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BARRIERS TO GROWTH OF THE HONG KONG SOFTWARE INDUSTRY

by

Jacob J. Seid

Submitted to the Department of Electrical Engineering and Computer Science

in Partial Fulfillment of the Requirements for the Degrees of

Bachelor of Science in Electrical Science and Engineering

and Master of Engineering in Electrical Engineering and Computer Science

at the Massachusetts Institute of Technology

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ABSTRACT

Over the past fifteen years, much of Hong Kong's low-value-added manufacturing sector has moved over the border into China to exploit lower labor and land costs there. Recently, leading Hong Kong politicians and industrialists have identified software development as one of the keys to reinvigorating Hong Kong's local industrial base. Software is particularly attractive to Hong Kong because barriers to entry for individual firms are low, allowing small firms to thrive, and because production of software does not require large amounts of land or major public investments in infrastructure. However, a vibrant Hong Kong software industry has not yet emerged.

Many leading Hong Kong politicians and industrialists point to the lack of technology-focused venture capital funds in Hong Kong's capital markets and Hong Kong's small domestic market size as the key variables that are inhibiting the growth of the software industry. However, comparative research on software industry development in Ireland, Israel, India, and the U.S., as well as Hong Kong, suggests that fundamental factors inhibiting the growth of Hong Kong's software industry lie in the field of human resource development and in the lack of "source" organizations. These results have important implications for Hong Kong's industrial, political, and educational communities as they formulate priorities for the development of a local software industry.

Thesis Supervisor: Richard K. Lester

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First and foremost, I want to thank my thesis advisor, Professor Richard Lester. Prof. Lester first placed his faith in me by inviting me to participate in the Made By Hong Kong study. Through this invitation, I was able to have some of the most fascinating experiences of my life living and working in Hong Kong for four months. Prof. Lester continued his support of me by taking on the role of my thesis advisor despite his very busy schedule. In his role as my thesis advisor, he has provided me with tremendous support, insight, and feedback throughout.

I'd also like to thank the numerous people in Hong Kong without whose help this thesis would not be possible. They provided me with a tremendous amount of key anecdotal data which were invaluable in helping me develop the various conclusions of this thesis.

Finally, I'd like to dedicate this thesis to my mom, Anna Kruger, and my uncle Emanuel Kruger. Their support has brought me to the point I am at today.

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1. INTRODUCTION

This thesis looks at the nascent software industry in Hong Kong and the factors that could potentially be inhibiting its growth. The basis for my research was a broader research project called Made By Hong Kong (MBHK). The project was done by MIT's Industrial Performance Center (IPC) with the goal of understanding the future of industry in Hong Kong. The MBHK study was a year long project sponsored by Hong Kong's Industry Department and a group of private sponsors, and it involved 9 faculty members and 12 graduate students and research staff members at MIT. The research focused on 5 sectors of Hong Kong industry: textiles and clothing, electronics, information technology, biotechnology, and capital markets. Cross-cutting studies of Hong Kong's capital markets and its education and training institutions were also carried out.

My role was as part of the team studying the information technology (IT) sector. As its work progressed, the IT team began to see software as a potentially important, but still underdeveloped segment of Hong Kong industry. Even as Hong Kong's traditional manufacturing sector was relocating to China to take advantage of the lower land and labor costs, a software industry could provide high wage jobs with relatively minimal use of land space. The potential value of a software industry to Hong Kong was not only our view, but also the view of many leaders in Hong Kong as well. According to KK Yeung, former chairman of one of the government committees focused on information technology, "If we [Hong Kong] are to explore what opportunities remain which promise high long term growth,

attractive profitability and little impact to the environment, it must be apparent that the development of a local software industry could be most attractive"[i] The importance of high-technology to Hong Kong's future growth is even being acknowledged at the highest levels of government. In late 1997, in an unprecedented move which went against Hong Kong's long history of not picking industry's to favor, C.H. Tung, the chief executive of the Hong Kong SAR, announced a new government led industrial policy with the goal of building a role for Hong Kong in East Asia's booming high-tech industries[ii].

Other governments, including those of Taiwan, Singapore, India, Israel, and Ireland, to name a few, have played a more active role in developing an indigenous high-tech sector. While the pessimist might call Hong Kong a late-comer to this game, the optimist would say that Hong Kong has many models from which to pick and choose.

My role as part of MBHK's information technology team was to understand the current state of Hong Kong's software industry and the challenges to growth it faced. My research entailed secondary research as well as almost 60 interviews in Hong Kong spread among people in the software industry, academia, and the Hong Kong government. The results of that research turned up a variety of challenges to the growth of the Hong Kong software industry. However, what it did not do was provide a context for understanding the relative importance of each of those challenges. The work done for this thesis builds on my MBHK research by providing a framework with which to understand not only what the challenges to the growth of the Hong Kong software industry are, but more importantly, what the relative importance of the different challenges to the growth of the industry are.

The analysis of the barriers to growth of Hong Kong's software industry is conducted via a framework consisting of 5 key variables. These variables and their definition are shown in the table below.

Variable	Issues
Intellectual Property Protection	Software piracy in the domestic market
Domestic Market	The size and sophistication of domestic demand for software.
Capital Markets	Opportunities for the financing of young software firms via equity placements and initial public offerings.
Human Resources	The quality of engineers going into the software industry.
Source Organizations	Organizations which provide the technological or managerial base of new enterprises.

Table 1: Barriers to growth in the software industry

These five variables were selected because they neatly capture essentially all of the challenges to the growth of the Hong Kong software industry that were uncovered during my research with the MBHK project[iii].

The goal of this thesis is to provide a context for understanding which of these issues are relatively more important in their impact on the software industry's growth in Hong Kong. This context is developed by looking at Hong Kong in reference to software industries in four other economies—the US, India, Ireland, and Israel.

These particular countries were chosen for different reasons. While India, Ireland, and Israel all have what many consider to be "successful" software industries, they are successful for very different reasons. India has built its success on selling professional services and custom

software. Ireland's success is built mostly on MNCs, but also has an emerging indigenous industry. Israel's software industry, much like silicon valley, is built on the growth of indigenous firms with sophisticated technology products. By looking at software industries with such very different reasons for success, we can better understand if there are any fundamental variables that are key to the growth of a software industry in general. The second reason for choosing those three countries is that, despite their success, they seem to be relatively similar to Hong Kong along several dimensions. Namely, they all have small domestic markets for software, problems with intellectual property protection, and relatively nascent commercial high-tech industries. The US was chosen as a comparison economy because of the rich amount of data on how various high-tech industries developed, the challenges those industries faced, and how they overcame those challenges.

By taking the data from the MBHK study on Hong Kong's software industry and placing it in the context of these four comparison economies across each of the 5 key variables, the goal is to understand the role of these variables in the growth of Hong Kong's software industry. The next five chapters consider each variable in turn as it pertains to Hong Kong and the comparison economies. The conclusion to this thesis draws together the conclusions of the previous five chapters. The results have important implications for industrialists and policy makers in Hong Kong who are concerned with the development of a vibrant domestic software industry.

APPENDIX A

SOFTWARE INDUSTRY INTERVIEWS

person A is a senior official in Hong Kong's Customs & Excise Department, Intellectual Property Investigation Branch.

person B is a senior official in Hong Kong's Intellectual Property Department.

person C is a senior member of the Software Industry Information Center

person D is the managing director of a successful Hong Kong software firm which serves the textile industry

person E is a software consultant with a Hong Kong software firm.

person F is the founder of a Hong Kong software firm.

person G is a manager in the information technology department of a Hong Kong bank.

person H is the founder of a Hong Kong software company specializing in the graphics.

person I has served on information technology policy making bodies of the Hong Kong government and is the managing director of a Hong Kong non-government organization.

person J is the founder and managing director of a Hong Kong software firm focusing on the retail industry.

person K is the president and CEO of a Hong Kong software firm producing software for the retail industry and a member of one of Hong Kong's IT policy making committees.

person L is the president and CEO of a Hong Kong software firm focusing on the financial service industry. His firm not only serves the Hong Kong community, but it also exports software throughout Asia.

person M is the managing director of a relatively large Hong Kong software firm which serves the manufacturing industry. This firm has received various awards for producing exceptional software.

person N is the general manager of a Hong Kong software firm which develops software for the construction and architectural design industry.

person O is the managing director of a relatively large Hong Kong software company serving the financial service community. Person 0 also serves in a variety of positions in Hong Kong's IT trade associations.

person P is the managing director of young Hong Kong software firm still in the product development stage.

person Q is the founder and president of a Hong Kong software firm making sophisticated financial analysis software.

person R is a member of a non-profit organization serving the indigenous Hong Kong software industry.

person S is a senior member of Hong Kong's civil service who is involved in executing government policy with respect to the information technology industry.

EDUCATION SECTOR INTERVIEWS

person 1 was a professor of computer science for two years at Hong Kong University and is now a lecturer in computer science at MIT.

person 2 is a professor in the computing department at Polytechnic University

person 3 is a senior faculty member of Polytechnic University's computing department

person 4 is a senior faculty member of Hong Kong University's computer science department

person 5 is a faculty member of Hong Kong University's computer science department.

person 6 is a faculty member of Chinese University's computer science department.

person 7 is a university chancellor

person 8 is a senior employee at Polytechnic University's industrial training center.

person 9 is a senior faculty member in the department of electrical engineering at the Hong Kong University of Science and Technology (HKUST)

person 10 is a career office counselor at HKUST

person 11is a career counselor at Polytechnic University

person 12 is a IT engineering career officer with City University

person 13 is a professor at the University of Hong Kong and a senior officer with their industrial training program

person 14 is a senior career officer with Baptist University

2. INTELLECTUAL PROPERTY PROTECTION

2.1 INTRODUCTION

Given the intangible nature of software and the ease with which it can be copied, adequate intellectual property protection (IPP) plays an important role in allowing software developers to reap the financial returns of their creative work. However, given the ease with which many types of software can be copied and the difficulty of detecting when copies are made, piracy has had a large impact on the software industry overall. According to the 1995 results of the first global survey on software piracy in 1995, an estimated $13.1 billion dollars were lost world-wide due to piracy[iv]. Piracy percentage rates ranged from the high twenties in the US and Canada to the high eighties and even high nineties in Eastern Europe and some parts of Asia. The extent of the problem can be seen when countries which have piracy rates in the high thirties and low forties, like Germany (42%), UK (38%), and Australia (35%), are considered to have "low" rates of piracy[v].

In Hong Kong specifically, the rate of piracy is of concern to many. For the first time ever, in 1997, Hong Kong was moved onto the US Trade Representative's (USTR's) "Watch List" in the USTR's annual Special 301 Review[vi]. This review details the US view of foreign shortcomings in IPP and rates countries as "priority foreign country," "priority watch list," or "watch list" according to the level of piracy ("priority foreign country" represents the most

egregious level of piracy). The 1997 Special 301 Review found that piracy actually got worse in Hong Kong over the preceding year despite government efforts to combat the problem. The USTR is not alone in its concern over the level of piracy in Hong Kong. The Washington based International Intellectual Property Alliance (IIPA) recommended that, in December 1996, the USTR move Hong Kong to the "priority watch list."[vii] Further more, a 1994-95 study on the Hong Kong software industry, conducted by the international market research firm Dataquest, commented that piracy is "the most important market factor that must be addressed for Hong Kong to realize success in the packaged software market." One of this study's three main recommendations was that "the government should step up enforcement of IPP laws, especially against those creating and selling illegal copies of consumer software.[viii]"

While piracy seems to be significant in Hong Kong as well as on a world-wide basis, the goal of this section is understand how large an impact Hong Kong's domestic IPP situation has had on the growth of its indigenous software industry. This issue will be examined in three main parts. First, I will consider why people pirate software and what kind of software people pirate in general. Second, I will look at the extent to which piracy exists in Hong Kong, paying particular attention to which segments of the software industry in Hong Kong are affected the most. Third, I will try to understand some of the causes of piracy in Hong Kong and how effective the government has been in dealing with those causes. Finally, I will examine what this evidence suggests regarding whether or not IPP is a key barrier inhibiting the growth of the software industry.

2.2 WHY DO PEOPLE PIRATE SOFTWARE AND WHAT TYPES OF SOFTWARE DO THEY PIRATE?

The research on why people pirate software and the types of software they pirate is rather limited, but what exists provides some interesting insights into what part of the software industry may be most vulnerable to piracy. Cheng (1997) conducted a study to identify people's reasons for purchasing versus pirating a given piece of software[ix]. Interestingly, according to Cheng, people don't decide to purchase software because it is the law or because of company or school policy. The main reason why someone will purchase a piece of software is because it is required for their work and because it is something that they believe they will use very frequently. Cheng also looks at the reasons for pirating software. It is widely believed that people pirate software is because it is easy to do so. However, the main reasons Cheng's research participants cited for pirating software was because the software is either too expensive and/or they want to try the software out. The fact that software is easy to copy and that there is little chance of being caught are ranked as relatively unimportant reasons. The table below summerizes Cheng's findings.

Reasons to purchase software	Reasons to pirate software
#1 reason: Required for school or work	#1 reason: Software is too expensive
#2: Use the software all the time	#2: Want to try out the software
#3: Availability of a manual	#3: Can't afford the software
#4: It's the law	#4: Only use it for a short period of time
#6: It's school/company policy	#5: Easy to copy
#8: No viruses on original software	#7: Little chance of being caught

Table 2: Reasons to purchase versus pirate software[ix]

An interesting conclusion from Cheng's research is that computer games make a prime target for piracy. Computer games don't meet the top reasons to purchase (i.e. "required for work or school" and "use all the time"), and they do meet a top reason to pirate (i.e. "want to try out the software"). This is because it is often hard to know how entertaining a game will be before it is purchased and, even if it is entertaining initially, the intensity of computer game usage is typically short compared to productivity software. Cheng also notes that the strong perception that software is overpriced could be further enhanced by the low cost of pirating software. Finally, Cheng's data shows that people are not concerned with breaking the law or company policy when it comes to copying software. Many studies have similarly showed that there are very low moral costs associated with software piracy. A study by Logsdon, Thompson, and Reid further confirmed that software piracy is perceived as an issue of low moral intensity, and suggests that the software industry should focus on moral intensity at the individual level instead of focusing exclusively on institutional compliance.[x] Solomon (1991) showed that business students view piracy as socially and morally acceptable[xi]. Even more relevant to Hong Kong, Swinyard (1990) found that Asians have a more casual attitude toward piracy than Americans because of Asian attitudes which are rooted in cultural mores that emphasize sharing creative work[xii].

In light of these findings, how industry can best control piracy? One method suggested by the data above is that piracy would be better controlled if people associate a stronger moral cost with pirating. Gopal (1997) tries to understand the impact on deterrence activities (such as increasing the moral cost of pirating) versus preventative measures (i.e. measures which prevent people from buying pirated software or which prevent them from copying original software themselves)[xiii]. As long as individuals perceive certainty and severity of punishment, deterrence theory suggests that individuals will be inhibited from doing illegal acts. Gopal's results show that, while both deterrence and prevention decrease piracy, deterrence methods have a positive impact on software producer profits while preventative measures have a negative impact. Beyond the results shown by Gopal's quantitative model, anecdotal evidence is presented to further support his claim. Around 1985, a number of US software companies started removing copy protection devices from their software and began active educational and legislative campaigns. Furthermore, the effectiveness of deterrence, especially when focused on raising the "moral cost" of an action, has been cited in several studies. Schwartz found, for example, that appeals to the conscience were more effective in getting people to comply with tax laws than legal sanctions[xiv]. Paternoster studied juvenile delinquents and found that moral considerations significantly impacted their criminal behavior[xv].

