Hong Kong Innovation Project

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How to Revive Hong Kong's Integrated Circuit Design Industry

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Introduction: Taiwan's Tortoise and Hong Kong's Hare

Today Taiwan is recognized as the largest center of fabless integrated circuit (IC) design firms (firms which design but do not fabricate chips) after the United States while Hong Kong is a bit player in this global industry. Fifteen years ago things looked quite different. At that time, Hong Kong was arguably ahead of Taiwan in terms of the technical sophistication of its integrated circuit industry. While Taiwan's large and cutting-edge pure-play foundries, firms which fabricate[1] but do not design chips, were already in existence and beginning to grow, Hong Kong at that stage had the technical edge in design activities. Furthermore, these design activities were eminently suitable for Hong Kong given its lack of a tradition of state support for large capital investments for industrial enterprises, just the type of support needed to jump start IC fabrication plants (fabs for short) in emerging economies. Thus, fifteen years ago one could have easily forecast that building on their respective strengths, Hong Kong would become a center of design to complement the fabs sprouting up in Taiwan, Singapore and Korea where generous state support for investment in fabs was forthcoming.

In the early 1990s, the pillar of Hong Kong's IC design activities was Motorola. Motorola had built up an impressive team of IC designers in Hong Kong to complement its manufacturing activities there. This team grew to such technical strength that it provided the lead on the Dragonball series of microprocessors in the 1990s. Taiwan had no technologically comparable design activities at the time of the design of Dragonball processors.

[1] Fabrication is the front-end of the manufacturing process where circuitry is created on a wafer, usually made of silicon, to create a semiconductor device.

Beyond Motorola, Hong Kong also had Valence Technology Ltd., a very homegrown Hong Kong firm. Valence started out in 1985 and began by offering layout design services to NEC and Fujitsu. The firm quickly developed the capability to develop application-specific integrated circuits (ASICs) that captured product differentiation on a chip (Reif and Sodini 1997). During the 1990s, the firm began to develop chips for Sony Playstation and between 1998 and 2004 the firm made quite a lot of money designing chips for VTech and other system houses (firms that design and manufacture complete products, such as telephones) in Hong Kong (Interview with ex-manager of Valence). This firm was at least as technically sophisticated as the leading Taiwanese fabless firms of the 1990s as witnessed by its winning the Top 10 EDN Asia Component Design Award two years in a row (1995 and 1996). Indeed, the ability of Valence to serve major MNCs during the 1990s points to it having technical capabilities at least equivalent to those possessed by the major Taiwanese fabless firms of the time.

Despite the strong technical advantage Hong Kong enjoyed over Taiwan during the first half of the 1990s, Taiwanese fabless firms began to grow into relatively large-scale fabless firms during the latter half of the 1990s,. By 1997, Taiwan had four companies (VIA, SiS, ALI and Utron) with over US$100 million in sales. Significantly, three of these design houses (VIA, SiS and ALI) were focused on PC chipsets, a very large market in Taiwan given the strength of Taiwan's PC manufacturing industry (IT IS 1998: Ch. 8 p. 11).

Despite Taiwan's advantage in having local PC manufacturers to consume its chips, Hong Kong was still a significant market for Taiwanese IC design firms in 1997. While 51.9% of Taiwanese design firm sales were in Taiwan, Hong Kong represented the second largest market with 29.5% of sales. Hong Kong actually represented a larger market share than Taiwan in consumer electronics ICs with 55.1% of all Taiwanese consumer electronics chip sales (ITIS 1998: Ch. 8 p. 12). Thus, Hong Kong at the time still offered opportunities for fabless firms, especially in the consumer electronics space. Precisely because of Hong Kong's competencies in consumer electronics, Reif and Sodini urged Hong Kong to take advantage of the IC design opportunities afforded by Hong Kong's cluster of electronics systems houses (Reif and Sodini 1997: 203-204, 208).

While the goal of this chapter is not simply to benchmark Hong Kong against Taiwan, this comparison does bring out questions worth asking about Hong Kong's IC industry. Simply put, what went wrong with Hong Kong? Why did Hong Kong not build on its earlier strengths in the area of IC design? More importantly, how can Hong Kong recapture its past success and build a flourishing, globally competitive IC design? This chapter intends to answer these questions.

The chapter proceeds as follows. The first section presents an overview of the evolving structure of the global IC design industry over the last thirty years. The second section evaluates the current state of Hong Kong's IC industry and highlights its developmental bottlenecks. The third and final section will present recommendations to remedy these bottlenecks.

1. The Restructuring of the Global Semiconductor Value Chain

The global semiconductor value chain has witnessed a revolution in its structure over the last three decades.[2] In the late 1970s, the industry was still dominated by merchant IC firms (also referred to as Integrated Device Manufacturers or IDMs) that designed and produced and sold ICs and vertically integrated electronics conglomerates that produced their own ICs which more often than not were used in their own electronics end-products (e.g. TVs, radios and other electronics "boxes"). In either case, these firms controlled and conducted all the main activities of the IC value chain in-house from designing the chips to assembling them into packages that could interface with other components and testing these final packaged chips.

