducted as part of the IPC globalization project, and from official and industrial statistical sources. The interviews were conducted with founders and executives of private companies, top civil servants in all the developmental agencies (ITRI, III, MoEA, IDB, NSC), academics, and venture capitalists. Building on these sources, this paper presents a detailed micro-level understanding of the industry's evolution as well as of industry-financial industry, industry-universities, and industry-state, interactions.[5]

This paper starts with two sets of hypotheses. First, the public research institution-based industrial technology policy of Taiwan has been fruitful in helping the growth of private industry when: (1) these research institutions created and expanded multiple and broad interactions over ideas including policy development, knowledge and information, finance, and personnel, with the private IT industry; (2) when the public research institute saw private IT firms as their final customers. On the other hand, the public research

institution-based industrial technology has hampered the growth of the industry when the institute has competed directly with the industry for its own customers.

Second, this paper hypothesizes that the particular trajectories of development supported by government – for all that they enabled spectacular and rapid growth – still limited industry to a fairly narrow range of activities in the global IT product chain. Activities that focus only on 2nd generation innovations, i.e., innovating on designs of products that are based on technologies developed elsewhere and on products with markets that are already well defined. For example, in the case of chip design, although the Taiwanese semiconductor industry is the third or fourth largest in the world, with skills and technological capabilities as competitive as any other industry, no Taiwanese IC firm has yet managed to produce any cutting edge innovative IC design. Most are not even trying. This might not matter, but as long as the industry does not develop these capabilities it will remain dependent on the decisions and technological development of foreign firms.

The paper is divided as follows. The first part reviews the literature and theoretical issues by analyzing Taiwan's experience of rapid IT growth. The second part presents an account of the IC design industry, its development, strengths, and limits. The third part focuses on the software industry, and argues that the almost adversarial relationship between the private industry and III has played a major role in the weak growth of the sector. I conclude with sketching out a few policy alternatives for these two sub-sectors.

Theoretical Review and Analysis of Taiwanese IT Industrial Growth

The last few decades have seen fierce debate about the exact role of the state in economic development. The main arguments in the literature on East Asia, particularly on Taiwan, can be summarized as a softer version of the developmental state theory. The adjectives given to this newly found category of developmental state constitute a small cottage industry in itself. However, be it the flexible developmental state, the developmental network state, or the embedded autonomy industrial bureaucracy, the same basic model is advanced (Amsden 1989; Amsden and Chu 2003; Evans 1995; Mathews 2002; Mathews and Cho 2000; O'Riain 2000; O'Riain 2004; Wade 1990; Yongping 2001).[6] This model argues that for a state to initiate industrial growth, especially in technologically intensive industry, it needs to interact constantly and to evolve a division of labor with the local industry. The neo-developmental statists argue that the state's main role is in the co-designing and coordination of industrial development and do not attribute to the state the role of visionary plans development and implementation that the older statists ascribed to it (Amsden 1989; Anchordoguy 1989; Evans et al. 1985; Johnson 1982).

According to the neo-developmental statists the state needs to: (a) make and implement decisions from a public point of view taking the national interest rather than private interests as a reference point; (b) be informed about the needs, abilities, and difficulties of the industry so it can tailor its policies and refrain from policy initiatives that harm the industry; (c) change its policies in tandem with the changing needs of industry; and, (d) let the industry gain more and more power to decide on its future as it

finds its feet; hence, the state needs to be able to change its own role from initiator and leader to that of a supporting actor.

However, the theorists of the new developmental state portray the state as a completely binary and teleological variable: the state is either successful hence a neo-developmental state, or failing, therefore not a neo-developmental state. The literature do not entertaining the possibility that the same state can succeed in some attempts to create high-technology industries and fail in others. An example is Sean O'Riain's recent study of the Irish software industry where he defines the flexible development state:

> "The flexible developmental state (FDS) *is defined by its ability* to nurture post-Fordist networks of production and innovation, to attract international investment, and to link these local and global technology and business networks together in ways that promote development." (O'Riain 2000. P. 158. Italics added)

This definition obscures more than it reveals; it classifies the cases using the depended variable and it automatically assume that the correct analysis is at the national level as well as seeing the state as a unitary actor. This prevents us from conducting a full micro-level analysis to understand the different ways in which the state can spur innovation-based industrial growth, post-Fordist or not. It also prevents us from realizing that, in many cases, the same state that in one industrial sector has been an ideal example of the new "softer" developmental state, successfully nurturing spectacular high-technology industrial growth, is failing miserably in another.

The tendency to define state is either a neo-developmental state or not is the result of two common traits of recent studies, first, the use of either an national level of analysis looking at the aggregate industrial development, or the use of sectoral analysis of a specific industry or region which is then generalized to the national level. The second trait is the tendency to focus on either successes or failures without an attempt to analyze

these at the micro level and understand both the limits of the successes and the positive effects of the so-called failures. This tendency can be attributed to the under-defined nature of the concept and the need to classify the cases studied using the dependent variable. If we seek to understand how state policy shapes industrial development, this oversight is preventing us from seeing the full picture. In order to fully understand the ways in which policy and state actions shape industrial development it is not enough to look at them from the aggregate level, nor is it enough to look only at the successes. We must analyze the failures and understand why they fail, and we also need to analyze the successes and see their limitation if we seek to continuously improve industrial growth. The use of the more inclusive levels of analysis biases the researchers to concentrate on the macro level successes and does not enable them to fully explore the limits of those or pay attention to the failures. That focus colors most analysis of Taiwan in overly rosy predictions.

In most accounts Taiwan seems to be an exemplary case of a state that has managed to handle these complex and sometimes contradictory roles. Three recent accounts of Taiwan's high-technology industrialization reached almost complete agreement on the ways in which the state and industry in Taiwan have developed the IT industry since the early 1970s (Amsden and Chu 2003; Hong 1997; Mathews and Cho 2000). While each author has a different vocabulary, each describes a similar two-phase process. First, the state's research agencies acquire a technology from abroad, absorb it and improve it, and then spin off private companies to spur the industry. Second, after the private industry has emerged, the industry and state settle on a new division of labor in

which the state's role is to locate, absorb, and infuse the industrial system with new technologies, and to assist private firms with their own advanced R&D projects.

The most famously successful subsector of the industry where the state was not only the initiator but managed to transit successfully into a more supporting role is IC silicon chips fabrication (Fuller 2002; Fuller et al. 2003). Here Taiwan's particular version of science and technology industrial policy, based on big public research institutions, created a world leading industry. In 1973, the Industrial Technology Research Institute was founded, and in 1974, ITRI's Electronic Research Service Organization lab commenced its operations. Developing on an obsolete IC technology acquired from RCA in 1976, ITRI started to spin-off companies. Of these companies the most important were UMC, TSMC, Winbond, and Vanguard. One spin-off, TSMC, proved critical. Under the management of the then head of ITRI, Morris Chang, TSMC set out to, and succeeded in, developing the new business model of pureplay foundries. In so doing TSMC completely transformed the working of the international IC industry (Fuller 2002).

After this success and with the rise of the IC fabrication industry, ITRI changed course and now acts as an important channel of foreign technology and the loci of some intensive research activities, as acknowledged in many of our interviews with private companies (Amsden and Chu 2003; Hong 1997; Mathews and Cho 2000)). The success of the IC fabrication subsector is impressive by any standard. However, even in this story we see not only the successes and capabilities of the Taiwanese state in spurring new innovation-based sectors, but also its limits and weaknesses.

As Fuller et al shows, Taiwan's main difference with that of other NICs, mainly Korea and Japan, is that the state under the KMT purposely built a financial system with a severe scarcity of patient capital, a fact that limits the ability of Taiwanese companies to compete in many IT manufacturing sectors (Fuller et al. 2003). Taiwanese companies average equity/debt ratio has been as low as in the US and sometimes even lower (Cheng 1990; Cheng 1993; Fields 1997; Gold 1986) in a stark contrast to the famous Gerschenkronian model of late development (Gerschenkron 1962). This helped the Taiwanese economy as a whole to pass relatively unscathed from the East Asian financial crisis (Park 2000). However, as a consequence, it seems to limit Taiwan's ability to successfully innovate in IT manufacturing. Generally speaking, in the last decade Taiwanese IC fabrication companies excelled only as pureplay foundries with the IDM companies losing ground both internationally and domestically (Fuller 2002).