2.3 EXTENT OF PIRACY IN HONG KONG

While the level of piracy in HK is not as high as in many other locations, it has recently been increasing instead of decreasing. The increase from 1996 to 1997 is what prompted the USTR to put Hong Kong on its "watch list" for the first time in Hong Kong's history. The average piracy rate in Hong Kong in 1995 was 62%, which resulted in software losses of US$123 million. The piracy rate was actually unchanged from 1994, but 62% in 1994 only equated to $64 million[v]. Much of the pirated software in Hong Kong seems to be productivity and entertainment packaged software for the PC. Recently, pirated software has been selling on CD ROMs which are traditionally produced in China and shipped to Hong Kong. CD ROMs allow pirates to offer a much greater amount of software on each disk than is possible with high-density floppy disks. The information on 400-500 high-density floppy disks could fit onto one CD ROM. This allows the pirates to produce "compilation" CD ROMs which have dozens of software titles from multiple vendors. These CD ROMs might contain $10,000 worth of software and sell for about $10.

CD ROM pirates are surprisingly effective at delivering the most recent software titles to the Hong Kong market. In 1995, many were shocked when pirated versions of Windows '95 were on sale only weeks after its official launch. However, pirates have become much more sophisticated and have cut down the delay between the official launch of a product and the "launch" of the pirated version. Electronic Arts released Fifa '97 (a soccer video game) and, within three days of its US launch, a pirated version was on sale in Hong Kong. A pirated version of Microsoft's Encarta '97 (an electronic encyclopaedia) was actually available for sale in Hong Kong before its official release[xvi].

In Hong Kong, the greatest rate of software piracy occurs in the video games segment. It is estimated that more than 90% of video game software sold in Hong Kong is illegally

copied. To get a sense of the retail distribution capabilities of the pirates, one raid involved 43 retailers at 7 separate shopping arcades throughout Hong Kong[xvii]. The retail sellers of pirated software have public store fronts and keep regular business hours. The reach of the pirates in Hong Kong is hard to fathom. One game developer handed out evaluation copies of a new game to only five of his most trusted distributors but, within a few days, a pirated version of the game still turned up in the Hong Kong shopping arcades[xviii]. The total losses for the video game sector were estimated to be at $90 million for 1996 alone[xvi]. This evidence is consistent with the research presented in Section 2, which suggested that video games are an especially vulnerable segment given that the intensity of their use is typically very short, and that it is typically the type of software that people like to "try out."

Consumer software like video games is not the only segment to see pressure from pirates. Pirated packaged software for corporate customers is also widely available in Hong Kong. For instance, the latest versions of Autodesk's AutoCAD Release 13 (retail price US$4,250), Novell's NetWare 4.1 (retail price $2,845) and Lotus's Smartsuite were packaged with over 100 other programs owned by different companies and sold openly in Hong Kong in October 1995 for Hong Kong$50 (US$6.50). Hong Kong corporations seem to be taking advantage of this type of software. In February 1997, Roman Financial Press, Hong Kong's biggest publishing group, paid the Business Software Alliance (BSA), a whistle blowing agency, about $50,000 for using unauthorised Microsoft and Adobe software. Furthermore, the BSA has received tip-offs from employees in Hong Kong that have allowed it to put over 60 companies under investigation.[xviii]

What the data above suggests is that piracy in Hong Kong is particularly concentrated in the segment of packaged software for the mass market. In terms of productivity software, piracy has its greatest impact on US firms, while the extensive piracy in the video game

segment effects Japanese, US, and Taiwanese firms. Given the high level of piracy in Hong Kong, the next question we ask is why is it so seemingly unchecked?

2.4 CONTROL OF SOFTWARE PIRACY IN HONG KONG

Two key influences on the rate of software piracy are the IPP laws and the degree to which those laws are enforced. According to Kiichi Nishikura, general counsel for Sega, one of the largest video games manufacturers in the world, Hong Kong has some of the toughest IP laws in the region[xvii]. Hong Kong's copyright ordinances have become even more stringent in recent years. The following excerpt from the ordinances shows the current fines and the fines in place only a few years earlier in parenthesis:

> *"Anybody possessing infringing copy for business or trade is liable for HK$25000 (HK$1000) per copy and imprisonment for two (one) years. Max penalty for possessing equipment for making infringing copies is fine of HK$250,000 (HK$50,000) and imprisonment for four (two) years."*[xix]

Given that the laws seem to provide at least reasonable protection, what can be said of the enforcement of these laws? The department responsible for enforcing the copyright laws is the Intellectual Property Investigation Bureau (IPIB) of the Customs and Excise Department. This type of specialized enforcement task-force for tackling copyright and trademark violations is unique among Asian economies. Over the three year period from 1995-1997, the IPIB increased its manpower by 40%, one of the fastest growing branches of the Hong Kong civil service[xx]. The increase in effectiveness of this department from 1994-1996 is shown in the table below.

	1994	1995	1996 (through mid Nov)
Cases	1,380	1,566	1,061
Arrests	1,112	1,447	1,061
CD-ROMs seized	5,406	256,138	258,487

Table 3: Enforcement of software IP by the HKIPIB[xxi]

Consistent with the data on the video game sector mentioned previously, confiscation data shows that 50% of the pirated CD-ROMs were video games.

How then can the tough laws and seemingly competent enforcement be reconciled with the fact that Hong Kong was moved on to the USTR's Special 301 watch list? Many in Hong Kong's government say this is because the actual CD's are made in China and that Hong Kong enforcement has no jurisdiction there. When, in December 1994, Dataquest recommended to the Hong Kong government that it should step up the enforcement of IPP laws, the government disagreed. According to the IT committee of the Hong Kong ITDC:

> *"The Committee considers that legal protection of IP in Hong Kong is adequate and notes that penalties for piracy have recently been substantially increased and enforcement actions have also been stepped up. . .on the other hand, the Committee observes that piracy in China is also rampant and Hong Kong can do little in this respect. . .The Committee therefore recommends that the government should relay this message to the Chinese authority through the appropriate channels."*[xxii]

In late 1996, when government officials were asked why it was so difficult to control piracy in Hong Kong, they responded that it is "a question of resources, working to the letter of the law, and the fact that the actual CDs are not made in Hong Kong but in China." According to officials, in the 1970's there was a huge problem with counterfeit music tapes, but that was eliminated because the manufacturing plants were in Hong Kong.[xvi] Person A, a senior officer at the IPIB, agrees that fighting piracy in Hong Kong means shutting down CD ROM manufacturing plants in China. According to person A, "the problem must be tackled at the

source. Until we can do something about the source, we won't be able to tackle the problem. So, we're cooperating with China" .However, despite the conviction by many that China is the main problem for piracy in Hong Kong, more recent data says otherwise. In a December 1997 news article, data shows that pressure on counterfeiters in China has caused them to move across the boarder into Hong Kong and Macao. Two years ago, there were no counterfeit software production lines in Macao and only 7 in Hong Kong. As of December 1997, there were 100 in Macao and 40 in Hong Kong. During that same period of time when production of counterfeit CD ROMs moved into Hong Kong, Hong Kong's piracy rate got worse. Apparently, because Beijing banned imports of machines that make CDs, much of the equipment was stranded in Hong Kong and Macao so the counterfeiters decided to build their base there.

To better understand the challenges of dealing with piracy in Hong Kong, consider the two basic ingredients identified in Section 2—prevention and deterrence. In terms of prevention, it is clear that while the IPIB is aggressively growing to deal with software piracy, it is still overwhelmed. Even though the IPIB increased its manpower by 60% between 1996 and 1997, the piracy rate in Hong Kong also rose[xviii]. Person A of IPIB puts the difficulty of preventing piracy in Hong Kong into perspective. Before working as part of the IPIB, says person A, he "worked to stop the drug trafficking going on between Hong Kong and China. Once [he] was successful there, the government decided to give him a tougher assignment—trying to stop piracy in HK." The extent of piracy in Hong Kong beyond just software lends support to person A's statement. Despite the significant seizures of CD ROMs in 1995, these only represented 43% of the total CDs and LDs (Laser Discs) confiscated in 1995. The remainder consisted of counterfeit music and movies. In addition to technology products, the IPIB also has to deal with counterfeit perfumes and clothing. Deterrence will be effective as long as individuals perceive certainty and severity of punishment. In terms of piracy, we can

look at the issue of deterrence on the supply side and on the demand side. On the supply side, the challenge in Hong Kong is that, while the laws are tough, there is no perception of certainty or severity of punishment. For example, while the maximum fine is US$3,205 per item, the average fine handed down was US$5.13 per item in 1996[xx]. This fine per item is less than the street price of the counterfeited CD ROM, which typically sells for US$8 to $10, and far less than the retail price of the software that may be on the CD ROM. Furthermore, while the maximum jail time can range between two and four years, the average sentence handed down is two months. This is compared with counterfeiter sentences in China which average 7 years[xviii]. For counterfeiters in Hong Kong, while the laws might be tough, the actual punishments handed down are more of a cost of doing business than a deterrence. On the demand side, there simply is no law in Hong Kong that prevents an individual from using pirated software. Furthermore, software companies see it as bad public relations to go after individual users.

The other aspect of deterrence is to raise the moral cost of "antisocial" actions—like pirating software. Having myself lived in Hong Kong for four months, I was able to observe a significant number of government-sponsored commercials that talked about how it was wrong to pollute, play on escalators, and throw trash out of windows, as well as several other activities. The government seemed keen on using these TV ads to raise the moral costs of a number of behaviors it considered "antisocial." However, not once did I see a government sponsored commercial on the damaging effects of consumer purchases of pirated software on the growth of the local software industry or the growth of the economy as a whole. The best explanation for why there was no TV campaign came best from person B, a senior official in the Hong Kong Intellectual Property Department, the department responsible for writing Hong Kong's IPP laws. According to person B:

> *"I tried to start a campaign earlier, but the government refused to give me the money. The problem comes with trying to get money for new staff. The government will pay for the cost of capital items, but they won't pay for labor. They'll buy me air time on the TV station, but they won't pay for me to get staff to produce the commercials. That's why you see all these terribly produced public service ads on TV. They want me to use the staff I already have to do the anti-piracy campaign, but my staff have to focus their attention on rewriting the IP laws before the handover."*

At the time of the interview with person B in late 1996, he was planning a campaign to generate better awareness, where the "goal of the campaign would be to get businesses to use legitimate software." However, it was not clear whether or not this would target the broader Hong Kong population.

Thus, from a prevention and deterrence perspective, we can see why Hong Kong is having difficulty combating piracy. The IPIB is being overwhelmed and there is very little to deter pirates or individuals from dealing in pirated software. This is not to say that Hong Kong is not devoting significant resources to combating the problem. The IPIB has been expanding its manpower significantly each year, and the Hong Kong Intellectual Property Department was spending a great deal of time rewriting Hong Kong's IPP laws before the handover. But the question of whether or not Hong Kong will be able to take control and significantly reduce software piracy in the near future remains unresolved.

2.5 CONCLUSION

In Hong Kong, controlling piracy in many areas, not just software, is a significant challenge for the current government. The IPIB cannot grow fast enough to keep up with the demand for its services, and the punishments handed down by the Hong Kong courts seems to have little deterrence effect. But the question remains: To what extent is the piracy and the government's inability to control it affecting the growth of the indigenous software industry?

The preceding evidence suggests that the piracy in Hong Kong is not in fact a key barrier to the growth of the industry. First, as we saw from the confiscation data, 50% of confiscated CD ROMS are video games. Thus a significant percentage of the software piracy is concentrated in one very narrowly focused segment of software—video games. A majority of the remaining 50% of pirated software seems to be productivity-type software packages produced for relatively horizontal markets. This makes sense because this type of software is the easiest to sell via retail—the preferred method of distribution for pirates in Hong Kong. The market for this type of productivity software tends to be dominated by companies in the US. Even if the piracy rate in Hong Kong were zero, the odds of a Hong Kong firm being able to compete in these horizontal packaged software markets with already established players is probably not great. Second, when we look at our comparison economies—India, Ireland, and Israel, they all have rapidly growing software industries despite high levels of domestic piracy. For example, India had a piracy rate of 78% in 1995, 16% greater than Hong Kong. In February 1998 the Software Publishers Association (SPA) asked the US Trade Representative (USTR) to specifically identify 24 countries as the world's worst software piracy havens in its annual review of unfair trade practices. In that report, Israel, Ireland and India were all identified, along with Hong Kong, as among the world's worst havens for software piracy[xxiii]. Thus, while piracy in Hong Kong is significant, there is no evidence to suggest that this piracy is impacts the vertical markets where young Hong Kong software firms can be globally

competitive, or that other indigenous software industries have failed to develop because of high levels of domestic piracy.

3. ROLE OF DOMESTIC DEMAND

3.1 INTRODUCTION

This chapter seeks to understand the importance of domestic demand, both in terms of size and sophistication, for the growth of Hong Kong's software industry. For many in Hong Kong, including leaders in the local software industry, professional trade organizations, and even outside consultants to the government, the small domestic market for software products and services is a major problem. They argue that Hong Kong's domestic market, with 6 million people and $200 million in demand for software products and services is not large enough to support the development of an indigenous software industry[1]. Leading academic researchers concur that a strong domestic market helps to build internationally competitive firms, while those firms developing in a weak domestic market have little chance of surviving international competition. However, when Hong Kong's situation is compared with other successful software economies like India, Ireland, and Israel, the case is less clear. These three economies all have very little domestic demand for software, yet all have successful software industries.

[1] Hong Kong's domestic market size for software was estimated in the 1994-95 Consultancy Study on the Software Industry.

By reconciling the theory on the importance of domestic market size with what we see in practice, we can gain insight into the degree to which Hong Kong's domestic market is affecting the growth of the indigenous software industry. This chapter is divided into five main sections. Section 2 starts with an overview of the theory regarding how the domestic market effects the international competitiveness of indigenous firms. Section 3 then focuses on describing Hong Kong's domestic market for software products and services in order to understand where potential competitive advantages and challenges may lie. Section 4 examines the software industries of India, Ireland, and Israel in order to understand how their domestic markets have impacted the growth of their software industries. The conclusions of this analyses are presented in Section 5.

3.2 OVERVIEW OF THEORY

Various authors focus on different aspects of how domestic demand drives a given domestic industry and the competitiveness of that industry in the international market. Motta et al (1997) investigates whether a country supplying low quality products can catch up with a rival country supplying high-quality products when both have access to the same technology[xxiv]. They find that, when countries open their economies to trade, firms' products start from an initial level of quality which depends on local characteristics of demand. The larger and more sophisticated the domestic demand, the higher the quality of the product produced at the time trade begins. Thus, when firms coming from a larger and more sophisticated domestic market begin to trade with those coming from a smaller and less sophisticated domestic market, those firms coming from the larger more sophisticated market will have the advantage. Using a simplified analytical framework, Paul Krugman also finds that, when two countries trade, the one with the larger domestic market for a given product will be the one who exports this product[xxv]. Michael Porter gives a more fine grained analysis of the role played by domestic demand[xxvi]. According to Porter, there are three components to demand which are significant in creating a national competitive advantage. The first is the segment structure of demand. While the absolute size of a market can help the competitiveness of firms, what is more important is the size of a particular segment relative to other segments in that nation. This is because the segments in a nation which are relatively larger will receive earlier and more attention by the nation's firms. The implication is that, in segments which are relatively important to a small nation, that small nation can be globally competitive even if the absolute size of that segment is smaller than similar segments in competing nations. The second important aspect of domestic demand, according to Porter, is having sophisticated and demanding buyers. These types of consumers put constant pressure on a firm to produce ever better products. The fact that these sophisticated consumer are close

physically and culturally to the firm means that it is easier for the firm to uncover new needs. The final component of domestic demand that is significant is if the domestic market is "anticipatory" of buyer needs elsewhere in the world. If customers in the domestic market have needs that anticipate those of other nations, then this will give the indigenous firm an advantage in producing the global product before their competitors do. What is important to note in Porter's analysis is that domestic market size alone is not a source of competitive advantage for firms. According to Porter, "provided that its composition is sophisticated and anticipates international and not just domestic needs, the size and pattern of growth of home demand can reinforce national advantage in an industry." These more subtle aspects of domestic demand will be important in helping us understand how the home market of Hong Kong and our comparison economies are impacting their respective software industries.