Over the course of the 1980s, new firms experimenting with new organizational forms that tried to segment the vertically integrated value chain into discrete segments in order to concentrate on one of these segments emerged. For example, some of these newcomers aimed to design but not manufacture their own chips. However, these organizational forms were stymied by the fact that they were in a larger industrial environment structured to meet the needs of vertically integrated firms. Furthermore, even when the existing firms were willing to accommodate these firms by servicing them, there were organizational and technical barriers to sharing the necessary information to make outsourcing of most functions cost effective.

During the first half of the 1990s, the technical barriers to vertical disintegration began to fall as the advent of increasingly sophisticated electronics design automation

[2] This section is based on a number of works documenting the changes in the global semiconductor industry including Berger 2005, Fuller at el 2003, Fuller et al (forthcoming) and Macher et al 1999.

(EDA) tools and other information technology innovations allowed for increasingly cheap and effective means of digitally transferring much of the necessary information needed to outsource various functions along the value chain. There emerged a co-evolution between these technical advances and the continued changes in industrial organization as more and more firms began to focus on discrete functions or narrow sets of functions rather than pursuing vertical integration. As this new industrial structure matured, significant cost and time-to-market benefits accrued to firms embracing this focused approach and these competitive advantages in turn pressured the remaining vertically integrated firms to shed functions.

The changes this co-evolution has wrought in the IC industry have been profound. Today, there are many firms, including large firms, that concentrate solely on design or fabrication or assembly and testing of ICs. Fabless firms that just design chips went from being just three percent of global market revenue in 1994 to twenty percent in 2006 (Hurtarte *et al* 2007: 7). Similarly, pure-play foundries, firms which solely offer fabrication services for others, have grown from essentially zero in the late 1980s to eight percent in 2006 (Hurtarte *et al* 2007: 7 and 26), and the revenues of foundries understate their importance in the global value chain since their share of manufacturing capacity is much larger than their share of revenues. Furthermore, the foundries and fabless have enjoyed a sustained growth advantage over the IDMs during the last two decades. Indeed, Taiwan's success in the IC industry is due to Taiwan being at the forefront of many of these organizational changes, particularly in creating spectacularly successful pure-play foundries.

The de-verticalization and segmentation of the global IC value chain opened up opportunities for smaller firms beyond those in Taiwan. Numerous successful fabless design firms have emerged in the US, Israel and elsewhere, and pure-play foundries have sprung up across East and Southeast Asia. These successes suggest that the current global industrial structure would be amenable to new entrants in fabless design from Hong Kong, particularly with so much of the global IC value chain in close geographic proximity to Hong Kong.

A note of caution for the future is needed however. Although the recent decades have offered tremendous growth opportunities even for small start-ups, there are troubling trends that suggest the future may be a bit more difficult for smaller firms as the IC industry matures. Principally, the costs of design and fabrication are escalating faster than the market is growing. For example, at 45-nm process technology (the cutting edge process technology), the cost of process technology, plant and equipment for a 300mm fab ranges from US$5 to 6.4 US$ billion and design costs range from US$20 to 50 million. At 32-nm process technology, those costs are estimated to rise to US$ 13 billion and US$ 75 million respectively. These trends suggest that the industry will undergo further consolidation as IDMs, foundries and fabless firms enter joint-ventures (JVs) to share costs (Hurtarte *et al* 2007, Ch. 14). Rising costs and consolidation may create larger barriers to entry than have been the norm over the last twenty years.

2. Findings: Current Situation and Developmental Challenges

Interviews

This chapter focuses on IC design and ignores the two other main activities in the IC production chain, fabrication and the backend of assembly and testing. The reason this chapter concentrates on IC design is that Hong Kong has had historical competencies in this area and has not had any significant activities in the two other segments of the IC production chain in recent years. Furthermore, Hong Kong is unlikely to develop the capital-intensive fabrication segment where investments of at least several billion dollars are needed to build one current generation fab and the backend of assembly and test is relatively less technology-intensive so unlikely to provide a boost to Hong Kong's knowledge economy. Indeed, assembly and testing facilities have been concentrating in developing Asia over the last several decades as these activities migrate from higher wage locations.

As the purpose of this chapter is to explore how to revive Hong Kong's IC industry and promoting IC design appears to be the most promising, the research for this chapter targeted firms involved in IC design in Hong Kong. Of the more than thirty firms[3] involved in the IC industry in Hong Kong, nineteen were interviewed.   Among these nineteen, seventeen are conducting IC design or are start-ups planning to do so shortly. Of the nineteen, six were MNCs and the rest were a mix of local firms ranging from large spin-offs from multinationals to tiny early-stage firms. Tables 1 and 2 list the firms and their features.

[3] According to HKSTP, there are 38 companies (39 by HKUST's count because it counts ASTRI as a firm) in the IC industry within the park. The list includes a number of firms that also have activities outside of the park so it should be viewed as basically comprehensive for Hong Kong.

Beyond the IC industry firms, the research also involved interviewing managers at key institutions within Hong Kong's innovation system including Applied Science and Technology Research Institute (ASTRI), the Hong Kong Science and Technology Park (HKSTP), universities and various government agencies, including the Innovation and Technology Commission (ITC).