As Taiwan cannot compete directly with the heavily endowed patient capital South Korean and Japanese IT manufacturing industries, Taiwan needs to develop different strategies for successful innovation. One might be to focus on subsectors with high granularity, high volume production, and no requirement for large amounts of patient capital, as suggested by Fuller et al (Ibid). Others strategies would be to develop a sophisticated innovation services IT industry, or to take a page out of the US' IT industry's book, and learn to excel in the development of technological cutting edge new products.

The next two sections analyze Taiwan's experiments with these two strategies by looking at the successes, limits, and failures of Taiwan's development policies for software and IC design/fabless IC chips. The use of a rich database of interviews,

combined with more quantative data, enables this paper to analyze the two subsectors' system of innovation, historical development, and institutional system. This paper follows the method advanced by institutional theorists in economics, sociology, and political science, who argue that in order to understand industries, one needs to analyze their institutional systems, i.e., regular pattern of behavior, interactions, competition, and cooperation that constraint grant certain capabilities, and motivate economic actors to act in particular ways in their search for material gains (Braczyk et al. 1998; Breschi and Malerba 1997; Breznitz 2003; Culpepper and Finegold 2001; Fligstein 1991; Fligstein 1996; Hall and Soskice 2001; Kitschelt 1991; Lundvall 1992; Nelson 1993; North 1990; Powell and Dimaggio 1991; Streeck 1991; Ziegler 1995; Zysman 1996).

In order to do so, the paper analyzes how the particular policies and activities of state agencies have created an institutional environment, both in the financial system and in the industrial system, that induces companies to concentrate on specific activities and favor certain business models over others. In the financial system, the analysis focuses on the kind of financing available to founders and companies in the developmental phases of their companies and to the specific incentives provided by the Taiwanese system of financial regulations. In the industrial system, the paper looks at the Taiwanese IT industry as a whole, analyzing the opportunity structure it present to new enterprises, as well as the skills and capabilities it enhances.

The Taiwanese IC design and Fabless Industry

Over the last ten years the Taiwanese IC design industry has had remarkable growth. From an industry that consisted of fifty-one companies in 1991, the industry

grew to sixty-six companies employing 2109 people in 1996, and to 225 companies employing 11,800 in 2002. This rapid growth made it one of the three biggest industries in the world, together with the US and Israel, with the sales of the largest 10 IC design firms alone reaching $3USD billion (ITRI 2003; ITRI Various Years). Looking at the largest ten companies by sales in 2000-2001, we see that the industry's skills are quite developed and flexible, as attested to by the ability of Taiwanese IC design firms to excel in almost every subsector of the semiconductor industry.

Table 1 top ten IC design companies about here.

However, looking more carefully at the leading companies, one common trait appears: none of them develops completely new innovative products that are first to the market. Furthermore, even the most innovative firms, those that manage to develop some own brand recognition to their products such as VIA and ALi, rely on developing secondary innovations on the basis of technologies developed by the leading American MNCs. This tends to leave many of them in an awkward and weakened position, where changes in technology or in the behavior of leading MNCs can rapidly weaken their market position.

The story of VIA, the largest Taiwanese IC design company in term of sales until 2002, is a case in point. VIA's main product line is PC chipsets. When Intel's Pentium 3 was the leading PC CPU, in part because of Intel's decision to stick with the more expensive Rambus technology, VIA approached global market share of almost 50% while Intel's market share shrank. With the move to Pentium 4 technology, Intel attacked VIA on multiple fronts. It did not license VIA its P4 technology and it took VIA to court over patent infringement allegations in October 2001. As a result of these moves all 1st

tier PC manufacturers such as Asus or Gigabyte refrained from using VIA's chipsets, fearing legal action from Intel. VIA countersued Intel for patent infringement and using monopoly status. The legal battle was fought in five jurisdictions. In April 2003, the companies reached a settlement that includes a patent swap agreement and a licensing agreement, but by then VIA had lost substantial market share and revenues. Moreover, as it agreed to pay royalties to Intel, it is not clear whether VIA can retain the profit margins it enjoyed before the legal battle started. If in 2001, VIA was the biggest Taiwanese IC design house with about $1USD billion in sales and controlled almost 50% of market share of PC's chipsets; in 2002 VIA was only the 2nd largest Taiwanese IC design house, with sales down to $729USD million, and global market share of less then 25%. In 2003, VIA sales continued to drop and its sales are at $600USD million (AFX 2001; FT 2003a; FT 2003b; FT 2003c; Hille 2003; Hung 2002).

As can be seen from the rapid growth of the design, or fabless, subsector after 1996, the main impetus for growth was the establishment and rapid growth of the pureplay foundries. Both major foundries, TSMC and UMC, have taken leading roles in the development of the design subsector, establishing exclusive foundry-IC design house relationships that they term club members whom they also financially assist. Many of the top IC design houses, such as MediaTek and NoveTek, were spun off from UMC. During the IPC study, we have interviewed most of the larger design houses as well as a large sample of the newer and smaller telecommunication and image processing fabless firms. This has enabled us to observe the overall development and structure of the IC design subsector as well as to gain deeper understanding of the two niches that have been the most innovative since the late 1990s.

Structure, development, and business models in the Taiwanese IC design industry

Analyzing the results of our interviews and looking at the business models employed by the ten leading companies it appears that apart from the few cases where a Taiwanese company manages to sell its own branded products to final customers, such as D-Link's WiFi (80211-based wireless LAN) bay stations and ASDL modems or VIA's Intel's CPUs chipsets, there is one main business model that is employed by Taiwanese fabless companies. This business model utilizes Taiwan's advantage in having local presence of both the world's biggest and most advanced pureplay foundries and of some of the largest system-houses/original equipment manufacturers (OEM) like Quanta or BenQ, i.e., companies that manufacture products for brand name (OBM) MNCs through OEM outsourcing contracts.

Most of the Taiwanese IC design houses employ two variants of the same strategy: to supply the Taiwanese (and more recently the Chinese) system houses with the chips they need in order to supply finished products at competitive prices and sufficient quality to OBM MNCs. The Taiwanese fabless companies rely on the proximity of the world's biggest pureplay foundries. This geographical proximity enables them to cheaply and speedily produce large quantities of newly-designed chips and to inspect and assure quality in almost real-time, at a relatively low cost. The Taiwanese IC design houses we interviewed, including these that focus on telecommunication and image processing, specialize in chips that are based on proven technologies, i.e., innovation on 2nd generation technologies with the aim of lowering costs and increasing reliability; they also do some process innovation. Apart from an unsuccessful attempt by ICreate, a

subsidiary of Etron, to develop and market chips on cutting edge technology in a joint venture with the Israeli company Zoran, no Taiwanese IC design house that we interviewed aims to develop original new products, new technologies, or products that are based on cutting edge technology.

Add Diagram I – Market Relations and Communication Environment of Taiwanese IC Design houses about here.

The Taiwanese fabless companies' business model has two variants that are not mutually exclusive. In the first variant, the design houses custom-design chips for clients using the clients' specifications (a local OEM with specific contracts with an OBM), test and quality-assure them, and then manufacture and deliver them using a pureplay foundry for fabrication. In the second variant, the IC design house builds "standardized" chips that answer the needs of OEM companies and other customers, manufactures them using a pureplay foundry, and sells them either directly or through distributors. By and large, all the firms we interviewed claimed that as the market for standard chips is vastly larger, revenues using the second variant with successful products are much higher. A significant number of companies, however, use both business models, mainly because custom design chips have the advantage of a secure customer and higher profit margins per fabricated chip.