3.3 THE HONG KONG DOMESTIC MARKET FOR SOFTWARE PRODUCTS AND SERVICES

Hong Kong's domestic market for software products and services in 1993 was roughly US$200 million. This is almost evenly split between products and services. However, almost 70% of software products purchased in Hong Kong were imported. While Hong Kong has a small market in terms of absolute size, among other Asia Pacific countries, IT spending per capita is second only to Japan. Hong Kong also has some of the highest growth rates for software and software services among the "developed" countries in the region. Hong Kong's vanguard industries: financial services, telecommunications and utilities, and retail & wholesale tend to spend more on IT than Hong Kong's other industries. For example, businesses in the telecommunications and utilities sector had some of the highest concentrations of PCs in Hong Kong. Almost 80% of companies in that sector had 50 or more PCs[xxvii].

One of Hong Kong's strongest markets in terms of size is manufacturing. Hong Kong is #2 in the world in clothing (behind Italy), #1 in the world in knitwear, #3 in toys (behind Korea and Taiwan), and #2 in watches (behind Switzerland)[xxviii]. However, Hong Kong's manufacturing sector as a whole was ranked 7th among 14 sectors in Hong Kong in terms the number of PCs owned by businesses[xxvii]. However, the relatively weak presence of computers in the overall manufacturing sector is consistent with the strategy of the manufacturing sector to move to low cost China. As V-nee Yeh, a venture capitalist in Hong Kong, described it, "sectors like manufacturing can afford to be behind in technology because they can make up for it with lower costs."

In segments other than manufacturing that are important to the Hong Kong economy, sophistication in using IT was also found to be weak. Small companies comprise a significant percentage of Hong Kong businesses. However, one study found that 62% of small businesses

in Hong Kong didn't even have a computer in 1994[xxvii]. During our research, we also found it odd that, while Hong Kong has the 3rd largest film production base in the world (behind the US and India), we couldn't find any software firms that targeted that vertical market.

Compared with the rest of East Asia, Hong Kong's consumer computer market seems to be fairly sophisticated. Approximately 15.4% of the population owns a PC. This is the second highest in East Asia, just behind Singapore at 21.9% and just ahead of South Korea at 11.1%. In terms of the Internet, Hong Kong has the highest percentage of the population among East Asian countries using it. Hong Kong's Internet access rate is currently 10.48% of the population compared with Singapore at 8.82% and Taiwan at 4.62%[xxix]. In terms of people, this would mean that Hong Kong has about 900,000 people who own a computer and about 600,000 people who are connected to the Internet.

Mainland China is a potential extension of Hong Kong's domestic market, but consumers there are only just beginning to purchase computers and connect to the Internet. China has about .4% of the population using computers, and only .03% connected to the Internet. This translates to about 5 million people who own computers and 400,000 people who are connected to the Internet. While the Hong Kong and China consumer markets may not seem particularly small, an important factor that has to be taken into account is the amount of piracy in Hong Kong and China. According to the US Trade Representative's Special 301 Report (the report which addresses "unfair trade practices"), piracy in Hong Kong is over 60% and piracy in China is over 90%. While most of the piracy in China is focused on packaged software for horizontal products, demand for IT by China's vertical markets is extremely limited at this point in time[2]. While the issue of piracy is addressed in more detail in

[2] Comments made by HK software companies already in China cite their biggest difficult in selling to the Chinese market as the lack of an understanding of IT.

the section on intellectual property protection, one has to be careful evaluating domestic market size given such high rates of piracy.

Porter has described how strong demand segments in the domestic market can create advantages for firms selling in those segments. Our research found several examples of very successful software companies in Hong Kong which seem to affirm the value of a strong domestic market. One example is Prima Designs. Prima produces CAD/CAM packaged software for the textiles industry. The company is number one in Hong Kong and in the top 3 in the global market. Mr. James Tam, Managing Director of Prima, describes the importance of learning from sophisticated customers in the domestic market. According to Mr. Tam:

> *"our first client was like a partner. We were almost like an in-house developer. . .They were a textile manufacturer who told us what needed to be improved with current CAD/CAM textile software. So he told us what needed to be done, and in exchange we gave him a free system. This partner then introduced us to other companies in the textile industry in Hong Kong."*

Not only did the sophistication and size of the Hong Kong textile market help them develop a competitive product and generate substantial revenue, contacts in the Hong Kong market helped Prima to expand internationally. According to Mr. Tam, Prima first expanded abroad because they "knew a Finish designer in Hong Kong who introduced us to companies in Finland."

TA Consultants, a company focusing on software application development tools for the financial service industry is another example of how a vanguard domestic industry in Hong Kong helped to create an internationally competitive software firm. Mr. Mowling Tung, CEO of TA Consultants, describes how the strong domestic market shaped his company's success:

"We started in Hong Kong in 1976 producing software for 32 different industries. When we decided to focus on banking in 1983, Citicorp was our first banking software client. Citicorp invests the most in technology of any bank. We were part of Citicorp's Asia Technology Group. Citibank is one of the most advanced and respected banks in terms of their use of technology. With their reference, we went to other foreign banks in Hong Kong. By going to other international banks in Hong Kong, we were able to spread to their branches located elsewhere. For example, our expertise developed with Citibank led us to Chase Manhattan and then Hong Kong Bank. We got our exposure with US and European banks (located in Hong Kong) first, then we moved on to the Asian banks. In Singapore, our software is in 3 out of the 4 major banks, and in China we are in 4 out of the 5 banks. We've also developed for banks in Thailand, Malaysia, and Indonesia. In Hong Kong, 15 different banks use our software. Similarly, 15 banks in Taiwan use our software. Today, we have 56 clients internationally, and we develop world wide solutions for over 60 countries."

From Mr. Tung's story, it is clear that the sophistication, and not just size, of the domestic market was an important factor in allowing his firm to expand internationally.

However, despite the progress made by Hong Kong software companies serving Hong Kong's vanguard industries, many in Hong Kong are concerned that the small domestic market size and lack of sophistication in many other sectors will hold back the overall growth of the software industry. The Hong Kong Computer Society (Hong KongCS), the most influential IT professional association in Hong Kong, feels that the small domestic market in Hong Kong is hurting the growth of the local software industry and wants the government to take action. According to the Hong KongCS, "The local software market is lacking the breadth and size needed to sustain and to grow its software industry. Unless this confining factor is removed, it will be very difficult for the Hong Kong software industry to grow healthily."[xxx] In order to address this issue, the Hong KongCS observes that "it has been proven in many nations that public expenditures can be used very effectively in fostering the growth of a needed new industry. . .we believe this could begin [in Hong Kong] with the preferential use, in Government, of IT products and services provided by local firms."[xxxi] The concept of getting the government to purchase more domestic software was brought up by

others too. Mr. Fritz Chiu, Director of the Software Industry Information Center (SIIC), noted that one of the major concerns conveyed to him by many Hong Kong software companies is the question of how to get the government to buy more Hong Kong made software[3]. According to Mr. Chiu:

> *"Small software developers cannot get government tenders because those tenders are usually given only to the big players. Local companies have the technical ability to do the contracts but they lack the size required by the government. The government needs to give some type of preference to local companies. Government contracts are very important to give local companies experience so they can grow. Industry doesn't want loans, they want experience. The way things are structured, the government doesn't have projects for the small guys now, but industry hopes this can change."*

As can be seen by the comments above, the concerns caused by Hong Kong's small domestic market is prompting many to want the government to become a more important customer to Hong Kong's domestic software industry.

[3] The SIIC was set up because of the recommendations of "1994-95 Consultancy Study on the HK Software Industry." It's goal is to assist local software companies acquire market information.

3.4 THE ROLE OF DOMESTIC DEMAND IN DRIVING THE SOFTWARE ECONOMIES OF INDIA, ISRAEL, AND IRELAND.

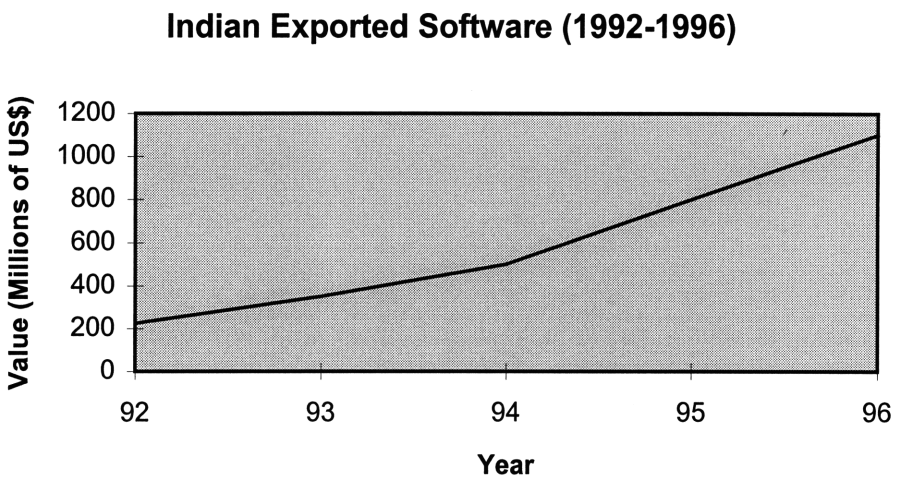
3.4.1 OVERVIEW

In order to provide broader context for how the domestic market affects the growth of a software industry, I looked at three other economies that have burgeoning software industries but that also have relatively small domestic markets. By understanding the domestic market of the different comparison economies and the type of software industries that are developing, we can see both how universal the theories on the importance of the domestic market are, as well as the extent to which the concerns of those in Hong Kong are valid.

3.4.2 INDIA

In 1996, India's domestic market for software products and services was US$470 million[xxxii]. With a population which is 150 times larger than Hong Kong, India's domestic software market size was only twice as big. This is because India has one of the lowest concentrations of IT in the world. There are only 7 computers for every 10,000 Indians compared to the world average of 250 computers per 10,000. The concentration of telephones is not much better with only 70 for every 10,000 Indians[xxxiii].

While the Indian domestic market for software is quite small, total sales of Indian software and services are much larger and have been growing much faster than the domestic market might suggest. The chart below summarizes the growth in exports of Indian software from 1992 to 1996.



Source: Data compiled from Correa, Carlos M., "Strategies for Software Exports from Developing Countries," World Development, Vol 24, No. 1, pp171-182, 1996.

Figure 1: Growth in exports of Indian software

Thus, while the domestic market for software in India was about $470 million in 1996, the total market for Indian software was nearly four times bigger at $1.6 billion. Furthermore, the structure of the domestic market is significantly different than the structure of the export market. In 1996, 75% of the exported software was in the form of professional services[4]. Only 10% of exports are products and packaged services. This is radically different from the domestic market in which about 40% comes from products and packages and 45% comes from turnkey solutions. Less than 10% of the domestic market is for professional services[xxxiv]. Thus, it is clear that India's strength in exporting professional services came from something other than experience derived from the domestic market.

Software developers in India are providing much more sophisticated consulting for their export markets than would have ever been required for their domestic market. For example, one successful Indian software exporter named Infosys Technologies has as its clients Nordstrom, Xerox, Visa, GE, Reebok, and AT&T. Infosys dedicates a full time team of

[4] Professional services typically involve developing customized software for a particular client. In this type of arrangement, there is relatively little need for marketing and essentially no need to invest in R&D.

software professionals to each of its clients. In many cases, the team acts as a virtual extension of the company's own in-house IT staff. The Tata Group, one of India's largest conglomerates, entered the software business with the help of companies like Unisys. As far back as 1990, Tata had 650 professionals experienced on Unisys, IBM, DEC, and HP hardware environments who were exporting software to clients in 47 different countries[xxxv].

While domestic Indian software firms focusing on consultancy services have played an extremely important part in helping the software industry to develop, foreign firms are now starting to play an increasingly important role. Companies like Oracle, Motorola, GE, and IBM have all opened development centers in India. These centers were not opened to make software for the local market, but instead were opened to develop software specifically for export. For example, Oracle's development site in India will develop a large part of the operating system that will be going into its Network Computer. Motorola's site in India develops software that helps it to simulate and test new microprocessors. With little connection to the demand of the domestic market, sizeable foreign investments are being placed in India's software industry.

Given India's domestic market and given the type of software being produced in India, what can we say about how that domestic market affected the growth of the industry? The table below compares Porter's model of domestic demand to India's situation.

Factor	Situation in India
Strong demand segment relative to other sectors.	No. Indian software producers are developing custom "mission critical" software for foreign companies. There is no evidence that shows that, relative to other sectors, that local demand for mission critical business software was significant.
Sophisticated end user	No. The software being developed for export needs to be much more sophisticated than what local companies would use.
Anticipatory buyer needs	No. As a customer, the US and other foreign countries represent lead users much more than India's domestic market.

Table 4: Is domestic demand in India important?

What we see is that the types of software coming from India, both from the local firms and from Indian sites of MNCs, have really not been driven in any way by local demand. While there are a number of ways to explain this, what it does tell us is that the importance of the domestic market might not be as great as people in Hong Kong may believe.

3.4.3 ISRAEL

Israel is a country that is only about 50 years old and has about 5 million people. Despite this, its indigenous IT industry had 1997 sales of roughly $7 billion dollars. About $2 billion in sales goes to the domestic market while the rest gets exported[xxxvi]. How did this strength in technology develop? Link Magazine, The Middle East International Business Magazine, gives a concise explanation:

> **Military Origins:** Israeli expertise in microelectronics and software evolved directly from the country's defense needs. The first impetus came after the 1967 Six Day War when France, which had been Israel's principal supplier of sophisticated weaponry, joined an arms embargo against Israel.
>
> The first need was to supply spare parts. For example, Blades Technology, a company jointly owned by industrialist Stef Wertheimer with American's United Technologies, was formed to make replacement fan blades for the jet engines of Israel's French-made Mirage fighters. This led to the world market for blades for military jet engines, and hence to civilian jets. At the same time, Elbit, a name that is a Hebrew acronym for electronics and security, was founded by Uzia Galil as the first non-state-owned electronics company in Israel.
>
> **Imaging skills:** The second major wave of military development came after the 1973 Yom Kippur War when Israeli troops were surprised by the capabilities of Egyptian troops using off-the-shelf night vision equipment that the Israelis lacked.
>
> Image processing, starting with thermal imaging, became a high priority, and

the Technion, Israel's premier technology university, started to churn out graduates who went on to develop cheap and effective electronic defense systems. In the late '70s this specialization in imaging led to the first two civilian companies who made a name for themselves in the world . These were Scitex in digitized pre-press systems and Elscint in computerized tomography.

These were also the trailblazers in another trend that was to mark Israeli technology companies. They went public on Wall Street, a radical move that increased their capital base and turned management attention to first a US then a global scale of operations.

The fighter that didn't: During the early 1980s there were only a handful of companies in what could loosely be called civilian high-tech. Defense was still a high priority and a good market with customers all over the world. The cutting edge of skills were engaged in the attempt to build an all-Israeli combat jet, the Lavi.

Economically, it was foolhardy for such a small country to try developing its own combat aircraft, but the Lavi's avionics systems demanded skills in software, imaging and communications on an unprecedented scale. A few cynics claim that the best thing that ever happened to Israeli technology industries was the cancellation of the Lavi program in the mid eighties because thousands of professionals were fired, releasing large numbers of talented engineers into the market with the clear notion that they could build world class products.

A networked world: The rate of company formation increased drastically in the late '80s with many firms specializing in imaging and communications technologies.

At the same time US companies like Intel, Motorola, IBM and National Semiconductor started to entrust their small Israeli R&D subsidiaries with more critical parts of development work, leading to a higher level of expertise and new skills in fields like semiconductor design, fabrication and equipment. Another major boost with the invention of Local Area Networks (LANs) when dozens of Israeli firms started making the routers and hubs that could connect the LANs of the world. Companies like Lannet or Lanoptics, started up, went public and thrived. They were usually well ahead of their field in technology, few had enough marketing skills and none had enough clout to confront the major American players in this industry once the LAN market grew to its current size.

The skills developed in this market have been put to good use in the current crop of interesting firms in the Internet technology field. Significantly, the leader in this field, Lannet, merged last year with a major British competitor because its principal stake holders realized that the company, though successful, lacked the size needed to make an impact in this extremely competitive market.