Overall Situation

Hong Kong has taken a large step backwards in its relative position in the global IC industry over the last 15 years. Freescale (the former Motorola) has drastically scaled back its design operations in Hong Kong and shifted most of this work to Suzhou with ancillary operations in Shanghai and Beijing[4]. Motorola asked for state support in 2002 and reportedly Francis Ho, Secretary of the Commerce and Economic Development Bureau (CEDB), refused this request so then Motorola decided to shift operations to Mainland China. Spin-offs from Motorola, both domestic (Solomon Systech) and multinational (On Semiconductor), have emerged, but these firms do not make up for the loss of this major design center. The MNCs that have moved in over the last decade claim that Motorola's ability to train good analog design engineers lured them to Hong Kong. However, none of these new operations are very large and analog design generally needs a few experienced hands rather than a large number of engineers so there are not any opportunities for training large numbers of new engineers in these MNCs.

[4] It is unclear if the small design team in Beijing is in addition to the previous small design team in Tianjin or has replaced it. In any case, Freescale's website no longer reports a design team in Tianjin or Hong Kong although the website only reports "major" design centers, see http://www.freescale.com/webapp/sps/site/overview.jsp?nodeId=060A60.

Reif and Sodini (1997: 211) called for the government to bring in MNCs to spur the development of IC design activities that Hong Kong desperately needed, but Hong Kong failed to pursue these activities even as peer competitors in the region and beyond competed to take advantage of the globalization of R&D (Reddy 2000). Even Taiwan, traditionally rather reluctant to offer MNCs attractive deals to locate in Taiwan, began promoting MNC R&D centers during the current decade. Today, the MNCs have already established substantial offshore R&D sites for IC design in India, Singapore and elsewhere. Unfortunately, Hong Kong has basically missed out on this opportunity.

The lack of MNCs has created fewer opportunities for engineering employment in Hong Kong and fewer opportunities for learning from large, technologically deep companies. Engineering graduates in Hong Kong have often gone abroad if they desired to pursue a career in engineering (see Vivek Wadhwa and David Hart's chapters). If Hong Kong had been able to create a more vibrant labor market in part through luring MNC design activities, engineering graduates could have stayed put in Hong Kong and created a virtuous cycle of a deepening labor pool luring more firms to locate design activities in Hong Kong. Such a virtuous cycle possibly could have even spurred IC industry entrepreneurship as well.

Few domestic start-ups have emerged to follow in the path of Valence. This lack of technology entrepreneurship is primarily due to the lack of funding for such start-ups in Hong Kong in addition to the shallow talent pool. The other factor missing to spur more technology entrepreneurship is the link provided by returnees. Hong Kong has been unable to attract back the human capital in the form of returnees and investment capital from Silicon Valley and other foreign technology centers that have proven driving forces for technology development in Taiwan, Mainland China, India and Israel (Saxenian 2006). The dynamic combination of returnees and investment capital has not appeared even though a substantial number of engineers from Hong Kong are active in the technology sector in North America.

Hong Kong has tried to spur innovation through several new institutions created over the past decade, principally ASTRI and the HKSTP. While these institutions embrace the right ideas, they have not been able to overcome the bottlenecks in the form of lack of entrepreneurship and the lack of further development of MNC design activities.

These factors will be considered in greater detail below.

Funding

For the major centers of IC design across the globe, venture capital funding has been critically important to encourage firm creation.[5] The IC industry is fraught with risk given its high technical demands and rapid product life cycles, and the main assets of many IC design firms are their human capital so banks are ill suited to support new ventures in this area. Furthermore, the expenses to complete a chip design are increasing rapidly (see p. 6 of this chapter) so small amounts of seed funding no longer provide sufficient investment to cover development costs. In this context, ample angel funding and venture capital are required.

Unfortunately, in Hong Kong, the funding situation remains miserable. Venture capital (VC) firms simply are not interested in investing in technology enterprises in Hong Kong. Angel investors in the vibrant technology clusters of Silicon Valley and Taiwan often hail from within the technology sector itself. Hong Kong's lack of such a

[5] Korea and Japan are exceptions to this rule, but they developed their industries through reliance on very large integrated device manufacturers (IDMs) combining design and fabrication. This capital-intensive model is not suitable for Hong Kong.

cluster creates a dearth of potential angel investors for the IC industry. The only other options are self-funding or getting customers to pay non-recurring engineering expenses (NRE) up front, but given the increasing expenses involved in designing complex chips, these options are also not very promising.

The funding experience of many of these companies is not very encouraging. Only three of the firms interviewed received any outside funding and all were from angel investors. One holding company bought a small fabless firm with the idea of turning it into a captive design house for the firm's planned OEM electronics expansion, but this type of tie-in between fabless design firms and other electronics firms has been rare. Since this acquisition just occurred last year, it is too son to hail it as a success. Valence itself struggled for funding over the years. It received small amounts of funding from some of the Japanese firms that hired it to do design services and then was given funding by Legend Holdings acting as an angel. In 1998 Valence was sold to SRS Labs, an American audio firm. One former Valence manager described the period under SRS Labs' ownership as the firm's golden age since the ties to SRS Labs provided more adequate funding. However, even SRS Labs was often reluctant to invest enough in IC development as it was not an IC firm itself. SRS finally sold the firm to Singapore-listed Willis-Array, an electronics supplier. Subsequently, the design team for this firm reportedly shrank to a small fraction of its former height of over 100 IC designers.