As the first, or custom-made, business model also has lower costs and companies can secure revenues either upfront or rather quickly, until recently it has been the preferred mode of operation for new companies. The story of Sunplus, consistently one the top four companies in term of sales since 2000, is illuminating. Sunplus was established by a group of former ITRI-ERSO engineers who left ITRI to join Silicon Integrated System (SiS) and left SiS after its restructuring in 1989. The idea of the

founders was to focus on the consumer market, especially toys; thus reliability and price have always been much more important than the latest technology and features. Using their own money to seed the company, the founders immediately sought revenues to supplement their capital and started operations with custom-made ASIC designs. In 1994, Sunplus manufactured its first standardized chip, a micro controller for toys with LCD monitor, from which it branched out to other multimedia related chips. Today Sunplus uses the custom-made chips business model for its entire gift and toy markets businesses and own-spec developed standardized chips business model for the rest.

Most of Sunplus's revenues originate now with its standard chip; however, as there is a fierce competition in the multimedia mass market, a large percentage of profits comes from the smaller custom-made chip division. Sunplus is very aware that while it does not use cutting-edge technologies, in order to be able to continually excel it must keep abreast of new technologies and be able to quickly implement them once their price goes down. In order to do so, Sunplus, in a way similar to many successful Taiwanese fabless companies, employs a few strategies. First, they continue a close relationship with ITRI, especially with its CCL lab using ITRI as a channel for new technologies. Second, Sunplus has established its own investment arm that invests in foreign and local start-ups in fields that Sunplus thinks it might need in the future. Third, Sunplus directly licenses technologies.

The Taiwanese IC design houses do not rely on in-house developed cutting-edge IP to give them market advantage, but on their ability to deliver moderately sophisticated products more speedily, cheaply, and reliably than their competitors. This is true even for companies that pass through the new governmental sponsored Small Business Innovation

Research (SBIR) program and/or ITRI's incubation center. For example, one interviewee told us: "our game plan is to focus on the China market. The US is far too technologically advanced for us" (IPC interview with an ITRI incubation center' graduate IC company 1/28/2003). Another interviewee, a serial entrepreneur who is now the founder of a company that is still in ITRI's incubation center added, "The customers we want need to have good chips but not state-of-the-art chips, they care more about reliability, mass production, and unit costs than about cutting edge technology. They are not looking for innovations" (IPC interview 1/30/2003). Two other interviewees, from two of the most technologically advanced communication Taiwanese fabless companies, were even more pessimistic about the state of innovative activities in the industry:

> "There is only one place in Taiwan that develops new technology and cutting edge products – ITRI – I sometime miss being there; the only reason I left is because I wanted to get rich."
>
> "I do not know about any real R&D-based company in Taiwan, apart from ITRI of course. Everybody is interested in revenues and profits. Mediatek is the biggest model of success. The biggest problem for any R&D-based model to work is the stock options/bonus regulations these pull all the talent into the big manufacturing companies" (IPC interviews with companies in Hsinchu Park 1/30/2003).

Hence, the fabless chip sector evolved around a particular business model that relied on the unique institutional features of the Taiwanese IT industrial system as a whole. The main three of these are, first, the existence of large system houses and OEM companies that sell profitability in foreign markets, hence a large demand for chips based on 2nd generation technologies. Second, the industry is relying on the close proximity of the world's largest and most advanced pureplay foundries. Third, the industry relies on an innovation system with a division of labor between ITRI and the industry that excels in

quick technology transfer and 2nd generation innovation, while continuously infusing the system with the most recent foreign technologies.

Utilizing this business model, the IC design subsector is providing complementary assets to the Taiwanese OEMs and pureplay foundries. First, it supplies the pureplay foundries with a constant stream of orders in a variety of IC designs helping them to stay profitable and to extend and maintain some of their own technological capacities. Second, in regard to the system houses and the OEM manufacturers the Taiwanese IC design industry is supplying them with the chips they need to either profitably offer solutions for Western OBM companies or to compete successfully with western and Japanese OBM by lowering their costs structure.

The development of the IC design subsector thus enriched the Taiwanese IT industry with positive feedback, strengthening the Taiwanese position as mid-level suppliers within the global IT product chain. Each part of the Taiwanese IT hardware industry, system houses, pureplay foundries, and IC design companies strengthens and is strengthened in turn by the existence, outputs, and demands of the others. Despite this positive outcome, the IC design industry still is unable to develop alternative business models for capturing the higher rents that come from original innovative designs.

The role of institutions and government policy in the structure of the fabless subsector

What are the institutional settings that induce the Taiwanese fabless companies to employ a specific business model? And how does the implementation of government policy matter, even if the declared policy aim of encouraging the Taiwanese fabless companies to be more innovative and conduct more technological cutting-edge R&D has

not been reached? There are two systems of institutions that underlie the particular economic and innovative behavior of the IC Design subsector, the financial and the industrial. Governmental agencies and regulations have very much influenced the structure of each. By the financial system, I refer to the kind of financing available to founders and companies in the developmental phases of their companies and to the specific incentives provided by the Taiwanese system of financial regulations. Special attention is given to regulations that deal with public and private companies that aim to go public in Taiwan and to Taiwanese regulations on employees' stock options. By industrial system I mean the past and current industrial activities in the Taiwanese electronic industry as a whole and the incentives they give to a particular kind of activities.

There are two main financial constraints on fabless companies that wish to develop innovative products in Taiwan: one affecting the beginning of a firm's life and the other the end of its developmental stage. The first constraint is the scarcity of finance for the early stages of firms that rely on technologically cutting edge R&D activities. The second constrain derives from the fact that the Taiwanese stock-option system gives enormous advantages to companies that have already gone public, not only granting them stronger financial capabilities, but also giving them an almost total stranglehold on hiring of the best engineering graduates. It does so because of Taiwan's peculiar employees' stock-option regulations. These prohibit companies, both public and private, from giving stock options to employees (one of the main attractions that a cash-starved start-up can offer to entice new employees in the US), but allow already-public companies to give actual stocks (i.e., not an option on the stocks but the stocks themselves) to their

employees at a sharply discounted rate under the "profit sharing system," where the stock is treated as profit sharing. Moreover, the stock-bonuses are taxable only at the time of sale and only on the nominal par value (set by law at $10NT per stock no matter what the stock's market price is), giving the employees in reality a tax-free capital gain bonus. For example, according to TSMC's annual reports, the average profit per employee received by TSMC employees through stock per year was more than $1.5NT million in 1996 and reached more than $2.5NT million in 1998; engineers with a masters degree earned much more than the average. A CFO of a leading IC design house calculated for us that after 4 years, an engineer with a masters degree will get an annual bonus worth about $300,000USD; a good annual salary for the same employee stands today at $18,000 (IPC interview with IC company's CFO 11/5/2003). Hence, a graduate of a good university with an advanced degree who wants to become well off needs only to join an already public company to be virtually assured of reaching that goal in a few years. Not surprisingly, new private companies find it very difficult to recruit graduates of the top engineering schools.

Consequently, the regulations regarding employees' stock options in Taiwan motivate new companies to seek the shortest and surest route to an IPO. In order to go public on the main exchange, a company needs to show a few years of constant profits, so most Taiwanese fabless companies use a business model that assures quick revenues, in contrast to one employed by innovative-product-based firms that involve incurring a few years of heavy losses during their R&D phase before sales.

The Taiwanese government declares that over the last few years it has been supplying a large amount of capital for R&D operations directly to private companies.

However, it is not clear that what the government declares as its R&D goals and the effects of the vehicles and programs it uses to distribute this financing are the same. For example, most of the government-sponsored critical technology areas development programs are constructed in a way that limits the development of new product innovation capabilities in the business sector. A recent example is the current "System on Chip" development program. The program is organized in three discrete stages. In the current first stage the government focuses on specific end-products it thinks that the Taiwanese IT industry must be able to manufacture in the mid-future. In the second stage, the universities and ITRI are asked to propose the intellectual property and technology they think are necessary for companies to develop these products, and how they are going to develop these technologies and transfer them to the industry. In the third stage the universities and ITRI develop the technologies and intellectual property and transfer them to the industry. Hence, the industry's role in this innovation capability development program is limited to one of developing products decided upon by governmental officials, using technology developed elsewhere and transferred to them.