Israeli entrepreneurs used to avoid selling out their companies or technologies, but have realized in recent years that this is often the best option for their

shareholders, themselves, and their workers. Other companies in smaller niches like Aladdin, a world leader in software protection, went the other way and recently bought FAST, a major German competitor to give it a keener edge against Rainbow, an American competitor.

Russian Reinforcement: The industry received a major boost in the 90's with the arrival of over 700 thousand new immigrants from the former Soviet Union. Many of them were trained professionals with relatively little knowledge of newer western technologies, but their superior training in basic mathematics and physics enabled a large number to adapt very quickly to the field.

Secure that data: While declining rapidly, the military still accounts for a sizeable chunk of the local electronics industry, with about 20% of the sector's total output. Army training and orientation has been particularly significant in the technologies of data compression, data security and digital signals processing. Much of the premium in this field is on algorithms that require extensive mathematical flair.

Furthermore, the army is still a major supplier of expert personnel, ideas and technologies to the civilian market. Many start-ups begin in Israel when a group of young engineers with advanced knowledge in a specific field develop an idea and then leave the army to continue work in civil life.

What can we learn from this historical perspective on the growth of the Israeli high tech industry and the role of the domestic market? What the story above tells us is that well trained people, heavy investment in technology, and the Israeli military all played a key role in the development of the high tech industry. This might lead one to conclude that it was the Israeli military that drove domestic demand for high tech products. Using Porter's model we could be tempted to say that Israeli military met all three criteria of being an important segment relatively in the economy, a sophisticated and demanding user, and, because of this sophistication, anticipatory of buyer needs elsewhere. However, the story is more complicated than this. The Israeli military meets Porter's criteria as a consumer of advanced core-technology and not as a consumer of commercial technology products. For example, developing advanced avionics for the Lavi would give companies (and the engineers in those companies) experience with a core imaging or communications technology, but that in and of itself does not tell a company how that core technology needs to be incorporated into a commercial product, what features that commercial product needs to have, or what the needs of the commercial customers are both in terms of the product and support. The fact that the Israeli companies were so far ahead in terms of their core-technology made up for their initial lack of understanding of what exactly the commercial market wanted. For Israel, the military's contribution to the commercial success of Israeli technology firms was along an important, yet narrow dimension—it spurred investments in R&D and in training of man power. However, if we look at the domestic market for commercial Israeli high technology products and services, beyond just the core technology, there seems to be little correlation between the important components of domestic demand outlined by Porter and the global competitiveness of Israel's technology firms today.

3.4.4 IRELAND

Of our 3 comparison economies, Ireland has the smallest population by far with only three million people and a domestic software market worth IR$186 million in 1995. However, despite this small domestic market, a recent survey put Ireland within the top five global software exporters. Employment in indigenous software firms is at 5,773 people, and is almost equal to the 6,011 people working in foreign owned companies[xxxvii]. However, as might be expected, the average size of indigenous companies is much smaller than their multinational counterparts. Irish software companies have an average of 15 people per company with only 24 companies having 50 or more people. This is as compared to the MNCs in the software industry which have an average of 64 people per company. Total software revenue in 1995 was almost IR$3 billion, with about 87% of that coming from MNC software firms.

The success of the Irish software industry is clearly led by the multinational software companies located there. Further, the success of the multinationals is clearly distinct from any aspect of domestic demand. Multinationals in Ireland had revenues of IR$2.6 billion, a full 99% of that came from exported software. However, two questions that we might want to answer are: 1) to what extent is the indigenous software sector growing and 2) to what extent is the indigenous sector's success based on the domestic market.

While growth in the indigenous software sector in Ireland has not been as rapid as in Israel or India, it still seems to be very healthy. The graphs below summarize the growth of the indigenous software industry and compare it with the growth of the MNC software sector in Ireland[xxxviii].

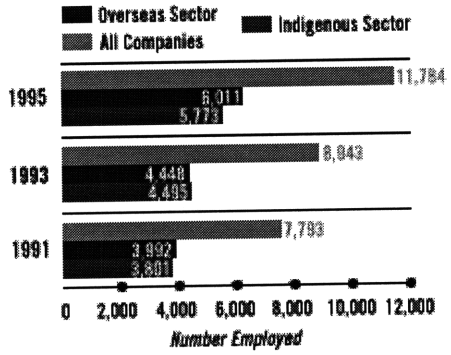


Figure 2: Employment growth in the Irish software industry

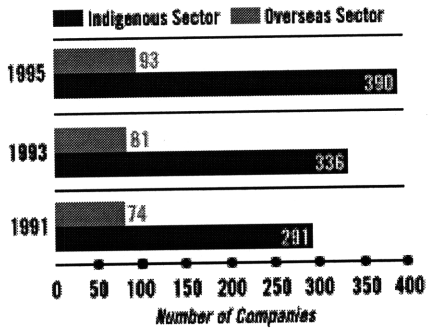


Figure 3: Rate of company formation in the Irish software industry

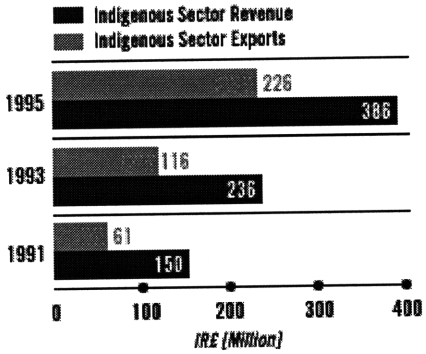


Figure 4: Revenue growth in the Irish software industry

What we see from the graphs above is that, even though the indigenous sector is significantly smaller than the MNC sector, every growth measure for the indigenous industry is strong. Given that there does seem to be healthy growth in the indigenous sector, the next question address is the extent to which the domestic industry depends on the domestic market. The

following charts paint a picture of the importance of the export market versus the domestic market for the indigenous Irish software industry[xxxviii].

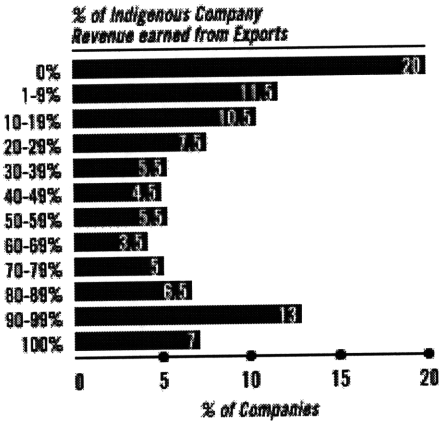


Figure 5: Exports by indigenous sector

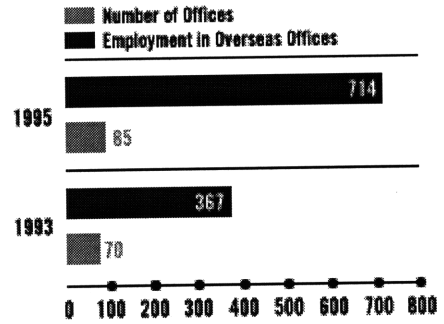


Figure 6: Overseas growth of indigenous sector

The charts above seem to show a moderately strong dependence by the indigenous software industry on the domestic market. 42% of the indigenous sector's revenue came from the domestic market, and 42% of firms get less than 20% of their revenue from exports. However, there are still several issues to consider before passing judgment on the role of the domestic market. First, in 1995 indigenous firms generated more money in absolute terms from the domestic industry than MNCs. Indigenous firms generated IR$160 million while MNCs generated only IR$26 million, almost 85% less than the indigenous industry. What this seems to suggest is that the indigenous firms are not competing in the same market as the MNCs. This is based on the logic that, if they were in the same market, the vastly greater

resources of the MNCs would give them larger absolute sales than the indigenous industry. Since most of the MNC sector offers packaged software products, the fact that the indigenous sector generates more in absolute terms than the MNC sector could mean that the indigenous sector is offering custom software or packaged software targeted at more vertical markets. The second issue is that, while the largest percentage of companies export none of their product, the second largest percentage of companies export 90-99% of their product. In fact 31.5% of indigenous companies export less than 10% of their product, but 20% export 90% or more. This tells us that there seems to be two main types of companies in Ireland, companies which have a strong dependence on the domestic market and companies which have a strong dependence on the export market. Unfortunately, what is not clear is the extent to which companies who now heavily depend on the export market may have once depended on the domestic market. What is also not clear is how many of the 20% of companies which are exporting nothing are in the development stage of a product whose competitiveness will not be related to the domestic market. Finally, regardless of the domestic market, the export market has been extremely important to the growth of the Irish indigenous software industry. The table below compares the growth in employment and revenues for the domestic market versus the export market.

	Growth from 1991-1993	Growth from 1993-1995
Domestic Employment	18.26%	28.43%
Overseas Employment	n/a	94.5%
Domestic Revenue	35%	33%
Overseas Revenue	89%	94.8%

Table 5: Growth in export versus domestic markets

The evidence for the role of the domestic market on Ireland's indigenous software industry thus presents a mixed picture. However, what we do know is that 20% of firms get 90% or more of their revenue from exports and that the growth of the indigenous software industry is being driven by the export market. Perhaps the best we can say about the effect of domestic demand on the indigenous Irish software industry is that its effect may not be important. Despite vagueness of that statement, it does have important implications. It implies that, while having a strong domestic market can certainly help an industry, not having one is not a key barrier to the industry's growth.

3.5 CONCLUSION

The theory that a strong domestic market can help the international competitiveness of an indigenous industry is well supported by scholars such as Michael Porter and Paul Krugman. Here, however, we are addressing a different questions: is not having a strong domestic market a key barrier to the growth of an indigenous software industry. The cases of Ireland, Israel, and India suggest that the answer to this is no.

4. CAPITAL MARKETS

4.1 INTRODUCTION

According to a recent consultancy study by International Data Corporation (IDC), "the primary constraint to software innovation in Hong Kong is the result of three inter-related factors that start with the ISV's [independent software vendor's] acute lack of capital."[xxxix] A follow-up study on the Hong Kong software industry by Dataquest, another consultancy firm, further made the recommendation to the Hong Kong government that "having regard to the fact that there is in general a lack of capital for small software companies in Hong Kong, [we] recommend that the government should establish a small business loan program to finance these companies."[xl] Many leaders in Hong Kong agree with these findings that a primary barrier to the growth of the indigenous industry is the lack of capital available to the individual firms. Furthermore, a great deal of energy is being spent by these leaders in Hong Kong to address this problem in the hopes that it will invigorate the indigenous software industry.

This chapter tries to put into perspective how important domestic capital markets are to the formation and development of a software industry. The important role that capital markets play in an industry is the ability to raise money through a variety of means. The two possible ways of raising money are via equity and debt. Software companies, especially younger and smaller ones, have more limited options. Since the product of a software company comes in the form of a piece of intellectual property, debt is usually more difficult (although not impossible) to raise by these younger, smaller companies given their lack of

collateral. Thus, equity financing becomes an even more important tool in financing growth than it might be to other industries. Because of the disproportionate importance of equity in financing young software companies, this chapter will primarily focus on financing via venture capital (VC) and initial public offering (IPO) opportunities.

This chapter is divided into four main sections. Section 2 looks at the role of the equity markets in financing the Hong Kong software industry. Section 3 looks at the role domestic equity markets have played in developing the software industries of our comparison economies—the US, India, Ireland, and Israel. Finally, section 5 draws together the findings in Hong Kong and our comparison economies to answer the question of how critical strong domestic capital markets are to initiating growth in Hong Kong's software industry.

4.2 EQUITY MARKETS IN HONG KONG

4.2.1 INTRODUCTION

The section looks at how VC and IPO opportunities in Hong Kong are affecting Hong Kong's indigenous software industry. First, I present an overview of the types of venture capital opportunities available in Hong Kong. Second, with that understanding, I then examine possible reasons why VC firms may not be investing in Hong Kong software companies. Third, I try to develop an understanding of the direction of causality between the lack of investment in Hong Kong software firms and the lack of a software industry in Hong Kong. Finally, I conclude this section with the goal of understanding the true role capital markets have played in affecting the growth of Hong Kong's indigenous software industry.

4.2.2 VENTURE CAPITAL IN HONG KONG

While venture capital exists in Hong Kong, instances of VC money going into high-tech Hong Kong firms are few and far between. According to Raymond Ch'ien, a leading Hong Kong industrialist, "to Asian investors, if VC in high-tech is not a dirty word, it is a dangerous word."[liv] To understand why this is so, it is first important to understand the extent of Hong Kong's VC industry and what that industry invests in.

Hong Kong's VC industry is home to some of the largest VC firms in the world. These firms include AIG, Prudential Asia, Advent International, Walden International Investment Group, Hambrecht & Quist, and TransPac to name a few. In all, as of May 1998, the Hong Kong Venture Capital Association (Hong KongVCA) had 54 full members, all of whom are firms or individuals participating in venture capital[xli]. Research by the capital market's team of the MBHong Kong study characterized the type of funds these large VC firms operate[xlii]. According to the research, many of these funds are set up with relatively long investment horizons targeted at well established companies. Furthermore, while these funds are located in

Hong Kong, many actually focus on investing in business expansion or infrastructure projects in China. Hong Kong's VC money also goes to the domestic property market. The factors that seem most behind drawing money to China and to the property market in Hong Kong has been their relatively high returns without correspondingly high risk. These factors also seem to be some of the most important reasons for the lack of interest by VC's in the high-tech sector. The table below characterizes several of Hong Kong's major VC firms and funds. It highlights the typically large minimum investments and the focus on mezzanine investments.

Firm Name	Minimum Investment	Criteria
BancBoston Capital	US$3-10 M	Firms with greater than US$2 M in operating profit and pre-IPO
Citicorp Capital Asia	US$2-15 M	Prefers to give expansion and mezzanine funding
Donaldson, Lufkin & Jenrette Asia Ltd.	US$ 10 M	Companies with a valuation of greater than US$50 M or track record of strong profitability.
HSBC Private Equity Management Ltd.	N/A	Established profitable companies which require additional capital to expand. Start-ups are only considered under special circumstances.

Schroder Capital Partners (Asia) Limited	US$ 10-100 M	Growth opportunities in the manufacture and distribution of consumer products and services.

Table 6: Characterization of VC funds in Hong Kong[xli]

Anecdotal data provided further evidence of the investment behavior of Hong Kong's VC firms. As one senior executive at a major international VC firm known for its investments in high-tech in Asia. put it, "Hong Kong doesn't have a mentality for investing in high-tech." One of the founding members of the Hong KongVCA further describes the dearth of VC money targeted at start-ups, high-tech or otherwise. In his experience, he "has not seen a young company [in Hong Kong] where plant and equipment wasn't financed by 1 year loans." Those in the software industry also provided ample supporting evidence for the dearth of VC money going to software firms. Of the 12 software firms interviewed, none had received venture capital or had heard of anyone else receiving it. As person M describes, "I've never met one bold enough to invest in software."

4.2.3 WHY VC'S DON'T INVEST IN HONG KONG

Why don't VC firms invest in Hong Kong software companies? The leading reason cited by fund mangers during interviews was that there is no exit for high risk, high-tech start-ups[xlii]. Industrialists in Hong Kong have also cited the challenge of taking young high-tech companies public as a key barrier to the growth of the high-tech industry. During a public address on ways to promote high-tech in Hong Kong, Dr. Raymond Ch'ien, a leading Hong Kong industrialist and the chief technology policy maker in Hong Kong, stated that "I think the time is right for a NADAQ. We need to give investors an exit."[liv] Mr. Herbert Hui, deputy CEO of the Hong KongSE, agreed, stating in the newspaper that, in order to promote high-tech, Hong Kong needs to figure out how to list technology companies and how to educate investors on how to invest in high-tech companies[xliii]. This focus by many on creating an exit

for investors in Hong Kong seems to be consistent with the findings of the MBHong Kong research team on why fund managers in Hong Kong seem not to be investing in high-tech companies.