The two most successful domestic firms in Hong Kong are self-funded Appotech and Solomon Systech, which started as a local management-buyout/spin-off from Motorola. Appotech stands out as its founder, Chuck Cheng, returned from Silicon Valley after founding start-ups there. While returnee-start-ups have been common in

Mainland China and Taiwan, this type of start-up is rare in Hong Kong. Solomon Systech also received angel funding from the Solomon Group in Taiwan. However, this firm had a contract with Motorola to supply the firm with chips from one product line for several years after buying out that product line from Motorola so it was not the typical early stage IC design firm without any revenue.

ITC/ASTRI

Most firms had little good to say about the ITC's Innovation and Technology Fund's (ITF) funding process. The ITC has too many layers of vetting committees of which only one necessarily has technical expertise in the relevant area. This vetting process takes too long for the research to keep up with product life cycles in the technology sector. The ITC vetting takes 3 to 4 months (according to firms which use ASTRI often) so this adds an intolerable lag in time-to-market for projects that should be completed in 6 to 9 months in order to get into the marketplace on time. However, some of ASTRI's own personnel suggested the whole time to be vetted by the ITC was more often 6 to 9 months (a whole product generation!) rather than 3 to 4 months. Indeed, there are five review panels[6]. The five panels are: internal, industrial review, technology review, ITC review and board of directors. ASTRI personnel suggested that the process should just be delegated to the technology review board to speed up the process.

Problems are compounded because the ITC pretty much insists on the R&D centers controlling the IP they create by requiring that participating firms pay for 50% of the research in order to claim IP rights. This requirement creates an onerous burden for

[6] These five panels do not include the Legislative Council (LegCo) approval needed for projects over HK$21 million.

local firms in the context of Hong Kong's small technology sector. Some ASTRI personnel defended the ITC's IPR management pointing out that when the ITC intervenes in royalty negotiations (negotiations made at the start of projects) it usually is fair-minded enough to ask for a price that allows the projects to go forward. Another problem is that many small private firms in Hong Kong simply cannot readily absorb and commercialize the technology created in the 90:10 partnerships (research where private firms contribute ten percent of the research cost). Given the low level of venture funding, even providing the ten percent up front that the ITC wants is a problem. Even for projects with a scale of ten million HK dollars, smaller firms found it a burden to pay one million HK dollars up front before the project even starts given that these projects can take one year, but currently if ASTRI is given money after the fact it cannot use that money for another project. The ITC has relaxed the 90:10 rule for ASTRI so private firms can donate less than ten percent (see below).

According to ASTRI personnel, the ITC is somewhat more flexible than the private sector believes. For example, the ITC will some times provide start-up fees for ASTRI to work on a project while ASTRI finds a corporate sponsor to pay the ten percent fee. This may be in line with the ITC's own report that not all funding is completely predicated on finding some industry funding. However, these "start-up" funds are quite small. In one case, the ITC gave the IC group HK$ 350 thousand out of a total project budget of HK$ 8 million and a time limit of six months to find a corporate partner. The ITC also allows ASTRI to contract out its services with the customer paying 100% of the cost, but with ASTRI allowed to get an extra 10% from the ITC as long as the contract service work is related to projects being funded. In effect, through contract service work, ASTRI can receive 110% funding.[7] The ITC also lets ASTRI's industry partners make in-kind contributions that treat expenses the partners incur on the project as payments to the project in order to lower the cash contributions the industrial partners have to make. Furthermore, the ITC also allows ASTRI to get an average of ten percent from a number of projects rather than a full ten percent from each partner. However, there is a rumor that the ITC will up the amount industry partners have to pay from ten to twelve percent.

Another major problem with ITF funding is that every grant over HK$21 million needs LegCo approval. This requirement is particularly burdensome for chip design because with this paltry sum one can barely cover the cost of getting a prototype. Neither Korea's ETRI nor Taiwan's ITRI have had to deal with such low levels of funding and lack of longer term block grants. ASTRI's stopgap measure to deal with this problem is to ask for a review of all grants at once, even for those not starting right away. However, this method does not solve the problem of responsiveness i.e. some projects need to be approved quickly so ASTRI can stay ahead of the curve in producing innovations.

The length of ASTRI IC projects is a problem from two perspectives. On the one hand, these projects are too long to keep up with changes in the marketplace. ASTRI projects typically last one to one and a half years so they need to be allowed to change midway through in response to shifting market demands since market windows for products typically last 6 to 9 months. In this manner, the projects can be re-directed to those market opportunities that will be available when the projects finish. However, the ITC does not tolerate any changes in the projects. On the other hand, these projects are too short to encourage ASTRI to do real research. The ITC's funding of 12 to 18 month-

[7] There are conflicting accounts from ASTRI about whether this amounts to 100% or 110%. It appears to depend on how one does the accounting. In any case, ASTRI can leverage contract work paid by the private firm as that firm's ten percent contribution to the ASTRI-led, ITC-funded project.

long projects does not encourage real forward-looking research so the ASTRI is mainly doing development work, but even with development work, the funding is too little to deploy technology into full-fledged commercial products. Of course, it appears many of the firms want development work from ASTRI more than they want research in any case. Nevertheless, if ASTRI wants to be like ITRI and serve to create and diffuse advanced technologies, it must make a more serious effort to do research.