While the responsible ministry of state has promoted this program as the latest government effort to induce innovative activities and capabilities, and with the government budgeting this program at $80USD million a year and sponsoring eighty-five new faculty positions, it is still not clear whether it will expand the industry's new innovative product design capabilities (Interview with the Minister of State and S&T policy 11/7/2003). Another example is the R&D tax incentive programs of one of the main governmental investment vehicles, the Industrial Development Bureau of the Ministry of Economic Affairs. This program gives tax incentives and other benefits only

to companies that make products that are specified in extensive detail by the IDB itself. The products are gathered in a list by the IDB every two years. Therefore, the list inherently cannot include truly innovative technologies whose market is unpredictable or does not exist. The program specifies that the tax incentives are given only to companies that control the whole production chain, i.e., from the design to the manufacturing and sales. Moreover, it only promotes products that the responsible official described as, "are not in niche markets that are so innovative that we cannot predict the future so we cannot really help" (IPC interview 5/28/2001). In sum, while it is true that the state aims at generating more R&D and innovation activities in Taiwan and at sponsoring programs to achieve this goal, it is not clear whether the final result will indeed raise ground-breaking innovative capabilities in Taiwan, or just extend the old technology transfer and division of labor between industry and state to a new set of more complex technologies.

There are many government programs to finance industrial R&D; in fact several of our interviewees from the major developmental agencies complained that Taiwan has too many small agencies and programs, each with its own bureaucracy, with the result a policy hodgepodge and confusion. Of these programs the three most relevant to the fabless industry are the SBIR, the Technology Development Program (TDP), and the Leading Product Development Program (LPDP), all of which are sponsored by MoEA Department of Industrial Technology (DOIT). Aside from SBIR, most programs assist mainly in the development of products that are based on some R&D effort, whether or not they are new to the world markets. Most of the grants to fabless companies assist them in pursuing 2nd generation product innovation, and do not provide incentives for a riskier approach. Moreover, although DOIT has been leading the way in fostering more

R&D activities in the private sectors in the last three years, it started to channel grants directly to private companies only in 1998, after intense lobbying of the industry convinced the government to channel a small percentage of the funding that was formerly given to the public research institutions (ITRI and III) directly to the private industry.[7] Both the SBIR and the TDP are staffed with ITRI personnel who are seconded to the programs. Indeed, according to our interviewees around 1/3 of the IC companies that are funded through SBIR also have contract research relationships with ITRI.

Looking at private VCs we found that, unlike their American counterparts, most of them prefer to invest only in the later stages of development, and only after firms have already proven their success by becoming profitable. There are several institutional reasons for this behavior. First, by law VCs in Taiwan must be registered companies, not limited partnership. This limits their ability to invest in young companies in two ways. First, as a registered company VCs are not allowed to invest in a venture that is not already registered, ruling out true seed investment. Secondly, as a registered company the VCs (that is the person who act as a VC, what in the US and Europe will be called the general partner) must submit all their investment decisions to the board of the VC firm, which consist of the investors themselves, making the VCs more conservative. Taiwanese VCs also are more conservative because of their sources of capital and the education of the VCs themselves. Most VC companies have strong ties to one individual or company and operate in accordance with the sponsor's industrial investment strategy, which is usually more conservative and tends to focus around companies with established business models that the sponsors can easily understand. This is especially evident in software where most VC companies do not invest at all.[8] The VCs themselves are drawn mostly

from the financial industry or the traditional industries, hence, they do not have intimate knowledge of the industry, and prefer to invest in less risky endeavors.

Lastly, the structure and listing regulations of the Taiwanese Stock Exchange, where most of the exits take place, favor companies that are already profitable for a couple of years. This in turn, motivates the VCs to invest in companies with a business model that is focused on achieving quickly large sales figures without a long loss-incurring R&D phase. Even when Taiwanese VCs do invest in young Taiwanese companies they usually prefer companies that follow the well-trodden path of producing products based on 2nd generation technologies with the prospect of near-term revenues.[9]

The current industrial structure of the IT industry also motivates fabless companies to pursue business models that exploit 2nd generation innovation, and limits the ability of companies that try to conduct original product R&D. The Taiwanese system supplies virtually infinite opportunities for a small new IC design house that can offer the already defined chips needed in the production of various electronics products more cheaply and reliably, especially for those with skills in the telecommunication and image processing area.[10] In addition, the economic and management skills that are needed to profitably run these kinds of operations are abundant. In other words the Taiwanese industrial system is richly endowed in the "specific economic competencies" needed to succeed in 2nd level innovation-based design (Carlsson 1995; Carlsson and Eliason 1994). The whole Taiwanese system of innovation is primed to give private companies rapid and continuous access to new technologies from abroad. In the last few years this kind of technology channeling became one of ITRI's main roles.

ITRI, especially its computer and communication lab (CCL), has become a main provider of R&D in the industrial system as well as an important channel for foreign technology. The answer of each and every fabless company interviewee to the question of whether there is any company that conducts technological cutting-edge R&D was that only ITRI and its CCL lab do this. A top official of CCL told us in frustration that he thinks that CCL's own activities, instead of fostering more innovational activities in private companies, actually allow these firms not to innovate:

> "Technology transfer from CCL is very important in Taiwan. The companies use us to train their people, take our technology, and create some products. After which they go to their customers, show them the products as a proof that they can do OEM, sign some OEM contracts, and just do the same things a couple of years down the road. Our aim is to help and spur them to routinize R&D and product innovation. However, the end result is that they do not really do it. A main reason is that they can more cheaply rely on technology transfer every time they need to upgrade their skills, and continue to operate as a pure OEM." (IPC interview 5/24/2001).

On the other hand, a company that wants to innovate faces significant obstacles, from the lack of finance, the difficulty in recruiting high skill personnel, and the relative scarcity of business and management skills to run a Silicon-Valley-like operation. All of these problems are augmented by the fact that if geographical proximity to customers and suppliers helps companies to sell to OEM and ODM companies, then their distance, both physical and cultural, from the US, their main market for innovative products, makes the operation more complex and more expensive.

The Taiwanese Software Industry

If the story of the semiconductors and the IC design/fabless subsector is one of impressive growth and successful policies, the software industry offers a less sanguine tale of industrial policy and growth. Official statistics are inflated, but even they show the

one major failure of the Taiwanese software industry: the fact that it is mostly a domestic-oriented industry. Official figures show a rapid growth in sales from $22NT billion in 1991 to $149NT billion in 2001, but exports in 2001 amounted to $16NT billion, or a little over $490 million, which is only 10.73% of total sales (III Various Years). It is not clear how much of the sales should be attributed to foreign companies. In addition, the official figures include in the definition of the software industry several activities, such as internet services providers, that are usually not counted as software. In an attempt to estimate the size of the Taiwanese-owned software industry, we calculated the software sales figures (i.e., not including bundle and other sales) of Taiwan's public companies, added the sales figures of the top private software companies we interviewed, and finally added III's total budget as a way to estimate the maximum dimension of the industry. Our calculation for 2002 was around $1USD billion (or around $34NT billion), which is one fifth of the official figure. However, our calculation approximation was similar to the official one in export sales (ours were lower but that can be explained by the practice of Taiwanese companies to mask some of the sales of their Mainland China subsidiaries). With this in mind we can understand why a high ranking official in MoEA mused in one of our interviews,

> "Look where we are and where other countries like India, Israel, and Ireland are with their software industry, nobody heard about them 30 years ago, I must admit that we <Taiwan> are not doing very well with software" (IPC Interview 5/30/2001)

In a striking contrast to electronics and semiconductor industry and the positive role played by ITRI, the research institution responsible for software, the Institution for Information Industry (III), has no stories of ERSO-like successful spin-offs or any other initiatives spurring the creation of an industry to tell. III has very little to say for its own

positive role in the development of the software industry. Indeed, III can be seen as partly responsible for the less than satisfactory state of the industry.

Unlike ITRI, III was created after the private software industry in Taiwan had already established some of the companies that are now the leading companies in Taiwan. Thus, one might question the need to spur the creation of an industry. The agenda and the funding granted to III by the Taiwanese government were vastly different from ITRI's. First, III was asked to promote the software industry; then, III was given the task of promoting the use of IT and software throughout Taiwan and asked to help the government with its own computerization. Finally, III was also asked to generate enough revenue to cover most of its activities. The different agendas proved to be contradictory, with the end result that III transformed itself into one of Taiwan's biggest IT consultancies and software houses and has been competing directly with private software firms.