The listing requirements of the Hong KongSE are a major obstacle to exit. In order to be eligible for listing, a company is required to have approximately US$2 M in profits in the year prior to listing, and must have had a combined profit level of about US$ 3 M in the two years prior to that. Companies must have an initial market capitalization of about US$10 M and must offer at least US$ 5 M in shares to the public[xliv]. These requirements, especially the ones regarding profitability, are very difficult to achieve for young high-tech companies. The result has been that, of the 542 companies listed on the Hong KongSE, only 15 could be classified as "technology" companies--even when using the most broad definition of what defines a technology company[xlii]

What those advocating the importance of exit are essentially saying is that there are great high-tech companies in Hong Kong that are not realizing their potential because they can't go public on the Hong KongSE. This simply does not make sense. If there are high technology companies in Hong Kong with internationally competitive products, investors would then have the option of exiting by going public on NASDAQ or exiting via the sale of the company to an MNC. Israel presents an important example of how foreign high-tech companies utilize the US capital markets to provide an exit. For example, 1996 saw 13 Israeli companies go public on NASDAQ. As of early 1998, over 100 Israeli companies, mostly high-tech, now trade on the NASDAQ market[xlv]. Probably the most famous is Checkpoint software. With seed capital of $300,000 in 1993, it went public on NASDAQ in 1996. Based on the December '97 share price, the company is worth almost $1.2 billion. Other Israeli high-tech companies on NASDAQ include Elbit Vision Systems, and VocalTec, leaders in the field of computer vision and Internet telephony respectively. Among foreign countries, Israel ranks

second only to Canada in the number of companies traded on US stock exchanges, but Islaeri firms are certainly not the only ones to use NASDAQ as an exit vehicle.[xlvi] In 1996, 15 European companies and 5 Asian companies also went public on NASDAQ[xlv]. An Irish newspaper described the reason why high-tech foreign companies look to list in the US: "until Irish investors realize the potential of technology stocks, local companies feel they have little option but to look abroad for sources of additional capital."[xlvii] Bill McCabe, Chairman of Irish software firm CBT, states that they chose NASDAQ for an IPO because "the NASDAQ market understands and knows how to value technical companies."[xlvii] NASDAQ is extremely favorable to foreign listings. In fact, NASDAQ lists more non-US companies than both the NYSE and AMEX combined[xlviii].

If there are world class high technology start-ups in Hong Kong, buyouts or acquisitions would give investors another option to recover their capital. In the US, acquisition exits outpaced IPOs for the three years including 1987, 1988, and 1989[xlix]. Acquisitions have also acted as important exit vehicles in Israel and Ireland. In Israel, many high-tech MNCs acquire young Israeli high-tech companies for their superior technology and engineering talent. The list of US companies acquiring Israeli firms reads as a who's-who of Silicon Valley. Acquirers of Isreali firms include Siemens, Applied Materials, US Robotics, and Bay Networks[xlvi]. In Ireland, many successful high-tech start-ups also choose to be acquired by European MNCs instead of going public. Thus, if there are startups in Hong Kong producing world class products and technologies (the types of companies that are fundamental to the growth of an industry in an economy with a small domestic market), then evidence shows that investors would have a variety of exit opportunities.

A second major issue mentioned by many as to why VC firms may not be investing in high-tech in Hong Kong was mentioned previously. This was the issue of alternative investment opportunities in China and in Hong Kong real estate which provide relatively high

returns without the corresponding risk. The basic argument is that there is no money for high-tech in Hong Kong because it is being invested in more lucrative opportunities elsewhere. Raymond Ch'ien commented that there is "no tradition of VC [in high tech] because of property.[liv]" Research from the MBHong Kong sector on capital markets also concluded that:

> *"Opportunities in property and opportunities in China, either manufacturing or property, remain attractive due to the expectation of continued high returns. The lack of investment in start-up companies in Hong Kong and, especially, in high-technology companies is less surprising in the presence of these appealing alternative investments."*[xlii]

However, there is a discrepancy with the argument many are making about the lack of technology oriented funds and its impact on Hong Kong's high-tech sector. First, it hasn't always been the case that there has been a lack of technology oriented VC funds in Hong Kong. Walden International Investment Group, a major international VC firm, started a fund in Hong Kong in the mid-1980's with a focus on hi-tech. However, they had to broaden their focus due to disappointing returns and the low volume of potential investments[xlii]. In the case of Walden, the money was there but the investment opportunities—the companies—were not.

Even in the late 1990s, one cannot say that there is an absence of venture capital available to promising high tech companies in Hong Kong. In the case of Walden, just because they have broadened their focus doesn't mean they don't invest in high-tech anymore. During a business conference in November 1996, Walden said they invested more in Asian software companies than they did in US ones[liv]. In December 1997, Walden closed their $328 million PacVen Walden Venture IV fund. This fund will focus on eight countries around Asia and will make investments from $2 to $15 M, but "investments in early-stage technology deals tend to be $2 to $3 M because of the risk associated with those types of deals." While the eight countries in Asia were not specified, the fund excludes Korea and Japan, and Walden has few investments in Malaysia, Indonesia, or the Philippines and none in Thailand. Thus, it would

be surprising if there weren't an opportunity for early-stage technology companies in Hong Kong to receive money from this fund. Furthermore, half of all of the funds are allocated to the technology sector because "Walden has a competitive advantage in technology"[l]. While the table above shows that about 10% of VC firms that belong the Hong KongVCA would not make appropriate investors in software start-ups, there are others in addition to Walden that seem like they would. For example, Donaldson, Lufkin, Jenrett's VC subsidiary in Hong Kong targets "small and medium businesses with a strong management team and credible business plan." They also state that they are a "value added" VC firm that "bring[s] equity and a total business solution" to their portfolio of companies. ACL is a Hong Kong based VC firm which manages two funds totaling almost $30 M. These funds are focused on "healthcare, communications and information technology, consumer services, leisure and, most recently, affordable housing in the Philippines."[li] While many leaders in Hong Kong had talked about the high return, low risk investment opportunities in property as a reason why Hong Kong VC firms did not invest in Hong Kong high-tech, there is the counter-example of Nomura Securities' Hong Kong VC branch, which looks to make investments between US$1 M and US$5 M in "any industry except property.[xli]" Also, while there were no examples uncovered of software companies receiving VC money, that is not to say that none was offered. Charter Venture Capital, a VC firm with a branch in Hong Kong, offered to take a majority stake in a local Hong Kong software start-up company called Creature House. The offer was made because Creature House had very innovative technology that could be used in packaged graphic design software. Besides Walden, Transpac is the other major VC firm that focuses on the high-tech sector in Asia. In 1996, they had a total of eight funds worth US$560 M[lii]. Even as early as 1991, they had investments totaling US$200 M. While a large portion of the funds get targeted at Hong Kong companies looking to regionalize their operations, Transpac says they "specialize in the provision of seed funding and start up funding. . ." Furthermore, as of 1991, they had equity interests in 16 companies in Hong Kong which were hi-tech industry-

oriented[liii]. More recently, Transkpac's president, Dr. Christopher Leong (an MIT alumnus), confirmed that his company makes numerous investments in technology companies in Asia, especially Taiwan and Singapore. As they did in the early 1990's, Mr. Leong's company certainly has the ability to continue to invest in Hong Kong high-tech companies, however, "in terms of technology, in the long run, Hong Kong will lag behind Singapore and Taiwan. . .[and that] It lags behind Taiwan by a lot [now]."[liv] Thus, while many say investment opportunities in China and in Hong Kong property are preventing capital from flowing into the high tech sector, the lack of capital flow may be due more to the dearth of investment opportunities in Hong Kong's high tech sector.

4.2.4 WHAT IS THE CAUSAL RELATIONSHIP?

While we have a picture of why Hong Kong VC firms don't invest in Hong Kong software firms, the question of the direction of causality has still yet to be determined. Specifically, is the cause of Hong Kong high-tech industry's restricted growth due to the lack of capital, or is there a lack of capital because there are few companies to invest in? One could imagine that the answer could be both in the sense that it is a "chicken and egg" problem. In fact, according to the chapter on capital markets in the MBHong Kong book, the researchers describe the problem as "a vicious circle where the lack of investors and the lack of entrepreneurs feed on each other."[xlii] Raymond Ch'ien also states that ". . .we are going to aggressively market our hi-tech industry to venture capitalists in Europe and the US because we have to break the chicken and egg problem."[liv]

While the outcome may be a 'vicious circle,' the circle may have been created by the dearth of companies with internationally competitive products. Data from the previous section showed that there was in fact a technology focused VC fund specifically in the Hong Kong region, but that it had to broaden its investment criteria due to the lack of potential investments. Aggregate data on the Asian venture capital industry shows that a total of $19.7

billion was invested in 18,172 companies in 1996. Investment in 1996 alone was about $5.5 billion. Money invested in Asia (excluding Japan) broken down by industry shows that investments in electronics-related and computer-related investments were ranked in second and third place taking 14.7% and 13.5% of Asian VC dollars respectively. This was behind industrial products which took 24.3% of the dollars. Excluding Japan, the breakdown of venture capital distributed by stage of venture expansion accounting for 48%, start-up at 24%, and mezzanine at 14% of total disbursements. (note: the term "start-up" used here typically refers to long-standing family businesses that incorporate themselves). When we include Japan, 5% of the $19.7 billion invested in Asia, or almost $1 billion went to companies at the "seed" stage. Disbursements broken down by geographic location (excluding Japan), shows that Korea (16.9%) is the top location for VC investments with Hong Kong and Singapore just behind at 10.8% and 8.2% respectively[lv]. While, as a percentage of the whole, there is not a lot of capital going for seed capital, in absolute terms it is not insignificant. Furthermore, in Asia, technology is an important sector for VC and Hong Kong is an important part of Asia for VC. However, despite this, we still don't see many success stories of venture backed software companies coming from Hong Kong.

The causal relationship between funding opportunities and industry growth in Hong Kong stands in direct contrast to the case of Israel. In Israel there is clear evidence that the industry did not grow initially because of a lack of venture capital. According to Yigal Erlich, the former Chief Scientist at the Israeli Ministry of Industry and Trade, "we found that despite a tripling of start-ups in the early 1990s, there was no corresponding increase in the commercial success rate." Because of this, in 1993, Erlich started Yozma Venture Capital Ltd, an Israeli state owned company that established venture capital funds and shared the risk with foreign investors. Yozma started 10 funds and the government put in $100 M while the international partners put in an additional $150 M. Of the companies the Yozma funds first invested in, over 20 went public in the US and over a dozen have been acquired by MNCs. This success

encouraged more money to flow into existing funds and for more funds to be created. However, despite all the money going into the Israeli VC market in recent years, one fund manager in Israel who just completed raising $110 million recently said that "even with twice as much money, we'd still face the problem of deciding between the many good opportunities." This is quite a different story from the fact that there are funds focusing on high technology in Asia, but that those funds are making minimal investments in Hong Kong.

Further evidence regarding the seeming dearth of VC directed at high-tech in Hong Kong came from the comments of Hong Kong software company leaders themselves. When asked to talk about the major barriers they face in growing their companies, only 2 of 11 software companies said it was because of a lack of money. Seven of eleven said a major barrier was people, and six of 11 said it was finding the right business partners. While person M, manager of one of the two companies stating that more capital was important, said "we need loans or venture capital now to expand our market,,." he added that "we're looking for partners with complementary assets, not just money." While findings show that software companies in Hong Kong are undercapitalized in general, data from the software companies themselves seems to say that this is not the major barrier to their growth.

4.2.5 CONCLUSION

While many people in Hong Kong have cited the lack of technology focused VC funds as a major factor restricting the development of Hong Kong's high-tech sector, two major pieces of evidence suggest otherwise. First, VC funds focused on Asia and focused on funding early early-stage technology firms do exist. Walden had a VC fund focused on high-tech in Hong Kong and there still exists today a variety of VC funds focused on high-tech in Asia. However, the Walden fund had to broaden its focus due to the lack of investment opportunities and the other funds seem to focus on Taiwan and Singapore because the firms coming from those countries seem to have a stronger technological basis. Second, the heads of

Hong Kong software firms don't even cite the lack of VC as a major barrier to their growth. Instead, they talk more about the difficulty of finding good employees and business partners.

4.3 THE ROLE OF VC AND IPO'S IN THE COMPAIRISON ECONOMIES

4.3.1 INTRODUCTION

This section looks briefly at the role of venture capital and IPO opportunities in the comparison economies of the US, Israel, Ireland and India in order to better understand how VC affects the growth of an industry.

4.3.2 THE US

Although researchers have shown how VC money has been behind the growth of major new U.S. industries such as semiconductors, computers, and biotechnology, it is less clear that VC money was responsible for the growth of these industries. Between 1967 and 1972, almost thirty semiconductor companies were started with VC money including National Semiconductor, Intel, and Advanced Micro Devices (AMD). However, in 1968, the semiconductor industry already had over a billion dollars in annual sales, with only a handful of VC backed firms contributing to that figure. In the computer industry, while DEC helped pioneer minicomputers in 1957 with the help of venture capital, there was already a tremendous amount of people and research in the computer field. For example, in 1957, IBM's computer division already had sales of $1 billion[lvi]. While the first biotechnology company was started by a venture capitalist, the foundation for the industry had already been laid by the large investment in biotech research by the National Institutes of Health (NIH). While venture capital backed companies were important in expanding these industries, there was a critical mass of research and people involved in these industries already.

A recent survey of companies founded by MIT alumni also gives an interesting perspective on the role of VC in the US. Among software firms started by MIT alumni the table below shows the relative importance of different sources of financing:

Source	Importance (5=most important; 0 = not important)
Founder's Personal Savings	3.92
Company Cash Flow	3.58
Strategic Partners	.8
Founder's Family	.74
Venture Capital Firms	.57
Informal Investors	.55
Commercial Banks	.46
Founder's Friends	.31
US Government	.28

Table 7: Importance of funding sources for MIT related software firms[lvii]

Thus, while many in Hong Kong cite the issue that most VC is critical to creating a software industry in Hong Kong, the table above shows that, even among MIT-related software companies, venture capital did not play an important role in financing the average venture's start. Like all of the software companies we interviewed in Hong Kong, personal savings followed by company cash flow were the most important sources of financing for the MIT related software companies.

4.3.3 INDIA

The success of India's software industry to date has had little to do with venture capital. According to a recent statement by K.V. Ramani, President of India's National Association of Software and Service Companies (Nasscom) , "Venture capital funds have made minimal impact on the Indian software industry. . ."[lviii] Given the type of software India's industry

focuses on (i.e. custom software), this statement makes a great deal of sense. India's software companies do not need to invest in R&D or marketing and thus can generate positive cash flows relatively quickly. However, based almost entirely on professional services alone, India has created an indigenous software industry which generates almost $2 billion per year and which is growing at 30%-50% per year. The most fundamental reason many cite for this is the quality of the engineering labor force in India and the quality of the services they offer. Many also note that the low cost of Indian software is a current advantage. However, according to MNC representatives, the cost advantage is only temporary and it is the quality of software engineering talent that is encouraging them to make long-term investments in the Indian software indsutry.

In order to take the Indian software industry to the next level of growth, many see VC money as playing a crucial role. According to Mr. Dewang Mehta, Executive Director of Nasscom, "for the software industry in India to reach an annual turnover of $ 6 billion by the year 2000, it requires at least $500 M of venture capital funds. . ."[lix] This seems to be a somewhat similar pattern to the semiconductor and computer industry's development in the US. Once a critical mass of trained and experienced people are already in the industry and once that industry has grown to a certain size, venture capital helps to accelerate the rate of company formation and industry growth.

4.3.4 IRELAND

The strength of the Irish software industry has developed because of MNCs' decisions to locate in that country. The growth of the MNC-led software industry in Ireland, as described in the chapter on human resources, seems to have been primarily caused by the quality of the workforce but also by various government incentives. In this respect, venture capital had very little to do with Ireland becoming one of the top 5 software exporting countries in the world.