ASTRI's IC Group consists of two different sub-groups: one focused on analog and mixed signal design (called Portable Analog Mixed Signal Design or PAD) and a digital team called the Applied SoC (system-on-a-chip) Design team.[8] In 2007, the budget for PAD was 17 million HK$ with 4 IPs transferred to industry and 6 US patents filed. In 2008, the budget for the same group was HK$25 million. The typical project has been ninety percent funded by ASTRI and the Industrial Collaboration Projects (ICP) with a 50:50 split were only started in 2008. Even with the 50:50 split, ASTRI co-owns the IP but it cannot license it out. For PAD, the customer base in revenue was 100% Hong Kong in 2007 and a 75:25 split between Hong Kong and Mainland China through the first two quarters of 2008. PAD projects that its budget for 2009 will be HK$30 million.

For the Applied SoC Design team, in 2007, the revenue stream was 70% Hong Kong and 30% Mainland. This team did not give any estimate for 2008 but suggested shift towards the Mainland with advent of 65nm technology. The budget for this group was not disclosed.

[8] The ASTRI website still lists a third team called the Mobile Terminal and Multimedia team, but ASTRI personnel have confirmed that this team is no longer part of the IC Group.

PAD has 23 engineers. The Applied SoC Design team has 13 engineers. Both can do the complete design flow. To place these groups in international context, ITRI's SoC Technology Center has over three hundred people with the large majority being technical staff. In addition to being quite small, ASTRI's IC Group has suffered from high turnover according to one firm that has interacted with ASTRI.

Firms use ASTRI's design service since it functions essentially as a subsidized design service compared to the commercial firms. These firms pay ten percent of the cost to use design services. While helpful, this is a far cry from the major learning and diffusion role that ITRI has played in Taiwan. Still, ASTRI has transferred some IPs and is trying to create programs to help industry in other ways. One project is a mask set for a mixed signal SOC. Such a mask set normally costs US$1 million, but as a number of customers (five to six thus far) want it, the firms only have to pay 50 to 60 thousand USD to ASTRI. One two-person team even spun-off from ASTRI to become multinational Marvell's Hong Kong design team. The main problem with these small efforts is that they have been undertaken in a situation where more concerted, larger scale efforts are probably needed to compensate for the other weaknesses of Hong Kong's quite small IC industry.

HKSTP/IC Development Centre

HKSTP's IC Design Centre and IC Development Support Centre (these two centres will be referred to here as the IC Centre or ICC for the remainder of this paper except when trying to distinguish a particular feature of one of the two since they both serve to support the IC industry with subsidized services[9]) offer a plethora of subsidized EDA tools, product analysis and testing services. Local firms use these services quite frequently. HKUST Semiconductor Product Analysis and Design Enhancement (SPADE) Center's services are generally considered equivalent or better than IC Development Support Centre because SPADE has some better equipment, but the IC Development Support Centre is cheaper. The MNCs only reported using the Park's Failure Analysis service and not the other services. Some MNCs use SPADE at HKUST.

The ICC in the first half of 2008 received the rarely granted ISO27001 certification for Information Security Management System. None of the IC centers in Mainland China have received this certification. Due this certification, the ICC has been able to lure new services from two providers. IBM will serve the HKSTP and its firms with new processes (65nm CMOS and 130nm SiGe). The processes are on the US export control list and therefore not available in Mainland China. IBM before never bothered to serve fabless firms with less than US$10 million in revenue, but now plans to work through HKSTP to serve the park's firms. The vast majority of the park's fabless firms have less than US$10 million in revenue. In a world first, Synopsys IP Trial has been made available to the Centre. It is claimed that this reduces cycle time from 18-24 to 6-8 months. With ISO27001, the ICC has virtual lock-in design rooms for the centre's design tools that one can log in to from anywhere. However, Synopsys has set specific geographic boundaries from which one can log in to the system. Mentor and Cadence have no specific geographic boundaries for the use of their tools. ASTRI is using it and

[9] The ITC (2004: 65) in discussing the role of the two centres essentially lumped the two together by referring to them as the IC Design and Development Support Centre. The two centres are both managed along with the park's other labs by the Business Development and Technology Support Division of HKSTP.

gets a twenty percent discount. Smaller firms get an additional thirty percent discount. This 50 percent discount represents what only the very largest firms receive worldwide.

The problem with these systems in terms of boosting Hong Kong's IC industry is that the clients appear to be Mainland firms with the exception of ASTRI (and even a fair number of ASTRI's clients are from the Mainland). For example, SWID from Chongqing is the sole user of the IBM processes thus far.

The ICC's subsidized services undoubtedly help the industry through providing the requisite industry infrastructure and lowering barriers to entry. Furthermore, the investment in these centres has been quite substantial by Hong Kong standards with HK$230 million spent from June 2003 through November 2007. However, they are not enough to propel the industry forward given the other bottlenecks. Furthermore, the extensive use Mainland Chinese firms make of the services[10] begs the question of how exactly servicing Mainland Chinese firms benefits Hong Kong.

Returnees/Expatriates

Despite the significant presence of Hong Kong engineers in Silicon Valley, very few have been lured back to Hong Kong to the technology business because the lack of an existing viable tech sector, lack of VC and limited government support combine to offer few incentives to return. Dr. Li, the founder of Kontel, came back originally to take care of the non-tech family business. The returnees in ASTRI (Ben Cheng and YK Li) either came back to ASTRI directly (Ben Cheng) or first went to try their luck in the Mainland IC industry (YK Li was at IP Core). The one significant entrepreneurial

[10] The Mainland Chinese firms usually obtain funding from regional and local governments in Mainland China to subsidize the cost of using the ICC's services.

success story is Appotech's Chuck Cheng, who returned from the United States. However, despite having had a track record in founding fabless firms in Silicon Valley (e.g. Ubicom), Chuck had to self-fund Appotech and the bulk of his design team is in Mainland China because without VC investment it is too hard to hire a large design team in Hong Kong.