For many years III has used its favored position within the state to capture all governmental contracts. In addition, III has been given almost the entire state's funds earmarked for software R&D. Furthermore, the inherent characteristics of software technology make a central research institution a less useful tool than in hardware. These three developments created a situation where III transformed itself into an aggressively competitive company that enjoys governmental funding to cover its R&D in its efforts to compete with the private industry.[11] Moreover, for the most part III used its role as the state's favored channel for foreign technology to grow a thriving business as a distributor for the biggest foreign software companies. This division, called PDD, was spun off in 1997 as Shinwave.

The responses of many software firms' to our questions about the role of the state in the industry's development reiterate a view of III as the biggest obstacle to the industry's growth. The response of a founder of a financial software company is typical: "The state does not have any positive role, as a matter of fact III is our greatest competitor. They also compete unfairly. I need to sponsor my R&D from my revenues, they have all their R&D covered by the state" (IPC interview 1/17/2003). A founder of another software company replied:

> "In our 17 years we managed to have direct conflicts with III only once so I am very lucky. However, I do not think III is good for the industry. They get government money to help the industry and nothing happens. III do not really care about the industry – they just talk and talk but do not do anything for the industry. They do not even properly do the more simple and straightforward task of consulting the government on policy issues so policy making is all tangled up. Even in the basic task of changing the perception of the software industry in Taiwan they do nothing. Customers think software and software companies should not be paid because they do not see software as a "real" product" (IPC interview 11/6/2003).

This view of III is shared not only by those we interviewed in private firms and in industry associations, but also by officials of other developmental agencies. One official of an industrial R&D agency responded to a question about the role of III in the software industry's development, "III is a funny organization. It both competes with and tries to assist the local software industry. On a charitable estimate I would say that they compete at least as much as they assist" (IPC Interview 1/29/2003) Another, a head of a different department gave a similar response, "I agree that III is a very problematic institution. I think that the problem of III is the confusion or the strange positioning that they are in. They try to compete and help at the same time" (IPC interview 11/4/2003).

III is well situated to play a role as a facilitator of collective action and organizer of consortia. However, even in this role both researchers and industry leaders criticize III.

For example, even in the crucial case of agreeing on a standard for Chinese writing input/output and internal conversion, a basic need for the software industry's attempt to grow, Noble claims that III's actions fostered distrust and hampered the industry's efforts to reach an agreed upon solution to this problem until an international body, on which Taiwan had no influence, settled the issue almost a decade later (Noble 1998. Pp. 123-147). This impression of the failure of state efforts is strengthened by our analysis of the software industry. As the next part of this paper shows, it became clear that the most successful subsectors are those in which III never intervened.

Structure, development, and business models in the Taiwanese software industry

The structure of the Taiwanese software industry reveals a divide between the older companies focused on the development of software application for big organizations that fiercely compete with III, and a newer cohort of companies developing software technologies, most of which were founded after the success of the hardware IT industry in the Hsinchu science-based industrial park. This division tempts one to contend that there are in fact two Taiwanese software industries. However, the reality is a bit more complex.

As was suggested earlier, it is extremely hard to gather precise sales figures on the software industry in Taiwan. Most of the bigger companies, faced with fierce competition from III, have branched out into sales and distribution of hardware and even into completely unrelated fields at time of severe need. Even publicly-traded game development companies, such as Summit, earning a large percentage of their revenues from bundle sales – the sales of their products on top of sale of DVD and other

entertainment electronics. Estimating software sales in Taiwan is also complicated by the fact that PC manufacturers have also been for many years some of the biggest software developers.

Nevertheless, the picture of the industry development that emerges is one in which until a decade ago most of the Taiwanese software companies had a business model that merged both IT consultancy and bespoke development, as well as the sales of specific software systems (Such as Automation or Finance) that were developed as part of earlier work with customers and then packaged. Most of the PC manufacturers were also successful software producers, especially in the 1980s when each manufacturer had its own slightly different version of the Chinese input/output system, and when most of the classic PC software packages from western companies, such as spreadsheets, were unavailable in Chinese.

Because III had captured the big governmental contracts and the big global IT companies competing directly on big projects, the industry was unable to develop big software houses specializing in customized development. An example from a founder of one of the companies that managed to survive these times is illuminating,

> "Competing with III it is like competing with Microsoft. If you compete you get killed on the spot, if you cooperate you get less money and you might be killed later, but at least you get some work. However, III always wins more contracts then what they can program themselves, so they then subcontract some of them. They will pay me less than what I will get if I could compete on the project in the free market but I preferred to cooperate with the Microsoft of Taiwan, and not get killed by it." (IPC interview 11/6/2003).

As a result most of the industry has evolved around a particular customer niche, such as international banking or security house trading systems. Today many of these companies realize that their future lies with Mainland China. Interestingly it is here that

they find that their former relationships as subcontractors of American MNCs in Taiwan are an important asset. For example, a CEO of one of Taiwan's oldest software companies described his decision to move to China:

> "The funny thing is that we never wanted to go to China, but our American MNCs partners asked us to come, both HP and Oracle. The best example is HP. They won the whole IT systems project for a big new plant and they asked us and three other Taiwanese companies to open a China branch and do subcontracting for them. We did that and before we knew what happened Oracle asked us to do subcontracting for them when they won a big Chinese state-owned company contract. I think that without the mainland my company would not have been able to grow at all in the last 3 years. Only because of China we have a chance to survive." (IPC interview 11/4/2003).

In addition, for the most part the industry has not been able to develop unique products or strong enough brand names that could give their own products a chance in the market after the big software MNCs launched their own Chinese version. Thus, when during the 1990s Western companies such as Microsoft came around to localize their products to Chinese, these companies' products have been wiped out of the market. The one sector that evolved differently throughout the 1990s was the PC games industry. Unlike other sectors of the software industry, the gaming industry had four tremendous advantages that allowed it to develop and thrive in Taiwan. First, III was not at all interested in this sector. Second, gaming, unlike many other software products, benefits from certain cultural traits, and Chinese-born gamers were very keen on playing "Chinese" games; for example, almost every Taiwanese game company has had a strategy or fantasy role playing (FRP) game based on the classic tale of the Three Kingdoms. Third, the costs associated with game development were very low for many years. Most gaming companies either started by sponsoring teams of high-school students who develop the games as a hobby on a cost-only basis, or had a mixed development strategy of in-house and semi-independent teams. Fourth, with 7/11 and similar vastly

popular chains in Taiwan selling local games on the corner of every block, gaming companies had distribution channels that reached each and every Taiwanese on a daily basis.

It is not surprising that until 2000-1 the gaming sector was deemed by many in both the private and public sector to be the most successful sector of the software industry in Taiwan. All the medium and big sized companies such as Softstar, Summit, Gamania (formerly known as Full Soft), Interserv, and Soft-World had gone public on the Taiwanese stock exchange in the 2000-2002 period. Since then, the industry has been hard hit and in 2003 most of companies that we revisited had either retreated from original game development, or were cutting down their development activities to the bare minimum. Apart from the worsening economic situation in Taiwan, the two changes that transformed the business environment of the Taiwanese game companies were technological: the wide diffusion of CD Read and Write technology and the rapid emergence of on-line gaming.

These two technological changes have significantly and swiftly lowered the revenues coming from the sales of PC games, with most but not all, of the leading companies reporting at best sales of tens of thousands of copies of their new games instead of hundreds of thousands of copies. These developments coincide with the maturation of the international gaming industry. The quality and technological sophistication needed to develop competitive game titles has drastically raised the costs of development per title. In addition, the Korean gaming industry, for many years the poor and unsophisticated cousin of the Taiwanese industry, was the first to develop on-line FRP games winning market share and financial backing and overtaking the quality

and technological sophistication of the Taiwanese industry in a critical moment. At the end of 2003, all but one of the extremely successful massive-multi-users-on-line FRP games running in Taiwan were developed by non-Taiwanese companies.