In terms of the indigenous software industry, venture capital seems to be more important to the expansion rather than the creation of successful firms. Many indigenous software companies that receive VC funding are already relatively successful on an international level. For example, an Irish venture capital firm named ICC invested in an Irish software firm named RFT Vision systems. While the company had only 8 people, it was 3 years old, profitable, and expecting to do 1 million pounds in business that year. Before the time of VC investment, RFT had already been selling its product to major corporations such as Guinness, Harris Corp, and Panasonic, and had a number of partnership arrangements with US companies. In fact, RFT was one of the youngest companies that ICC had invested in. ICC only did so because RFT's products were "highly innovative and because their directors were all very experienced in the industry."[lx] The managing director of ICC, speaking in general about his industry, says that Irish VC firms tend to invest only after the product is well established[lxi]. Delta Partners is another prominent venture capital firm in Ireland. One investment made by Delta was in an Irish software firm called Westboro. However, by the time of investment, Westboro had already achieved various milestones of success. At the time of investment by Delta, Westboro was 5 years old, had 25 people, and "already had a number of Fortune 500 companies among its clients."[lxii] Delta also made an investment in an Irish banking software company named Credo; however, at the time of the investment, Credo was 8 years old—relatively far from the seed or start-up phase.[lxiii] IONA, an Irish software firm focusing on the software tools market, didn't have any money, VC or otherwise, to invest in marketing when it started out. They built their brand, and their success, by selling a 60-day trial version of their product for 5% of the purchase price. If people liked it, they could purchase the full version for the remaining 95%.[lxi] The result is that IONA is the leader in the world in its market and is a public company on the NASDAQ.

The case of Ireland suggests that successful software companies are usually successful before they get venture capital funding. Even while they are relatively young and small, they

still have internationally competitive products and international customers. Venture capital in Ireland, as in Hong Kong, seems to be at the mezzanine level where it helps already successful firms to grow.

4.3.5 ISRAEL

Venture capital played an important part in the development of Israel's high tech industry, but it was not the first component. As described in the chapter on source organizations, Israel has had a long history of investment in innovative R&D, and, as described in the chapter on human resources, has a highly trained workforce. Thus, the infrastructure for a technology industry was being cultivated long before the capital became available. The inflow of capital was also preceded by strong incentives for Israeli engineers to start their own companies. Since the government was cutting back on military programs, thousands of engineers were fired. Given that the core technology had already been developed, and that the best alternative for Israel's brightest engineering talent was to go and start their own company, the venture capital money helped to grow the industry. In the Israeli case, the evidence seems to present a clear set of conditions which existed which then allowed venture capital to have a positive impact on the industry. However, as discussed throughout this thesis, whether or not Hong Kong has those prerequisite conditions is in question.

4.3.6 CONCLUSION

A major lesson provided by all four comparison economies is that venture capital cannot grow what is not there. In each of the cases, there is already something that is successful about the industry and venture capital helps to expand that success.

4.5 CONCLUSION

Many people in Hong Kong use the following logic to describe the effect of the domestic capital markets on the local software industry: Because there is no domestic exit for young high-tech firms, there is no VC money for those young high-tech firms. Because there is no money for them, the development of high-tech industry is being stymied. This then creates a negative spiral in which the dearth of high-tech companies and the dearth of high-tech oriented VC firms feeds off of each other. However, the evidence presented in this chapter raises questions about this logic. First, firms which have internationally competitive products have the opportunity to go public on the NASDAQ. Like India, Ireland, and Israel, Hong Kong's relatively small domestic market for most types of software means that it has to focus on the export market if it wants to develop a software industry. Good software companies are also important acquisition targets for MNCs. Thus, the issue of an exit does not seem to be as big a barrier as most in Hong Kong assert. Second, it is not clear that there is a lack of VC funds in Asia focused on high-tech. Given the existence of Walden and Transpac, companies that say they target early-stage high-tech companies in countries like Hong Kong, we would expect that companies in Hong Kong that had internationally competitive products or services could get financing. Finally, it is not clear that VC money has to be behind the start of an industry or a company for it be internationally competitive. This is suggested by our comparison economies but it is also evident in Hong Kong. Creature House is a Hong Kong software company which makes graphic design software. Its product, Expression, marketed by Fractal Design Corporation, was named as one of the top ten products of the year by Computer Artist Magazine in 1996, and is a top selling graphics package used around the world. Despite this, the firm does not have venture capital funding. Prima Design is another Hong Kong software company. It develops CAM/CAD software for the textile industry, and its product is a global leader. However, it too does not use money from venture capital firms. Thus,

despite what many think about the importance of exit vehicles or venture capital funding, the data shows that other elements needed to initiate the growth of Hong Kong's software industry may be more fundamental.

5. HUMAN RESOURCES

5.1 INTRODUCTION

In the high-technology sector, the growth of a company ultimately depends on the quality of its people. Software companies are no exception. The product of a software company is a piece of software which addresses a customer's problem. It is up to the creativity and ingenuity of the software engineer to help figure out what the problem is and how to solve that problem in the most effective way. In understanding the barriers to growth of a software industry, a key variable to assess is the overall quality of engineers in software companies and the factors that drive that level of quality.

In order to do this, I first came up with a model which generally describes the flow of people into the software industry. The model is shown in the figure below.

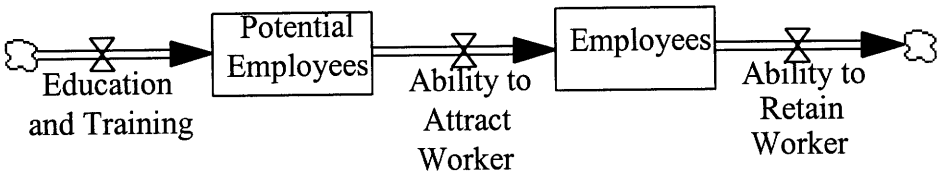


Figure 7: Human Resources Model

The model operates as follows. First, a pool of quality potential employees is created via quality education and training. In my research, "education" primarily focuses on the tertiary education sector while "training" looks at non-academic work experience. People who are educated and trained in software development become potential employees for a firm. The quality level of their education and training determines the quality level of the pool of potential employees. The level of quality of engineers in a firm or industry depends on the ability to attract quality engineers and retain them, but more fundamentally, it depends on the quality of the education and training of all engineers in a given labor market.

My analysis used this model in two steps. First, I sought to understand the quality level of current employees. This was assessed via primary and secondary data collected from employers of software engineers who assessed their manpower in both an absolute sense and relative to those educated and trained elsewhere. Second, I sought to understand what is driving the quality level of engineers in a given software industry. To do this, I analyzed each of the factors which determine the quality level of engineers in an industry. These include the quality level of education and training, and the industry's ability to attract and retain quality people.

By applying this method of analysis to Hong Kong and to our comparison economies, the goal is to better understand the extent to which the quality level of people affects the growth of a software industry. This chapter is divided into several sections. The first step, in section 2, is to develop a broad understanding of how important quality people are in helping to drive the growth of a software industry. This is accomplished by looking at the software industries of our comparison economies—the US, India, Ireland, and Israel—and assessing what people say about the quality level of their people and how that level of quality has contributed to the

growth of their software industry. Results from section 2 confirm the importance of this factor. Section 3 then looks at how employers rate the quality of software engineers in Hong Kong. Results from this section show that there is almost universal concern about the quality of engineers both in an absolute sense and relative to engineers from abroad. In order to understand why quality is perceived to be so low, the education and training of Hong Kong engineers, the most fundamental factor affecting the manpower quality in an industry, is analyzed in Section 4. Results show that the way engineers in HK are being educated and trained is causing the problems that employers are citing about their workforce. Section 5 explores the ability of Hong Kong's indigenous software industry to attract and retain quality people. Here, we find that the human resource strategies of Hong Kong firms need to be changed if the industry wants to see the increased participation of more talented people in their companies. Finally, Section 6 integrates the lessons learned from our comparison economies and from Hong Kong.

5.2 QUALITY LEVEL OF ENGINEERS IN COMPARISON ECONOMIES

5.2.1 OVERVIEW

This section looks at the quality level of engineers in our comparison economies—the US, India, Ireland, and Israel. This comparison is primarily done by looking at what firms, both indigenous and multinational, publicly say about the quality of the engineers they find in these countries. We will show that, in each of our comparison economies, the quality of engineers is rated very positively, and that the positive quality level is an important factor contributing to the growth of software firms and the industry in that economy.

5.2.2 THE US

It is hard to assess in the aggregate how employers rate the quality of US software engineers. Even so, one can look at successful firms and assess the extent to which they talk about the quality of their people, and the importance of this factor in their success. The most famous example of a successful software firm in the US is Microsoft. Microsoft's view towards building its success on the quality of its people has been well articulated by its chairman, Bill Gates. According to Gates, "there is no way of getting around [the fact] that, in terms of IQ, you've got to be very elitist in picking the people who deserve to write software. . . " Gates continues that the philosophy of Microsoft is to bias their hiring decision "toward intelligence over anything else, even, in many cases, experience."[lxiv] Clearly, Microsoft sees it as fundamental to its success that it has access to the best and brightest software engineers.

Cisco Systems is another example of how successful US high-tech firms strive to ensure that the quality level of their workforce is high. Cisco Systems, which makes hardware and software for computer networks, has seen sales grow 300% in two years--from $2 billion in

1995 to over $6 billion in 1997. To achieve this type of growth, Cisco has the "goal of getting the top 10-15% of people in our industry" according to their CEO, John Chambers[lxv]. Because Cisco realizes that talented people are probably not looking for jobs, it spends a lot of time trying to get good people from other companies. One approach it often uses is through simply acquiring the other company. It will often acquire companies to get their talent—regardless of the actual product the company may be developing. Furthermore, to encourage talented engineers to join Cisco, the CEO will even personally call potential employees—even those at the entry level position. This type of commitment to attracting top talent underscores the extent to which Cisco believes getting the best people is the key to their success.

While it is very difficult to do a complete analysis in assessing the quality level of the workforce in successful US high-tech firms, these examples serve to illuminate the point that successful US high-tech companies find obtaining a high overall level of workforce quality critical to their success.

5.2.3 INDIA

Many researchers point to the development of India's software industry as having important roots in the high quality of the people in that industry. Balasubramanam and Balasubramanam attribute the growth of software in India to three main factors, all of which have to do with the quality of people in the industry[lxvi]. According to their research:

> *"There are several economic and sociological explanations for the birth and rapid growth of software in India. First, the endowments of human capital referred to above, a product of India's education policies over the years which emphasised investments in tertiary education. Second, is the contribution of expatriate Indians to the growth of the sector. Third, several managers of software firms attribute India's comparative advantage in software to the innate mathematical abilities of Indians."*

In terms of tertiary education, Bangalore alone, one of India's largest software producing cities, has 3 universities, 14 engineering colleges and 47 polytechnic universities. The total number of computer scientists graduating from Indian universities averages 15,000 per year. To put this in perspective, this is just shy of the 18,000 students gradating from all of Hong Kong's universities in all disciplines each year. Stremlau (1996) also argues that expatriate Indians further fueled the industry by bringing their expertise from having worked and trained in major high-tech corporations in the US.[lxvii]

The quality of software professionals in India is described best by the people who employ them. One such company is Motorola. Motorola India Electronics Ltd. is only one of 3 companies in the world which has achieved the highest level rating, a level 5 rating, on Carnegie Mellon University's Capabilities Maturity Model (CMM), a model for rating the quality of software being produced by a given company. The only other two companies in the world to achieve this rating are both in the US and include Boeing's Defense and Space Group, and IBM Federal Systems Co. (now part of Lockheed Martin). Amreesh Modi, Managing Director of Motorola's Global Software Division says "we are in India because that's where a lot of talent is. . .the cost advantage is a short-term bonus." Motorola is not the only company that that has recognized the ability of Indian engineers to produce high quality software. Scott Bayman, General Electric's country manager in India, commented that the software quality in India is ". . .slightly ahead of what we get done in the US in our experience." The quality of the software engineering pool has prompted others including Lucent, Computer Associates, Hewlett-Packard, Northern Telecom, IBM, and ATT to open or think about opening software development centers in India. Furthermore, Oracle Corporation will use an operating system largely developed by the company's India

Development Center in Bangalore to power their recently announced Network Computer or NC[lxviii].

Both researchers and executives of multinational companies have found the quality of Indian software engineers to be relatively high. This high level of quality has led US firms to entrust their information systems development increasingly to indigenous Indian software consulting companies, and has prompted many high-tech multinationals to set up development centers based in India. The results of these activities have been to drive the growth of software exports from India to between 40% and 50% per year.

5.2.4 IRELAND

Evidence from Ireland also suggests that there is a relatively high quality pool of professionals involved in the high-tech sector. According to Finn Gallen, the Vice-President of Ireland's Industrial Development Agency (IDA):

> *"The biggest thing we have to offer US high-tech companies is skilled, English speaking labor—the people. We try to identify, 10 years in advance, the kind of investment that we can expect from overseas, particularly in electronics and software. A large part of our success lies in training ahead of time, the right type of people for the high-tech sector."*[lxix]

Irish officials started making these investments in education as early as the 1960's.[lxix] Ireland built its Technical College system in the late 1960's offering certificate and diploma courses. It also created two technically focused National Institutes of Higher Education (in 1972 and 1980) that both received full university status in 1989. While these investments in education were geared to attract high-tech multinationals to Ireland, they also had unintentional benfits for the indigenous high-tech industry[lxx]. Irish Prime Minister John Bruston further corroborates the effects of the well-trained high-tech workforce in Ireland. He

says that "there is a clear indication that the investments that we've made in education, particularly in electronics, have been very, very effective in attracting industry to Ireland. . .the age profile and the educational profile of Ireland has been very helpful to this takeoff of our economy"[lxxi] Thus, there is no lack of belief among Ireland's most senior officials that the growth of their high-tech industry has been driven in an important way by the quality of the local people.

Comparative data on Ireland's education system further enforces the story told by the Irish officials above. The Irish government invests 7% of GNP in education, and 60% of the current student population is studying computing, engineering, electronics, science or business based courses. The proportion of students completing secondary education is the highest in the European Union, and, according to the 1996 IMD World Competitiveness Report, the quality of Ireland's educational system was ranked ahead of Belgium, Germany, Netherlands, Spain, Portugal, and the UK[lxxii].

Anecdotal evidence from high-tech multinationals locating in Ireland further supports the argument that the quality level of the workforce plays an important role in driving the growth of the high-tech industry. Of 20 large high-tech multinationals surveyed, 16 said the labor pool was a prime reason for choosing Ireland as a location[lxix]. The case of Intel Ireland is illustrative. Intel chose Ireland as the location of its only manufacturing facility in Europe in 1994. The facility employs more than 2,600 workers, almost all of whom are Irish. The success of this facility has prompted Intel to invest a further $1.5 billion in Ireland in a new facility which will create another 2,000 jobs. What were the factors that encouraged Intel to invest to this degree in Ireland? Certainly tax holidays and other financial incentives given by the government played a roll. However, according to Frank McCabe, a vice-president at Intel and general manager of Intel Ireland, "the major attraction for Intel originally in locating in

Ireland was the quality of the education system and the quality of the people it produces." Mr. McCabe adds that "the results to date confirm the original assessment."[lxxiii]

Thus, as with India and the US, Ireland presents another strong example that having an adequate supply of well-educated and trained people in a high-tech industry is at least one key driver of that industry's success.

5.2.5 ISRAEL

As with the other comparison economies mentioned previously, Israel's high technology boom seems to have important roots in the quality of its labor pool. Proof of this talent can be seen in the types of responsibility multinational high-tech companies are giving to their Israeli development centers. In 1994, Motorola Communications in Israel became the exclusive development site of wireless data communications for the entire company[lxxiv]. IBM opened a research lab in Israel 25 years ago at the Technion and, in 1982, opened one of its 8 major research laboratories in the city of Haifa. This lab is now IBM's 3rd largest research facility in the world in terms of number of employees. It falls behind IBM's main research facility, the T.J. Watson center in New York, and the Almaden research center in Silicon Valley[lxxv]. The Intel processor with MMX technology, the P55C, was developed, debugged, and tested all in Israel. Also, Microsoft developed its Internet firewall technology, MS Proxy Server, in Israel. As important as the actual technical accomplishments themselves is the fact that the parent companies believed strongly enough in the quality of the work force in Israel to make the investments that would lead to these technologies being produced.