Cooperation with the Mainland

It is apparent that the Mainland firms are at least as active (and probably more so) than Hong Kong firms in utilizing the services of HKSTP's ICC. While this is not so costly for Hong Kong as the Mainland central and local governments are subsidizing the Mainland firms to use HKSTP's services rather than HKSAR subsidizing them, this does not do much to develop Hong Kong's IC industry and is offering benefits to firms that are competing with or are potential competitors to Hong Kong firms. HKSTP has astutely taken advantage of Hong Kong's better IPR regime to gain the trust of a number of firms offering valuable services to IC design firms (e.g. IBM, Synopsys, Cadence, Mentor), but by providing Mainland firms relatively equal access, one must ask if HKSTP is unwittingly undermining Hong Kong's competitive advantage by offering these services to firms that may compete with designers based in Hong Kong.

Although the ICC under the auspices of HKSTP is considered to be one of the nationally designated IC Centers (ICCs) of the PRC in the "7 plus one" formulation[11] in which ICC is the additional one alongside the seven national centers in Mainland China, what this means practically is that the ICC does not get any central government funding. However, it must also be said that most of the funding for the original seven national

[11] There are rumors that Jinan will be added as the eighth national IC design base in Mainland China.

design centers comes from the local government—especially for the more successful design centers. It is also important to recognize that the national ICCs in the Mainland do not provide firms outside their jurisdictions access to their services except at higher, non-subsidized prices.

The lack of central government funding for Hong Kong is true across the ministries that deal with the IC industry and S&T matters in general. All of the central government officials approached about this subject said that promotional policies and funding from the central government for Hong Kong in these matters was essentially non-existent. What did exist was basically funding for Mainland Chinese firms to avail themselves of services in Hong Kong that were not available in the Mainland.

The Hong Kong-Shenzhen Innovation Circle Program and Hong Kong-Guangdong Technology Cooperation Fund provide funding for Mainland Chinese universities and companies from these jurisdictions to work with ASTRI to apply for ITC funding. However, personnel at ASTRI were concerned that the ITC would no longer accept even 50:50 funding for big Mainland companies, probably due to concerns about the need to spend the ITC's money to support local Hong Kong firms rather than large Mainland Chinese firms.

One MNC firm reported extensive cooperation with Zhejiang University despite the fact that the MNC does not have any R&D in the Mainland. The firm described the decision to develop strong ties with Zhejiang University instead of with a Hong Kong-based university as having been made solely because "China was the flavor of the month" when the decision was made to look for a partner university in the region.

Hong Kong itself has dreams of jumping on China's technology bandwagon. The CEDB's *2008 Digital 21 Strategy* explicitly mentions cooperation with Mainland China on Chinese technology standards. Similarly, the ITC (2004: 27) envisions Hong Kong having an advantage in ICs through cooperation with the Mainland on its AVS and now essentially defunct WAPI standards.[12] The problem with this plan is that thus far Mainland China has failed to promote technology standards that have proven sustainable in the marketplace.

Labor Supply

Most firms presented this issue as a classic chicken-and-egg problem. What seems to be true is that there are far more graduating electrical engineers than there are new hires in the IC business or related engineering fields. Many of the graduates either leave Hong Kong or leave the field. However, one major MNC expressed deep concern that HKUST shut down its MPhil in IC design, which trained quality IC designers, and replaced it with a much lower quality part-time MS. This firm blamed the government for allocating too much funding for PhDs and not enough for MPhils. Of course, HKUST shut down the MPhil program because the labor market was so bad most of the graduates were leaving for work in the US and elsewhere. The firms concentrating on analog and mixed-signal design seem to have a decent supply because they do not need to grow very large teams and the legacy of Motorola left a pool of experienced analog/mixed-signal engineers in Hong Kong.

[12] AVS stands for audio and video standard and is a codec (coder-decoder) compression standard for digital audio and video compression. WAPI stands for WLAN Authentication and Privacy Infrastructure and is a wireless local area network standard.

3. Recommendations

These recommendations are listed in order of priority from most to least important. These recommendations need to be integrated with and adjusted to the recommendations for the policy areas with which these sectoral recommendations overlap.

1. ***Matching State Funds for Early Stage Investment***

Radical measures must be taken to encourage investment in the IC sector if it is to have any hope of flourishing in Hong Kong. One measure should be to target the largest VCs in the global technology sector (the top twenty or so) and/or the most active regional technology-oriented VCs (e.g. Acer Capital, Walden) and offer matching funds for early stage (seed and Series A) investment in Hong Kong's IC firms. For this to work, it is critical that the matching funds be predicated upon the investment decision by the international VCs preceding the investment by Hong Kong authorities. In other words, the investment by one of the targeted VCs in a Hong Kong-based firm should automatically trigger investment by the Hong Kong authorities, but the Hong Kong authorities would never first choose which local firms it would support. In this manner, the Hong Kong government can ensure that the vetting process is done by the VCs before using state funds. Obviously, the Hong Kong government would need to reach out to VCs to explain this policy in order to increase their interest in the local market. A related measure could be targeted investment aimed at encouraging returnees to set up IC design operations in Hong Kong (see below). Unfortunately, given the current global financial crisis, this measure will take time to bear fruit as the venture capital market currently is dormant.