The Taiwanese software games industry, without the financial resources of the Korean and Western gaming industry, finds itself technologically backward and stuck with business models that are based on low cost development. It has been unable for the most part to compete. Individually, gaming companies do not have the financial resources to regain the technological lead vis-à-vis the Korean industry, and as the industry is widely fragmented it has been unable to coordinate collective action. A few industry leaders approached III and asked for leadership or help, only to be rebuffed until October 2002. A CEO of one of the biggest companies recounted a tale of a failed attempt to cooperate with III in late 2002:

> "The worst of the worst is III. A representative of the gaming industry approached the president of III, the new one who promised to change III for the better and help the industry, and asked him to help our sector. Mind you, we are the only sector that was really successful in the Taiwanese software industry. After a few talks his answer came back from his secretary – "this is not III core business, therefore, we are not interested." I ask you: "what the hell is their core business?" they say their goal is to help the software industry, not to make profits, but they do not give a damn about anything but making money" (IPC interview 1/20/2003).

This failure by III is even more surprising because in October 2002 the Taiwanese government declared digital content as a key priority technological area, and specifically targeted on-line games as one of the more promising digital content sectors. However, both government official and industry leaders see the digital content initiative as a failure so far. One of the industry's representatives in the initiative described it as,

> "This is the latest government fad; they finally realized IP is important. So we sit there for a year, so many important people and so many people from the government and talk and discuss for hours every week and nothing happens. It is running for over a year now and still nothing happened. Elections are coming in six months time so nothing will happen until after the elections because the civil

> servants are waiting to see who will be their master and they are afraid to do anything" (IPC interview 10/30/2003)

This view of the efforts of the digital content initiative in the area of on-line gaming was also expressed by the Minister of State Ching-Yen Tsai, who is responsible for it, describing the efforts of the digital content initiative in on-line gaming as:

> "Nothing much is happening with on-line games. We basically did nothing; we do not even have a budget. We have to admit that a lot needs to be done with software and digital content. However, we <the government> still think that Taiwan's future is more in hardware" (IPC interview, 11/7/2003).

As of the end of 2003, most of the Taiwanese gaming software companies are fast retreating from game development. From an industry whose leading companies had operations in and sold their own published products throughout most of the greater China region, the industry is transforming itself to an industry whose core competency is games distribution and resale. This does not mean that two or three of the leading companies will not continue to prosper and grow and develop original games. However, the number of Taiwanese game developing companies is declining sharply with no new entrants coming to replace the exiting firms.

In the last few years a cohort of software companies with new business models have emerged and succeeded. These companies are much more technologically oriented. Their products either directly deal with software technology itself, or with new application of IT technology, e.g., anti-virus software, OCR application, or systems recovery. These companies appeared after the success of the IT hardware industry in Hsinchu Park; indeed, many of them are tightly connected to the industry. There are two types of operations: (a) supplying the Taiwanese hardware industry with software technology that enables it to add features to its products, differentiating them from the

competition, or supplying critical software that the hardware industry would find difficult or prohibitively expensive to get abroad; (b) producing software products that are directly associated with the software industry itself, such as anti-virus or application development tools. One prominent example of a company focusing on software technology itself is Trend Micro with its corporate anti-viral protection products. In 2002, Trend Micro became one of the largest software security companies in the world with sales of $364USD million. Trend was established by Taiwanese, grew in Taiwan, is run by Taiwanese, and still conducts a large share of its activities in Taiwan, but its management felt that it needed to leave Taiwan in order to be globally successful. In 1998 Trend moved its management team and headquarters to Japan, reestablished itself as a publicly traded Japanese company, and is also traded on NASDAQ.

The two most successful software companies that followed more closely a business model of alliance with Taiwan's hardware manufacturers are Ulead and Cyberlink. In 1989, three friends who worked together at III established Ulead with finance from the Taiwanese scanner manufacturer Microtek. Ulead's first business was to supply OCR and image processing software to the then fast-growing Taiwanese scanner industry that was facing difficulties in securing key software from American companies. A few years later, realizing that there is no true color imaging processing editor for the PC (Adobe was selling its Photoshop software only for Mac at the time), Ulead launched its own product called Photostyler. In 1992 Adobe bought the company that held the copyrights for the technology Ulead was using. Since then Ulead has came out with its own product for the mid-range user. Using the same OEM model Ulead wrote software for video imaging for the video capture cards industry. The Taiwanese video capture card

industry never took off. Ironically, this proved to be a boon for Ulead, which started to work with foreign manufacturers. Today, apart from its image processing products Ulead also produces and sells video and DVD processing and authoring software. Ulead sells either directly to private users or through OEM agreement with hardware manufacturers. In 1999, Ulead became the first software company to go public on Taiwan's stock exchange. By 2002, Ulead had sales of over $30USD million and operations in all five continents.

The latest globally successful Taiwanese software company is Cyberlink. Cyberlink is also interesting as it directly employs business techniques its CEO, Alice H. Chang, learned as a top executive in Trend Micro during Trend's rapid growth and IPO period. This is a clear case of learning and economic capabilities' diffusion in the industry. Cyberlink is the most successful company to be spun out directly from a Taiwanese university lab, attesting to the growing capabilities of Taiwan's computer science academic research. Dr. Jau Huang, Alice H. Chang's husband, the cofounder of the multimedia lab at National Taiwan University, established Cyberlink in 1994 together with four of his students. Encouraged by Mrs. Chang, then the Executive Vice President of Trend Micro, the team decided to develop a software product and not a hardware product.

In 1995, the company was founded using self-financing. The company finished developing the first product, a video decoder (VCD decoder), in November 1996. In January 1997 Mrs. Chang stepped in as CEO and embarked on a strategy of OEM sales to Taiwan's VGA manufacturers, the world's largest. These OEM agreements gave Cyberlink immediate market recognition and the company went on to develop a complete

suite of DVD products that now has about 50% of the world market in the DVD PC's multimedia tools niche. Today Cyberlink sells multimedia management tools and has just started to sell development tools for e-training and e-learning solutions. In 2000, Cyberlink went public on the Taiwanese stock exchange. In the financial year 2002, Cyberlink had sales of over $35USD with most of its sales originating with its DVD products done through OEM agreements with PC and notebook manufacturers in the US, Taiwan, Japan, and Europe.

In short, the Taiwanese software industry today seems to have a dual structure. On the one side are the older private companies dealing with business solutions together with III, which has become the biggest business software solutions provider. On the other side are the younger and more successful companies that are much more technologically oriented, with a few of them growing to have a true global reach. Overall, the Taiwanese software industry is still oriented more to the domestic market. Only a few companies possess the necessary capabilities and skills to develop products and services for the global market. Hence, relative to the Taiwanese hardware sector or compared with software in countries such as Israel or Ireland, Taiwan's software industry cannot be considered very successful.

The role of institutions and government policy in the structure of the software subsector

While III has played an inhibiting role in the development of the software industry, there are other reasons as well for the particular development path taken by the Taiwanese software industry. First, one of Taiwan's main industries has been PC manufacturing, and each of those companies was also busily producing software for its own machines, thus preventing the development of a large standardized market that could

support independent product-oriented software firms. Secondly, until the early nineties, partly due to internal competition within the state apparatus, there were no standards for Chinese input/output and internal conversion (Noble 1998). This spurred many companies to produce Chinese programs of the equivalent popular English packages, all of which were practically wiped as soon as the western companies published a Chinese version of their package. The third reason is that both the private hardware industry and the government did not see software as an independent industry but as a service component needed by other industries. This handicapped the industry in two ways: (a) software has never been on equal footing with hardware in the competition for government budget and grants; and, (b) software companies faced many problems selling pure software solutions for reasonable prices in the market.

The software industry has also suffered acutely from the lack of capital. Until the advent of the Internet, VCs were unwilling to invest at all in pure software companies unless they were already well established. Even today software has a relative difficulty to secure VC finance vis-à-vis hardware, as many interviewees in the VC industry, the Taiwanese VC association, and software companies pointed out. As for public finance, for many years pure software product development did not receive any grants. Even today, software is not included in the IDB's tax incentives scheme. For these reasons many of the older software companies, facing virtual exclusion from big projects, have branched out to other areas of operation, some of which have nothing to do with software, such as the distribution of gift packages. Thus, unlike their counterparts in the IC design subsector, many of the Taiwanese software companies have suffered from lack of focus and inability to concentrate enough resources, management and capital, on

R&D. The one subsector that proved to be nimble, innovative, and successful during the 1980s and 1990s was gaming.