Related evidence also speaks to the quality of Israeli engineers. Microsoft originally set up a facility in Israel because it did not want to lose Israeli engineers who wanted to return home. EMC, a $3 billion dollar US firm leading the world in storage systems and software, has Israeli

engineers comprising almost 8% of its R&D staff at its US headquarters. It invested millions of dollars in opening a development center in Israel because it was afraid of losing their Israeli engineers who were becoming homesick[lxxvi].

Evidence suggests that the quality of the labor force stems from an important combination of quality educational and training experiences. Israel's premier university of science and technology is the Technion. Its department of computer science one of the most selective in the country, taking only students with the highest scores. This is in direct contrast with Hong Kong, where many say the best students don't even go into engineering[5]. In Israel, overall, 28% of the population is college educated compared to 31% for Silicon Valley. The leading edge work experience opportunities for the country's engineers was initially provided by the Israeli military. The demanding technology needs of the Israeli military fueled much of the groundbreaking research at the Technion, and provided an opportunity for its students and faculty to work on some of the most challenging technology issues.[lxxvii] The concentration of engineering talent also fueled multinationals to set up R&D centers in Israel which further contributed to high quality training opportunities for local engineers. Israel was ranked first in concentration of engineers in a 1995 survey with 140 per 10,000 in the labor force. This compares to 80/10,000 in the US, 75/10,000 in Japan, and 10/10,000 in Hong Kong. However, the concentration of engineering talent in Israel was not only due to the education and training opportunities. Israel received additional talented manpower from the former Soviet Union. Russian immigration increased Israel's population by 12% in the years between 1990 and 1993. Many of these immigrants brought with them specialized science and engineering skills[lxxviii].

While a confluence of many factors led to the overall success of the Israeli high tech sector, evidence shows that a critical ingredient in this process was the quality of the local labor force.

5.2.6 CONCLUSION

When research data on education and training are combined with anecdotal data from employers, results show that the quality level of the labor pool in the high tech sector is very positive in each of our comparison economies. The data also strongly suggest that the quality of the domestic labor pool was a key factor in the growth of the sector by encouraging investments in high technology by both multinationals and the indigenous industry. These similarities between our comparison economies are especially significant given the very different growth paths each of the software industries has taken.

[5] Interview with person 4, a senior faculty member of the HKU computer science department, revealed that, while the university entrance exam scores of students planning to major in business were in the "A" range, those wanting to go into computer science were in the "C" range on a scale from A to E, A being best.

5.3 QUALITY LEVEL OF ENGINEERS IN HONG KONG

5.3.1 OVERVIEW

This section tries to assess the quality level of software engineers in the Hong Kong economy in order to understand if the quality of the labor pool is a key barrier to the growth of the indigenous software industry. The quality of engineers in Hong Kong was assessed via interviews with management and human resources personnel in both multinational and indigenous high-tech firms[6]. Results from the interviews show that most high tech firms in Hong Kong feel that there is a quality issue with locally trained software engineers.

The key skills that most thought were missing were problem solving skills and an ability to self-learn. Other issues were that students have a very narrow knowledge base (i.e. that engineering students have very little understanding of the issues beyond the technical ones), and that they have a very poor communication skills. These issues were not only brought up in an absolute sense, but also in comparison with engineers who came from abroad. Each of these issues is discussed in more detail below.

5.3.2 PROBLEM SOLVING AND SELF LEARNING

Of the 11 different software firms interviewed with regards to human resource issues, all of them commented on either the poor problem-solving skills, the poor self-learning skills, or both of Hong Kong educated IT engineers. Problem solving and self learning were grouped together because they both deal with the ability of an engineer to solve a problem in a relatively unsupervised fashion. These concepts are best explained through the words of those we interviewed. Person G is an IT Project Manager at Hong Kong Bank, one of the largest

[6] See Appendix A at the end of the introductory chapter

recruiters of IT engineers in Hong Kong. He comments that his "Hong Kong people are very good about gathering data to make a report for me, but it is very difficult for them to take data, analyze it, and make a decision." Person N agrees with person G, not only in a absolute sense, but also when comparing Hong Kong educated engineers to those educated abroad. Future Solutions is a 7-year old company specializing in architectural, engineering, and construction design software. Person N reports that their new hires are some of the best from Hong KongU (Hong Kong's oldest and most prestigious university). According to person N, "we select only people from Hong KongU that have good A-level exam results. We take people who have strict A's (A's on all their A level exams). We take these people because programmers need to do meticulous work. People with good academics shows that they are meticulous in doing work." However, even the best and brightest from Hong KongU seem to have trouble with problem solving and self-learning skills. Person N continues, "foreign grads think more before doing. With Hong Kong grads, you give them an order, then they do it. Foreign grads think about how to solve the problem—they have a problem-solving focus. Hong Kong grads focus on completing the job. Also, they don't know how to look for help themselves. They are used to being 'fed' the information they need to do the work."

Apparently, the lack of problem solving and self-learning skills isn't remedied later either. Person N comments that

> *"we don't like to hire people with experience because it's hard to find people who have been working in a similar learning environment. Experienced people know how to do one job. People with 1 or 2 years work experience forget how to think and learn because of the hierarchical structure of other companies."*

Similarly, person P, founder and Managing Director of a young Hong Kong software firm observed that "we like to hire fresh graduates because you can still teach them." Person P

further noted that, "I do find that people from foreign schools learn faster than students from local universities." The comments from the rest of the 11 software firms we interviewed were very similar in their concern for the inability of Hong Kong educated IT engineers to solve problems and self-learn.

5.3.3 NARROW KNOWLEDGE BASE OF FRESH GRADS

Another issue that many companies commented on was the narrow knowledge base of new graduates. This issue seemed to manifest itself in most cases with employers talking about the inability of Hong Kong trained engineers to think about using the technology to meet the needs of the customer. This issue came up especially often when we asked companies to compare Hong Kong-educated engineers to those engineers educated abroad. Person P says that "one big problem is that people in Hong Kong aren't trained to develop packaged software. They don't understand how to take the customer into consideration when developing software." Person L agrees that "local people in general don't know how to think about their customers. It's part culture and part the way they are educated." Person D, adds that "Hong Kong University grads are technically very good, but they have little understanding of the issues beyond that. For example, to develop a good user interface you have to understand more than the code, you have to understand what the customers are going to do." Person O also corroborates the very narrow focus taken by Hong Kong educated engineers and comments that it could relate to a lack of problem solving skills. According to person O:

> *"In terms of problem solving, our Hong Kong IT engineers always try to solve problems from a computer angle as opposed to a problem solving angle. That is to say, to solve a problem, you don't always have to change the computer program. It might be solvable by just communicating with the customer, but the Hong Kong IT engineers don't take that into account. That's one of the reasons we hire people with non-computer science backgrounds—we need people who can solve problems."*

Concern for the narrow focus of IT engineers went far beyond the people I interviewed. In their comments in the 25th anniversary edition of the Hong Kong Computer Society magazine, both Paul Chow, Chairman of the Hong Kong Stock Exchange, and John Strickland, former Chairman of Hong Kong Bank, independently commented about how two few IT professionals have a good grasp of business issues[lxxix].

One might expect that this narrow knowledge base is confined to fresh IT engineering graduates. However, person J, Managing Director of a local software firm, and an alumni of MIT's school of engineering and the Sloan School, says otherwise. According to person J, when comparing those engineers educated abroad to those educated locally :

> *"it's very difficult to find people educated locally who understand the technology as well as business. We need people who understand what the customer wants and how to meet his requirements. There is a big vacuum in my company because I do not have these people. I need fresh graduates with more common sense in understanding a business man's requirements for his industry. Students need a broader knowledge base. However, even when they're with the company for a few years, they still only know the basics. Now, in developing new products, we're trying to understand how the business processes of our potential customers interrelate. Locally trained employees only focus on certain technical areas and don't understand the interdependencies between the technical and business sides."*

5.3.4 DETERIORATING COMMUNICATION SKILLS

Another major skill gap employers repeatedly mentioned was the poor communication skills of Hong Kong graduates. Specifically, they cited the deterioration of written and spoken English skills as well as written Chinese skills. Person L was on the Industry Board Advisory Committee for Computer Science for several universities. One of his main findings was that the quality of English in the computer science departments of these universities was poor. Person K, ads that "the problem goes beyond speaking. Hong Kong students can't write

proper Chinese or English." Person D states that one of the biggest barriers to his company's growth is its difficulty in finding people in Hong Kong who can travel around the world to help market his software product. One of the key problems he cites is the poor language skills. According to person D, "local people don't have an 'international' understanding. They can't speak English and they can't write Chinese. It's even worse for people with technical backgrounds."

Faculty in the engineering departments agree that the communication skills of their students is below par. Person 6 is on the computer science faculty at the Chinese University of Hong Kong. He finds that the English skills of his students are "poor and getting poorer. English skills get noticeably worse year by year." Person 9 is a senior professor in electrical engineering at HKUST. When asked to rate the English skills of his students graduating from Hong KongUST with a bachelors degree on a scale of "poor, needs improvement, satisfactory, or good," his response was "needs improvement at best." Person 4, acting head of the computer science department of a prestigious Hong Kong university, states that "students have trouble understanding lectures when they first get here." Given that Hong KongU, Hong KongUST, and Chinese University are considered the most selective universities in Hong Kong, we can't expect that the situation is any better at Hong Kong's other universities and technical institutes.

It is interesting to note that, aside from the US, English is not the mother tongue in any of our other comparison economies. However, engineers in Ireland, Israel, and India are all cited as having extremely good English skills, a factor which some believe has been important in contributing to the success of their respective software industries.

5.3.5 CONCLUSION

As the data show, while employers in our comparison economies rate their engineers highly, Hong Kong employers feel there are important deficiencies in the skill base of locally trained engineers. Overall, this is causing high-tech companies in Hong Kong to favor foreign educated engineers over locally educated ones. The problem is that, compared to locally educated engineers, foreign educated engineers are in short supply and often much more expensive. Given that important skill deficiencies appear to be present in the Hong Kong labor force, the next question is why do those deficiencies exist.

5.4 ARE QUALITY IT ENGINEERS BEING CREATED IN HONG KONG?

5.4.1 OVERVIEW

As described in the previous section, interviews with Hong Kong employers show that most companies feel that their employees are missing certain vital skills. Returning to the model in Figure 7, we see that the pool of employees in a given industry is immediately a function of the industry's ability to attract and retain talent—In essence, the net of the inflows and outflows of people. However, more fundamentally, the quality level of people in an industry is a function of the education and training they receive. This section focuses on the extent to which education and training opportunities in Hong Kong are leading to the skill deficiencies cited by employers in the previous section. First, in subsection 4.2 we focus on understanding how the structure of the education system in Hong Kong may be leading to these skill deficiencies, then consider how work-experience opportunities may also be a factor.

5.4.2 EDUCATION

5.4.2.1 OVERVIEW

Hong Kong's education system follows the British system. Students spend the equivalent of 5 years in high school, up until Form 7, and then may enter their undergraduate program at the university. All universities in Hong Kong require three years to get a diploma. There are some shorter programs offered by some of the universities and by the technical institutes that offer higher-diploma degrees which are more vocationally oriented. Hong Kong has six full universities: Hong Kong University (Hong KongU), Chinese University (CU), Hong Kong University of Science and Technology (Hong KongUST), City University (CityU), The Polytechnic University of Hong Kong (PolyU), Baptist University (BaptistU), and Ling Nam University. All except two of the universities, The Polytechnic University of Hong Kong and

Ling Nam, are considered research universities. The ages of the various universities vary greatly. Hong KongU is about 80-90 years old, CU is about 30 years old, PolyU 20 years, CityU 10-15 years, Baptist U is 15 years, and Hong KongUST is 5 years. The average school has about 10,000 students, but Hong KongUST and BaptistU are slightly smaller[lxxx].

This subsection will focus primarily on the tertiary education sector. Using primary and secondary data, I will first examine the quality level of people entering the engineering departments from the secondary school system. Then, I will look at each of the three skill deficiencies mentioned earlier, 1) poor problem solving and self learning skills 2) overly narrow knowledge base and 3) poor communications skills, and try and see if those can be linked to the way Hong Kong's tertiary sector educates its IT engineers.

5.4.2.2 DO THE BEST HIGH SCHOOL STUDENTS CHOOSE ENGINEERING IN COLLEGE?

The first step in assessing why the education system in Hong Kong might not be producing the necessary skilled graduates is to look at the quality of people choosing to major in engineering. In Hong Kong, about 10% of the people we interviewed for our research on the software sector said that the best students don't major in engineering in the first place, but instead go into business or law[7]. Person 4, acting head of the computer science department at a major Hong Kong university, described the situation at his university in detail:

[7] This comment was made by person I; person 6 of Chinese University's computer science department; person 4 of HKU's computer science department; person G, IT project manager at Hong Kong Bank; person 12, a career councilor for engineers at Poly University; and person D, managing director of a Hong Kong software company.

> *"We definitely don't get the best. The statistics department gets the best because they just opened an actuarial degree program. Their students get A's on all the subjects of their college entrance exams. Civil engineering is second, their students average high B low A on their entrance exams. Computer science undergrads average C's on their entrance exams."*

Thus, the quality of the potential IT engineering labor pool is being affected at an even earlier stage than the model in Figure 7 describes. For some reason, the brightest students in Hong Kong are not even going into IT engineering. This brings into perspective why person O, when asked how he deals with the lack of problem solving skills of Hong Kong IT engineers, commented that he "just gets people with non-computer discipline backgrounds." The fact that top secondary school students in Hong Kong don't go into IT engineering is in direct contrast with what we see in a country like India. In fact, many in India are concerned that, because the brightest students are all going into the software industry, many other important sectors in the local economy suffering from an "internal brain drain."[lxvi]

One way to make sense of where the most talented students choose to go is to look at the success precedents for professionals in a given country. In Hong Kong, the wealthiest people work in finance, real estate, or trade. In our research, we found very few success precedents in Hong Kong in high tech. This is in direct contrast to India where software developers can easily make ten times the average Indian's income, and enjoy a lifestyle which is considered upper-class. Thus, the first challenge for Hong Kong in addressing the problems of the software industry may be to find a way to encourage more talented people to enter the profession.

5.4.2.3 EDUCATION'S EFFECT ON PROBLEM SOLVING AND SELF-LEARNING SKILLS

The most common skill gap mentioned by Hong Kong employers was the deficiency of problem solving and self learning skills among their engineering employees. Investigation into how Hong Kong universities educate their engineers suggests three possible explanations: 1) the focus on rote memorization in universities, 2) the lack of design experience in the university IT engineering curriculum, and 3) the level of cheating in the IT departments of universities.

While it is difficult to quantify to what degree the Hong Kong education system focuses on rote memorization, numerous pieces of anecdotal data suggests it is significant. K.K. Yeung, Managing Director of HACTL and a former Chairman of the IT Committee of the Industry and Technology Development Council (ITDC), claimed that "the universities, colleges and polytechnics tend to churn out robots by spoon-feeding vocational training for Hong Kong's computer market; but they fail to foster the students' ability to think and reason independently."[lxxix] Person O agrees saying that "it's a big problem that even at the university level they teach you how to take tests and not to think or do projects. I don't think there is much hope for universities." This view, that the reason why Hong Kong IT engineers don't have adequate problem solving or self-learning skills is because of the Hong Kong education system, was held by many I interviewed. Person P thinks foreign educated engineers are better problem solvers "because Hong Kong schools teach people how to work and not think." In fact, 8 of the 11 software companies I interviewed about human resources issues specifically commented that the lack of problem solving and self learning skills was due to the fact that the Hong Kong tertiary education sector teaches engineers via rote memorization.