Encouraging venture capital would also help to solve the problem of what IC industry activities to encourage given the maturation of the sector and the likelihood of increasing barriers to entry. With the VCs effectively exercising veto power over government investment in this sector through this linked investment policy, the government would have a mechanism to prevent it from continuing to support an industry that venture capitalists recognized as offering too few opportunities for growth.

How would this policy of matching funds be different from the earlier, failed Applied Research Fund (ARF) scheme? First, the principle of automaticity needs to be in place to avoid the failures of ARF. In other words, whatever government organ is in charge of distributing the matching funds should first vet the VCs and then automatically approve any investments the vetted VCs make in Hong Kong as long as the investments are in the approved sectors (potentially other sectors should be promoted along with IC design). Second, the principle of speed of approval must be employed. The government organ in charge should be given no more than a week to veto the matching funds based on one of the two agreed upon investment requirements (location in Hong Kong and sectoral). If this one week deadline passes without a veto from the government, the matching investment is automatically approved. Employing these two principles, the slow, bureaucratic approval process that hampered ARF will be avoided. Third, a longer time horizon should be given to this VC matching fund. The government should not demand to see any positive returns for at least one decade because the point of this scheme is to promote industrial activity (i.e. success may show up in positive externalities not captured by the government's return on investment) and it often takes a long time for such early stage investments to bear fruit. This third principle of a long time horizon will help insulate the matching funds program from unhelpful government interference demanding short-term profitability.

Luring Returnees Home

Hong Kong has terribly underutilized a great asset, namely the Hong Kong technologists living abroad. Returnees have played a significant role in the technology sectors of Taiwan, China, India and Israel and the fact that they are nearly absence from Hong Kong despite the obvious presence of Hong Kongers in global technology centers, such as Silicon Valley, needs to be addressed.

2. Funds for Hong Kong Technologists Living Abroad

One way to do so would be to tie in certain venture capital matching funds mentioned above to luring experienced expatriate technologists to set up design operations in Hong Kong in return for venture capital. The matching funds might have to be made at rates attractive enough to lure expatriates home (i.e. the Hong Kong matching funds would have to demand less equity than the market rate), but would have to be made predicated upon outside VC investment as mentioned above.

3. Set up an Expatriate-Hong Kong Bridging Institution

Another important route to bind expatriate Hong Kong technologists to Hong Kong's technology sector would be for the state to set up or at least financially support a Monte Jade-like organization in Silicon Valley. Monte Jade Science and Technology Association, a Taiwanese-American organization based in Silicon Valley, played an important role in encouraging Taiwanese-American entrepreneurship linked to Taiwan

(Saxenian 2006). Hong Kong must seek a similar means to connect to its expatriate technology community in the US and use this vehicle to communicate about opportunities and government support, such as the matching VC funding, to lure the expatriates to become more involved in Hong Kong's technology sector.

Labor Market Reforms

4. Targeted Labor Liberalization Schemes for IC Engineers

While Hong Kong has made it relatively easy for educated Mainlanders to come to Hong Kong through its Admission Scheme for Mainland Talents and Professionals and the 2006 Quality Migrant Admission Scheme[13], further targeted liberalization is required to bring engineering talent to Hong Kong. The Hong Kong government should make it much easier for Mainland Chinese and Taiwanese engineers to come to Hong Kong to work. A streamlined visa process for Mainland and Taiwanese engineers who wish to work in Hong Kong should be set up. For Mainland China, anyone with a MS from an accredited microelectronics program should be allowed to come to Hong Kong under this streamlined process. For Taiwan, anyone with an undergraduate engineering degree from an accredited university should be allowed to take advantage of this streamlined process.[14] Following this, the government should sponsor an active recruitment drive at the major engineering universities of the Mainland Chinese and Taiwan.

5. Reinstate HKUST MPhil Program

[13] The former scheme grants entry to those who possess skills not readily available locally and the latter has a points test through which potential immigrants compete to enter Hong Kong under a quota scheme (Office of the Chief Information Officer 2007: 43).

[14] The broader category for Taiwan is justified given the excellence of the engineering education available in Taiwan.

The full-time MPhil program at HKUST should be reinstated. However, this reform should follow the other reforms for venture funding and returnees so that a growing demand for engineers is already in place when the training program re-starts.

***ITC/A*STRI**

6a. Cut Extraneous Review Panels

The ITC should cut the review down to one panel, the technology review panel, in order to speed up the approval process dramatically. This measure is especially critical for the shorter term development projects.

6b.

The HK$21 million cap above which LegCo approval is needed should be lifted or drastically increased.

6c.

The required corporate contribution for projects should not be increased from ten to twelve percent.

6d. Extending the time for research projects

For projects that are oriented toward developing new technologies, the schedule should be allowed to extend for more than 18 months and the technology review panel should be convened at intervals to assess progress. Other review panels are not needed.