In our interviews, many companies complained that apart from a brief period in the late 1990s, before the latest government budgetary cuts, they have not been able to get any grants. In addition the Taiwanese state policy of sub-sectoral focusing is not appropriate to the current state of the Taiwanese software industry. Its effects are to deny many promising software companies access to R&D capital, but it hardly promotes the creation of new companies in the targeted sectors. Companies that did manage to secure a state grant complained that the bureaucratic regulations forced them to spend more money on getting the grant than the grant itself. Those that did get the grants in the late 1990s, though, did tell us that as other sources of financing were virtually nil these grants were critical in helping them to finish their first R&D projects.

Starting in the late 1990s, with the rapid growth and growing sophistication of the IT hardware industry in Hsinchu Park, with the competing standards issue solved, with III activities dissuading new companies from working on big business applications, and with growing skill base and sophistication in computer science in Taiwan, a new cohort of companies that are much more technologically oriented appeared. Some of these companies have already managed to become global competitors in their niches and a few more seem poised to do so. These companies and the gaming sector have had very little to do with III. In sum, in the software industry, unlike the IC design sector, the industry has not been able to transform itself into a successful exporter and a global competitor. What has been globally successful seems to have been achieved in spite of, rather than because of the government's main agency, III. In software because of the particular

characteristics of the industry and the timing of III creation, the Taiwanese policy of reliance on big public research institutions proved to be a hindrance to the industry's growth.

Conclusion

This paper has analyzed at the micro level two subsectors of the Taiwanese IT industry, software and IC chip design, and focused on the state's role. Using the same policy vehicle in both sectors – a big public research institution – the Taiwanese state had both successes and failures in its attempts to foster the growth of the IT industry. The role of the Taiwanese state in the development of the IT industry, in both hardware and software, strengthen the neo-developmental state theories of the ways in which the state can successfully promote innovation-based industry. Nevertheless, the analysis also strengthened our main contention with the new development-state theories. It is not that the state is either a neo-development state or not; the story of the Taiwanese IT industry shows that the same state can be both.

The answer lies in the particular ways in which the state tries to implement its vision for the creation of a new innovation-based industry, and in the state-industry relations and co-evolution process that evolved as the industry grows. If the state's responsible agencies, as in the case of ITRI and the hardware industry, have as their main goal the development of the private industry, and are able to manage the transformation of their own positions as part of the state-industry co-evolution process, then the state can successfully play a key role in the development of the industry. If, however, as in the case of III, the state responsible agencies, even when organized in a structurally similar way

and managed form above by the same leadership, do not see the development of the private industry as their primary goal, nor are they willing relinquish their leading position, then the same state that so successfully developed one industry can be one of the main causes for the stagnation of another.

Analyzing the two subsectors, this paper found that in the IC design the state, through ITRI, has had a major positive impact on the industry's growth and success. In software, however, the state's main agency, III, had inhibiting effects. The paper analyzed both the limits of the success in the more successful IC design sector and the successes in the more failing software industry. It showed that both are critically affected by the interaction between the state and the industry. Taiwan's IC design companies both utilize, and are limited by, Taiwan's industrial structure and innovation system. Taiwan's software companies excel in niches that are highly related to Taiwanese IT hardware industry and untouched by III.

In doing so, this paper expanded our understanding of both the capabilities and the limits of a "developmental state" in its attempt to create new technological industries. Our microanalyses showed not only the role that the interaction between state and business played in industrial development in both software and IC design, but also how the institutional setting in which they occur influence the final outcome. Thus, the development of the IC design industry within a system with large sophisticated OEM companies and the world's most advanced pureplay foundries, themselves the product of prior state's efforts, propelled the IC design industry onto a specific development track. This institutional system also provided the IC design industry with certain unique capabilities, while discouraging investment in others. The software industry's early

development was strongly influenced by a business environment that did not view pure software as "real" products, where a state agency was both competing with it for its best customers and preventing it from getting the state's direct financial help. The software industry's later development stage was strongly influenced by the needs and opportunities opened to it by the rise of a sophisticated IT hardware industry in Hsinchu.

This paper has focused on the successes and on the failures and weakness of the Taiwanese industry, and its findings are largely optimistic. For Taiwanese IC design houses to become truly innovative a major restructuring of the Taiwanese industrial and financial system might be required; but, the IC design subsector is highly successful globally and also provides the Taiwanese IT industry as a whole some important complementary assets, helping it to compete globally. The IT hardware industry's strength underpins the continuing growth of the IC design industry. This provides evidence of Taiwanese potential in innovative service activities.[12]

A powerful new motor for revenues would come into play if Taiwan could fully employ innovation-services business models throughout its industrial system. ITRI's new mode of operation with the IC industry, where ITRI conducts advanced R&D for the industry's use can be considered as a model. Finally, the state might rather easily tweak some of its own policies to spur more technologically cutting-edge innovational activities. A simple example would be the redefinition of R&D in its various grant schemes in a way that is more similar to Israel's, where in order to receive a grant the company must come with a proposal for a new innovative product or technology. This would ensure a financial critical mass for new companies that want to employ a new-

product-development business model necessitating longer R&D stages without revenues from sales.

In the software sector the need to restructure policy and state agencies is more acute. As VC finance in all its forms is lacking, it is a clear case of market failure where the state role should be to channel more funding into industrial R&D activities (Arrow 1962). With the current policy, all the state financial support goes directly into III. It is not clear whether this promotes the creation of new product-based innovative software companies. Why should a state agency be the biggest IT consultancy, bespoke software developer, and system integrator? These activities have little to do with the creation of a vibrant domestic software industry. More research would be needed to develop a plan for reorganizing III. Such a reconstruction of III does seem to be in order. One possibility would be to spin off III's main divisions as private companies, cutting them off from governmental finance, without a preferred position in governmental projects. Another step might be the reconstruction of software policy formation. Today III both suggests policy to different government offices and then competes on the projects to implement these proposals. A better system might be to limit III activity to policy formulation. In addition, if indeed the Taiwanese state is keen on the development of a globally successful software industry with a technological edge, it might re-channel the funds now directed to III into a grant program specifically for R&D software activities widely defined, and not subsectorally, e.g., digital content only,.

One venue for fruitful future research that seems to suggest itself is to look at the experience of other countries. Of those, one useful model for the future software-focused government agency could be Ireland's National Software Directorate, whose sole aim is

to assist private industry and which does not involve itself with actual software development. The Irish NSD with a staff of around ten permanent employees concentrated on policy formulation, information gathering, acting as a bridge between industry and government, initiating and looking after several innovating policy initiatives, and is widely seen as playing a critical role in helping the Irish-owned software industry's spectacular growth in the last ten years.

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[1] In international patent issuing, one of our most reliable proxies for industrial innovation, Taiwan moved from issuing one patent in 1973 to issuing 3693 in 1999, reaching as early as 1997 a rate of international patents per capita which is higher than any of the G7 countries except Japan and the US (Hall et al. 2001; Trajtenberg 2001).

[2] There is little research that supplies accurate data on which activity grants the highest rents. However, the studies done of the global hard-drive industry give a striking picture of the much larger percentage of the rents captured by the highest skilled activities, compared with any other activity on the value chain (Gourevitch 2000). The same picture appears in the analysis of the sales per employee figures of the Israeli versus the Irish software industries, as well as any of these two industries compared with the Indian one (Breznitz 2002; Breznitz 2004).

[3] The one example for such a study is Fuller et al. 2003. For examples of micro-institutional industrial case studies that try to explain both the strengths and weaknesses of specific national or regional industry, see Herrigel 1994; Hollingsworth et al. 1994; Streeck 1996. For examples of studies that concentrate on the software industry, see Mowery 1996. For studies in the statist approach and its particular variant of the developmental state, see Amsden 1989; Evans 1995; Johnson 1982; O'Riain 2000; O'Riain 2004; Wade 1990.

[4] According to III figures, the software industry grew from $11NT billon in sales in 1988 to $149NT billion in 2002, an impressive growth, if vastly smaller then the growth of the semiconductor sector. However, there are very good reasons to suspect that these figures are inflated. Adding up the figures of all the leading Taiwanese software companies does not approach this figure. In our own attempt to understand the

size of the Taiwanese-owned software industry, we added the software sales figures of Taiwan's public software companies, added the sales figures we got from the top private companies, and added on top of that the total budget of III to reach a figure which is just about $1USD billion, i.e., $34NT billion. We suspect that the official figure includes sales of both MNCs and Taiwanese companies, includes total sales figures and not just software sales, and/or that the definition of software used is a very broad one and includes for example internet providers services. Moreover, even according to these figures, exports in 2001 were only $16NT billion (around $400USD million, still higher but strikingly closer to our own estimation, leading us to suspect that our estimate of the total size of the domestic industry is closer to reality than the official figures) about 10% of sales, indicating that Taiwanese software companies face significant difficulties in developing an internationally competitive industry (III Various Years).

[5] In the period 1999-2004 a team of 24 researchers from MIT's industrial Performance Center (IPC) has been investigating the confluence of globalization and industry reorganization in several sectors. Field research for the IPC Globalization Study has consisted of semi-structured qualitative interviews with company personnel and relevant individuals from government agencies, unions, and academia. By early 2004, 582 in-person interviews and plant tours were conducted in Canada, Mainland China, Taiwan, France, Germany, Indonesia, Italy, Japan, Korea, Malaysia, Mexico, The Philippines, Singapore, Spain, Thailand, Romania, and the United States. Of these, 306 were conducted in Taiwan or with Taiwanese companies outside Taiwan, out of which 235 were directly linked to the IT industry. These interviews were given under condition of privacy and as such are masked to protect the interviewees' identity unless the interviewee explicitly authorized us to attribute his remarks.

[6] There is some diversity between the different neo-developmental state theorists, in particular between these that argue that the state should advance national champions, and these that prefer a strategy based around SMEs. It is unclear whether these differences arise because of the different context in location, timing, and industries that the different writers researched. However, in the critical part of theorizing about the optimal role and behavior of the state in its attempt to spur the growth of high-technology industries, and in their treatment of the state for all practical purposes as a unitary actor the authors are similar enough that we can treat them as advancing one model.

[7] The amount that DOIT channels directly to the private industry started at about 1% of the total DOIT budget in 1998 with $200NT million, and has been growing steadily both in size and as a percentage of budget to $2.8NT billion out of a $17.2NT billion in 2003.

[8] IPC interview with the Taiwanese VC association, 3/11/2003.

[9] Exit refers to the change of ownership in which the VC sells their share in a company and "exits" it; preferably with a profit.

[10] The strength of Taiwan's OEM and ODM companies is reflected in the fact that in 2001 Taiwanese companies manufactured 70% of global production of motherboards, 55% of laptops, 56% of LCD monitors, 51% of color-display-tube monitors, and 36% of digital still cameras (III Various Years; ITRI Various Years; MoEA Various Years).

[11] Again exact statistics are hard to come by; the funding III received from DOIT in 2003 was $760NT million. DOIT statistics estimate III's 2003 total budget in $3NT billion out of which a third is received from projects with other government departments and a third is received in the private market (DOIT 2003). In comparison, the combined total sales of Cyberlink and Ulead, the two leading Taiwanese software-product companies, in 2002, were $65USD million or $2NT billion. (Trend Micro, which is now a Japanese company had sales of $364USD). In a few interviews we conducted in 2001 with III's management team we were told that of III's budget, half originates from sources other then DOIT.

[12] For a different perspective, see Fuller et al. 2003.

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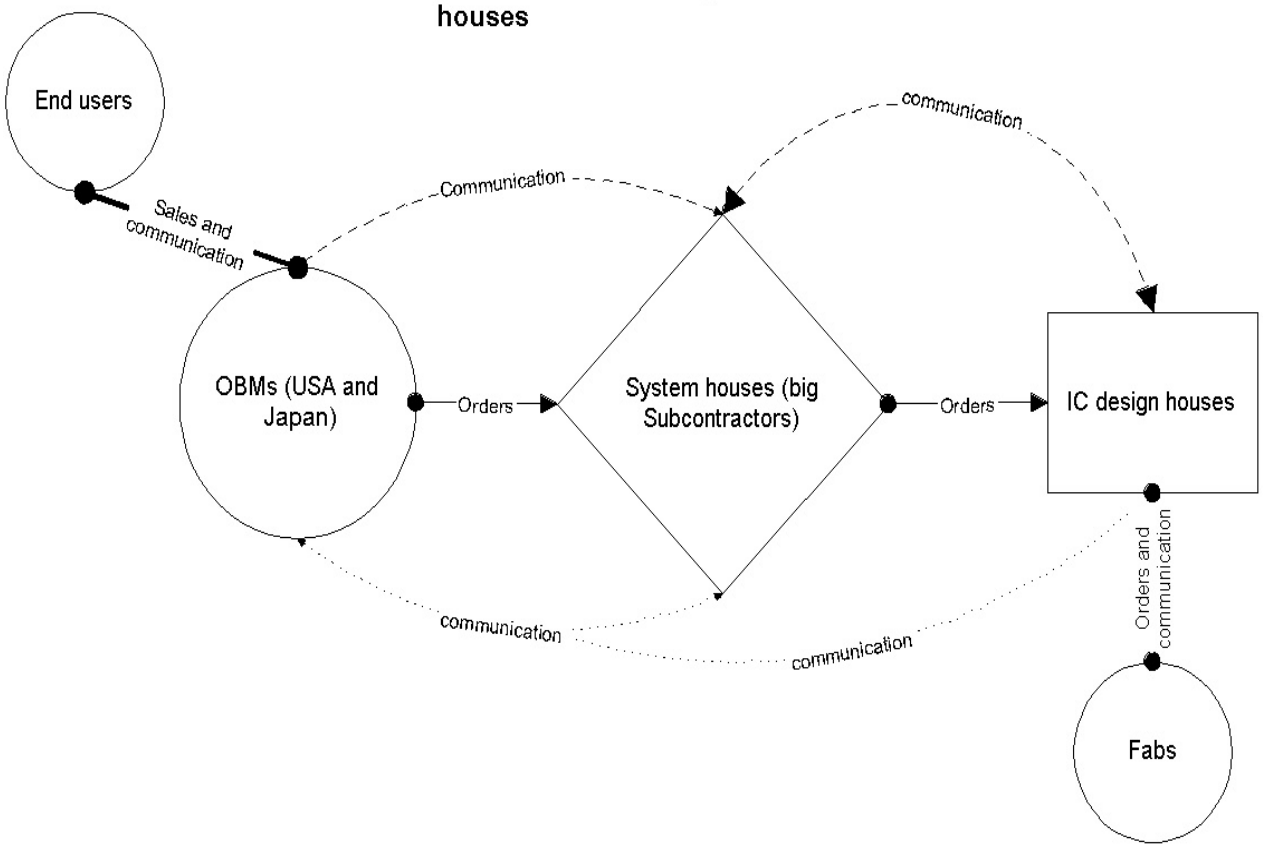
Appendices

Diagram I
Market relations and communication environment of the Taiwanese IC deign houses



Top 10 Taiwanese Design Houses by Sales - (NT 100 million)

2002	*2001*	*2000*		*2002*	*2001*	*2000*	*Main*
Rank	Rank	Rank	Name	Sales	Sales	Sales	Products
1	2	2	MediaTek Inc.	295	154	129	Optical storage
2	1	1	VIA	252	343	309	PC Chipsets
3	3	5	RealTek	92	73	54	Networking
4	4	3	Sunplus Technology	86	66	63	Consumer
5	6	8	Novatek Microelectronics Corp.	67	42	42	Consumer
6	5	-	ALi Corp.	61	54	31	PC chipsets/DVD Player IC
7	7	9	Elan MicroElctronics	40	36	39	Consumer
8	9	7	Elite Semiconductor	34	30	43	Memory
9	-	-	Faraday	34	24	-	Memory
10	8	6	Holtek Semicond uctor Inc.	33	32	45	Consumer

Source: Bandaoti Gongye Nianjian (The Yearbook of Semiconductor Industry in 2003), ITRI, 2003.