6e. Diffusing new technologies

These new technologies should be diffused to industry through two methods: 1) provide the technology to local firms at below market-value and 2) spin-off viable technologies into independent firms.

6f. Linking Funding to Location of Activities in Hong Kong (applies to HKSTP/IC Development Centre as well as to ASTRI)

For projects with Mainland firms, the funding should be recalibrated so that any non-contract service projects require that the Mainland partner place half of its engineers involved in the project in Hong Kong with the exception that this requirement should not extend to those projects where the Mainland partner lacks any IC design capabilities. For example, Hisense's Shanghai-based chip design team is working closely with ASTRI. Since Hisense is a Qingdao-based firm, it could just as well have part of its IC design team in Hong Kong since the team is not co-located with headquarters in any case. With eased visa restrictions, Hisense could choose to bring its engineers to Hong Kong or recruit engineers in Hong Kong. This requirement would serve to bolster the sectoral cluster effects in Hong Kong as more engineers come to Hong Kong to work with ASTRI.

Similar to ASTRI, the IC Design and Development Centres should require that firms wanting to access the park's services have the engineers who are using these services present in Hong Kong. The lure of HKSTP's superior services should serve as a lure for Mainland Chinese firms to set up design operations in Hong Kong.

Product Development Teams and the Chinese Market

7. Strengthen System-level Design Capabilities via ASTRI

The success of the major MNCs and the Taiwanese in the Chinese marketplace demonstrates that to sell into local Chinese manufacturers, chip designs must offer complete turnkey solutions i.e. offer a complete reference design and software to accompany the chip. Local Chinese producers usually have weak design skills and only want to purchase chips from vendors who provide the complete reference design for them. In some areas, Hong Kong system firms have strong system-level design skills, but these skills need to be built up or else Hong Kong will never be able to compete with the Taiwanese who offer very strong system design services for their customers. Funds need to be made available through ASTRI to target system-level design skills for those areas in the Chinese market where demand is high. Hong Kong's chip design houses could then access this system-level design service. In the medium term, the system-level design program should be phased out to push the fabless firms to hire the trained system designers themselves without subsidization.

Table 1 Interviewed IC Industry MNCs in Hong Kong

Nationality	Hong Kong Activities	IC Designers	Analog/Mixed Signal (AMS) or Digital Design	Complete Design Flow	Design Metric	IC Centres (utilization)	ASTRI (utilization)
MNC	design	2	Analog and digital	?	?	?	No
MNC	No IC design—only application design	N/A	N/A	N/A	N/A	N/A	N/A
MNC	design	12	?	?	?	Use SPADE instead	No
MNC	design	40 HK ; 1-2 in China (SH)	analog	Complete except for new process tech	advanced	Rarely	No
MNC	Managing backend of manufacturing	N/A	N/A	N/A	N/A	N/A	N/A
MNC	design	14	analog	complete	?	ICDS	No

Note: Question marks denote those questions firms declined to answer.

Table 2 Interviewed Hong Kong IC Design Firms

Note: Question marks denote those questions firms declined to answer.

Nationality (Year founded)	**Investment**	**Activities**	**IC Designers**	**AMP or Digital Design**	**Revenue**	**Complete Design Flow**	**Design Metric**	**IC Centres (utilization)**	**ASTRI (utilization)**
HK (2003)	self	design	10 analog HK; 60-70 Mainland China digital and analog	Analog and digital	2007: US$6 mil 2008: US$60mil	yes	?	?	No
HK (1999)	Angel investor; IPO in 2004	design	100-130 HK; 40 Singapore; 10 Mainland China	Mixed signal	2007: US$164mil	complete	?	Yes	No
HK (2007)	self	Design service	1	digital	No revenue yet	Mostly in-house	?	No chips yet so have not used	Talking with ASTRI
HK (2000)	Local investment company, Taiwan and German investors	design	8	AMS	2007: HK$18.7 mil	complete	.35 to 2.0	Product Analysis; EDA Centre, also SPADE	3 projects with ASTRI; 10 ASIC projects in 2007
HK (2001)	Started with several other ex-Moto guys	design	10: 3TW, 7HK	digital	2008H1: HK$25 million	complete	.25-.22	ICDC, ICDSC; SPADE, testing also in TSMC	Considering purchase of ASTRI IP for SOC
HK (2006)	Still not completely spun-off from public institute	Design service	6	Mixed signal	?	Complete when needed	130nm - 65nm	ICDC,ICDS; SPADE	Indirect—work for customer working with ASTRI
HK (2006)	self	design	2	analog	2007: 100k USD 2008: 200-300k USD	?	?	?	No
HK (2005 as IC firm)	self	Design in Shenzhen	4 designers in Shenzhen	AMS	2-3 million HK$	Complete?	.6 bi-CMOS	ICDC	No
HK (2002)	angel	design	6	Analog, RF	2007: 3 million HK$	Can do complete	.6 bi-CMOS, 1.5 bipolar at BCD	No, Use SPADE and other outside sources	ASTRI design service and projects
HK (2004)	Angel—IC industry; internal revenue now	design	4	RF and analog	2008H1: HK$3 mil		.18-1.0 CMOS	ICD, ICDS	No
HK (2005) (surveyed not interviewed)	?	design	1	analog	2007: 0	complete	.35-.5	ICDS	?
HK	planning stage	planning stage	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HK	Planning stage	planning stage	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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