More compelling evidence of the focus on rote memorization in the tertiary IT engineering curriculum and its impact on students' ability to problem solve and self learn

comes from the students and teachers in Hong Kong themselves. Person H was a lecturer in computer science at Chinese University for 3 years before going to work full time for the software company he founded. On the issue of his department's focus on memorization while he was a lecturer there, he says that:

> *"Universities don't teach problem solving skills. Tests don't require problem solving skills either because the students wouldn't be able to answer them. . .Students would score quite badly on my tests because my tests required them to problem solve. . .The students expect questions to come from the notes. . .[in general] they're given a lot of problems that just require them to regurgitate information."*

A group of students who graduated from Hong KongU in the IT engineering disciplines and who were even teaching assistants for some of the computer science classes add further evidence that the focus on learning is not just confined to one university. According to these former students:

> *"Students [in Hong KongU's IT engineering programs] spend a lot of time memorizing facts because there is too much to learn. Students know ahead of time what they'll be tested on. Also, they have one exam at the end of the year so there is less incentive to learn the material as they go along. The typical undergraduates enjoys 10 months of vacation and 2 months of studying hard. It's a very exam oriented system, and the exams are geared towards memorization."*

However, one might wonder how people "memorize" in an engineering subject. The Hong KongU students I talked with explain this:

> *"It's not always that they memorize. In teaching a subject, there are two layers-the conceptual layer and the mechanics layer. Students are very good at grinding through the math, i.e. doing the mechanics. However, they have very little understanding of why they are doing what they are doing, i.e. the concepts."*

While most of the discussion on the problem of memorization focused on tertiary education, the problem seems to go deeper than this. This appears to be an issue that starts in the primary grades and continues through to the tertiary sector. Clearance Leung, an intern in the MBHong Kong office, said they are "duck fed" in primary and secondary school. In other words, they are constantly fed information to memorize. Person O agrees that the problem starts even before the universities. "In Hong Kong, from primary school through the universities, you learn to take examinations, not to learn" says person O. Tracy Wong, a graduate of Harvard who was educated in Hong Kong schools, further supported this. Even though she went to Harvard, she said she could not keep up with her high school classmates in Hong Kong who had tremendous "hard drives" for storing information. "They could just store volumes and volumes of information and then regurgitate it for the test" according to Ms. Wong. She also commented that the tests, even the college entrance exams, focus on "spitting back large amounts of information instead of on problem solving." Thus, while we cannot quantify the degree to which the Hong Kong education system, and especially the IT engineering curriculum, focuses on rote memorization, anecdotal evidence seems overwhelmingly to say that it is extensive.

A related problem is the universities' lack of focus on engineering design. Engineering design courses help to develop problem solving and self learning skills by forcing students to solve an unstructured problem. Of the seven major universities in Hong Kong, 5 have engineering departments. I interviewed professors at four of these five universities and, in each case, the faculty felt that their students were not getting enough design experience in their curriculum. Professors in IT engineering from Chinese University, Polytechnic University, Hong Kong University, and Hong KongUST all comment that the students' final year projects are their only chance to tackle an unstructured design project. Person 1 even casts doubt on

the quality of design experience offered by students' final year projects. Person 1 worked as a professor for 2 years in Hong KongU's Computer Science department before returning to the US to join MIT's Laboratory for Computer Science. At MIT, person 1 teaches a programming languages class and graduate student seminar. He comments that computer science students in Hong Kong "don't program enough. Three years is not enough time to learn to be a hacker." He goes on to say that while students "can get good project experience doing their final year project. . .the typical final year project is junk. Students slack the whole year and then pull something together in the last month."

Finally, several in academia commented on the extensive cheating that takes place in the IT engineering disciplines and how it is hindering the development of problem solving skills of those engineers entering industry. Person H talked about cheating while he was a lecturer in Chinese University's computer science department. According to Dr. Person H:

> *"Even projects are a reiteration of the previous year's. This makes it quite easy for students to copy and not to learn. Plagiarism is also quite rampant. When I was teaching at CU, I wrote a program that would test to see if two sets of software code were the same. Using this, in a class of over 100, I found that 20% of the students had turned in the exact same code for their project. Because of this, they do poorly on their tests. . . . [however] the university never fails anybody. They just shift the standard."*

Person 1 found similar problems with cheating at Hong KongU as well as at other IT engineering departments in universities throughout Hong Kong. According to person 1:

> *". . .students cheat a lot. There is an immense amount of copying in classes at Hong KongU. My professor buddies at Hong KongUST and CU said the same thing. The professors don't do anything about it because they are afraid of reprisals by the parents. Francis Chin, the department head of Hong KongU's computer science department, said he heard of the parents bringing in lawyers to intimidate the professor that accused their child of cheating. This really hurts what the students get out of the class. When I strictly enforced a no cheating rule in my class, students thanked me for it when the course was over."*

When employers in Hong Kong speak of the quality of software engineers they are getting, every one mentioned the lack of problem solving and self learning skills both in an absolute sense and relative to those engineers educated abroad. The evidence uncovered suggest this may, in large part, be due to the way Hong Kong universities are educating engineers. Anecdotal data from industry and academia almost unanimously point to the fact that training via rote memorization, especially in the IT engineering curricula, is seriously impacting engineers' ability to solve engineering problems once they enter the workforce. The complementary issue to the fact that the IT engineering curricula focuses on memorization is that there are not enough design opportunities in the curricula—a fact unanimously agreed to by professors from the four universities I interviewed. Finally, the whole situation is further worsened by what seems to be serious problems in cheating at many Hong Kong universities by IT engineering students.

5.4.2.4 THE EDUCATION SYSTEM AND THE NARROW KNOWLEDGE BASE OF FRESH UNIVERSITY GRADUATES

Findings show that the structure of the tertiary education system seems to be a major factor contributing to the narrow knowledge base of IT engineers in Hong Kong. Interviewees repeatedly mentioned that the accreditation process used for the IT engineering

degrees was at the heart of this problem. The main issue seems to be that the universities apply an accreditation scheme meant for a 4-year long system to their 3-year long system. According to person 6 of the Chinese University computer science department:

> *"we have to squeeze a 4 year curriculum into 3 years. . . . this makes it difficult for the students to take electives outside of their major and extremely difficult for them to get a minor in an area not related to their major. This is especially true in the IT related majors where we have to add classes on new technologies without taking out the old ones."*

Academics were not the only ones to point to this issue. The Committee on IT Training of the Vocational Training Council produced a report that further supports this hypothesis. In their report, "The 1996 Manpower Survey Report on the Information Technology Sector," they recommended that "local educational institutions should also support the industry by providing a broader curriculum for IT-related degree and sub-degree courses to include essential business-oriented skills in addition to technical IT skills"[lxxxi]. However, perhaps the students in Hong Kong universities describe the situation best. When students at Hong KongU were asked to comment on the flexibility of taking classes outside their major, they said that "the engineering disciplines in general are very closed streams." Person E was an IT major at CityU who graduated in 1995. When asked if he had a chance to take classes outside of his major, person E responded "No. The major is structured so you can't take any business classes. There is some flexibility in your senior year, but you only have flexibility in picking your technical classes. In the 1st and 2nd year, the classes are fixed." In a survey I conducted on Polytechnic University IT engineering students, 61% said they wanted to take more non-technical classes. Of those who wanted to take more non-technical classes, 81.8% said they couldn't do so because they didn't have room in their schedule. Almost identical results came from a similar survey I conducted at Chinese University. At Chinese U, 59.7% of IT

engineering students said they wanted to take more non-technical classes and 82.5% of those said the could not do so because they didn't have enough room in their schedule. Of those who wanted to take more non-technical classes, over 40% wanted to take more language classes and almost 20% wanted to take more business classes[8]. It is interesting that the classes students want to take more of directly correlates with the type of classes employers wish students could take more of. Namely, classes which will help IT engineering students address their deficiencies in communicating and in understanding the business issues that go into creating a technology product.

Many companies complained about the narrow knowledge base of Hong Kong educated engineers. This problem seems to be explained, at least in part, by the rigidity of most IT engineering curricula at Hong Kong's various universities. This rigidity seems to come from the fact that the IT engineering programs are trying to apply an accreditation process meant for a 4 year university system to their 3 year university system.

5.4.2.5 THE HONG KONG EDUCATION SYSTEM AND ITS IMPACT ON ENGLISH SKILLS

A significant problem that many interviews brought up was the poor English communication skills of Hong Kong IT engineering graduates. Not only did those interviewed say the English skills were poor, but they said they were noticeably declining from year to year. Research seems to indicate that this may be a result of two factors: 1) an increasing focus on using Cantonese, the "Mother Tongue," to educate students and 2) a decrease in the admission standards of universities.

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[8] See Appendix A for a description of the response pool.

At Hong Kong's most prestigious universities, where English is claimed as the medium of instruction, a significant portion of instruction actually occurs in Cantonese. According to students from Hong KongU's IT engineering departments:

> *"Lectures have to be in English, but the tutorials are in Cantonese. This is because grad students, the ones who teach the tutorials, are more comfortable teaching in Cantonese. If a professor who speaks Cantonese teaches a recitation, he will teach it in Cantonese because it will be easier for the students to learn and interact."*

Person E, a 1995 IT engineering graduate from City U presents an even dimmer view of the use of English in instructing university students. According to person E:

> *"Most lectures are in English, but not all. If the lecturer is from Hong Kong, then he will lecture in Cantonese. The professors probably do this because they cannot speak English that well themselves. Also, all of the tutorials are in Cantonese. "*

While all of Hong Kong's major universities (except Chinese U) claim to use English as their medium of instruction, in practice the use of Cantonese in various aspects of teaching seemed to be quite common. Even the students feel they are not getting enough language training from their university education. My own survey of students indicated that, of those who want to take more non-technical classes, over 40% of them want to take more language classes. This was, by far, the area where more students I surveyed wanted to take more non-technical classes.

Further research indicates that the cause of declining English skills may arise even earlier than the university experience. In fact, it seems to start at the primary and secondary grade levels. Person 9 of Hong KongUST said that "when I was in primary school, we were taught in English. . .however, [today] primary and secondary schooling is increasingly taught in Cantonese." Person K agrees that "before, most people would go to high schools where most

of the classes were taught in English. Today, there is a push towards mother tongue teaching. Everything except the English class is taught in Cantonese." Person K actually pointed to the fact that it is not that schools are getting lazy about teaching English, but instead that the government is encouraging them to teach their students using Cantonese. According to person K, "The Education Department is encouraging mother tongue education because they think students can learn faster that way."

In 1984, the Education Commission of Hong Kong released its first report, ECR 1. The report made 13 recommendations with the "most significant" being that "individual secondary schools should be encouraged to adopt Chinese as the medium of instruction. . .".[9] According to the Education commission, this recommendation "was subject to research findings on the assumption that, all other things being equal, teaching and learning would generally be more effective if the medium of instruction were the mother tongue. . ." The result of ECR 1's recommendations was that:

> *"since September 1989, all government and aided secondary schools with 18 classes or more have been provided with an additional graduate teacher of Chinese. Of the 361 government, aided and caput secondary schools, 126 have adopted Chinese either fully or partly as their medium of instruction. 38 schools will soon follow suit. A further 120 schools are considering the issue. Since September 1986, teacher training courses have been modified to train teachers for a wider use of Chinese."*[lxxxii]

The Education Commission's 4th report (ECR 4) went further in making recommendations on the medium of instruction at the primary education level. The Education Comission's Working Group concluded that:

[9] In the Education Commission reports, Chinese refers to Cantonese and Putonghua refers to Mandarin

> *"given Hong Kong's situation, the use of Chinese as a medium of instruction in primary schools should be strengthened. It also concluded that the time spent on English should not be increased since it was unlikely that this would lead to higher standards and might indeed result in a distortion of the primary curriculum."*[lxxxii]

While another significant recommendation of ECR 1's recommendations in 1984 was to "improve the standard of English teachers and to strengthen the teaching of English in secondary schools," our interviews in 1996 suggested that this had not in practice been sufficient to counterbalance the effects of the push to mother tongue education.

Another factor that many interviewees mentioned as a potential cause of the perceived decline in the English skills of Hong Kong university graduates was the fact that the universities have become easier to get into. In 1989, the Hong Kong government announced its intention to increase the number of university students from 5% of the population of university age people to 18% over a 5 year period. In order to fill the seats in the newly expanded tertiary sector, the government had to lower the standards for university entrance. In fact, interviews at Hong KongUST, Poly U, City U, and Chinese U all indicated that English skills have worsened, in part, because college admissions standards have gone down.

5.4.3 WORK EXPERIENCE OPPORTUNITIES

In explaining why IT engineering students graduating from Hong Kong's tertiary education sector are missing skills, one must look at the professional training opportunities they are exposed to in addition to their academic experience. In section 3 of this chapter, we identified three main issues concerning the quality of Hong Kong trained engineers: 1) lack of problem solving/self learning skills 2) lack of a broad knowledge base and 3) poor

communication skills. My research suggests that the low quality and quantity of work experience for IT engineers in Hong Kong may be contributing to the first two problems.

Data from Hong KongU's summer job placement program shows that work assignments help students to develop their self-learning skills. Hong KongU places engineers in companies during their second summer in order to help them gain work experience. When students who returned from the work assignment were asked which skills have they improved through the experience, 74% chose "self-learning" skills. To put this in perspective, the second most frequently chosen answer was "human relations" skills with 58% of students selecting it[lxxxiii].

Most Hong Kong IT engineering students don't get meaningful work experience opportunities. One major factor seems to center around how the summers are utilized. Many IT engineers are required to spend one or both of their summers in "simulated industrial training." Simulated industrial training is essentially a lab class during the summer. One of the biggest centers for simulated industrial training is located at PolyU and is called the Industrial Center (IC). According to the IT engineering career counselor at CityU, person 12, 3 of the 5 IT engineering degree programs at CityU require students to spend 10-12 weeks out of both of their summer vacations in the IC. Electrical Engineers at Poly U also attend the IC for between 4 and 6 weeks of each of their two summers, and Hong KongUST had sent its IT engineers to the IC during the past. Hong KongUST has now created its own industrial training program called the Industrial Training Center (ITC). Hong KongU's University Industrial Center (UIC) provides in-house training during the students' first summer. The training is composed of a series of workshops at the university that last between 4 and 10 weeks depending on the major. Thus, as we can see, a significant number of IT engineers in Hong Kong are not utilizing their summers to get the real-world work experience—an

experience that those doing company internships at Hong KongU felt contributed greatly to their self-learning skills.

Beyond the fact that simulated industrial training prevents students from getting work experience during their summers, the quality of the simulated industrial experience is questionable. Person 12 commented that IT engineers from CityU felt the IC training was "too technician oriented—very low level junior technician oriented. Not the type of work professionals would do." Person 9 of Hong KongUST further confirmed this sentiment. He commented that "The feedback we got about the IC from our students was terrible. They called it useless, with terrible instruction and instructors. The modules they had for electrical engineers included plating, machining parts, and plastic molding." Because of this, Hong KongUST stopped using Poly U's IC, but they could not eliminate simulated industrial training from the curriculum all together. According to person 9:

> *"now, it's hard to get a program accredited if it doesn't have such a component. Chinese University wanted to get rid of it all together, but had to settle for reducing the amount of time students spent in it. Simulated industrial training, whether we provide it or whether PolyU provides it is a thing of the past. However, the Hong KongIE (the Hong Kong equivalent of ABAT) is even more short-sighted than ABAT. Accreditation organizations are bean counters, not visionaries."*

The result was that Hong KongUST created its own simulated industrial training program called the ITC. However, even Hong KongUST's improved simulated industrial training program casts doubt on whether such programs will give students the problem solving and self-learning skills asked for by industry. Hong KongUST's ITC will give students "product oriented training. Like how to be a UNIX system administrator. For example, we get SUN's UNIX administrator training program and modify it to include more exercises and some exams" says person 9. However, person 9 does give some insight as to why Hong KongUST,

the most prestigious technical institution in Hong Kong, is providing vocational style training to its engineers. Person 9 comments that "the difficulty is that there is not a job market for design engineers. The demand is for system administrators and IT administrators, both of which pay more than design engineers."

Another option that universities offer to students to help them get professional experience before they graduate is called the "sandwich" program. This program "sandwiches" a year of company internship experience between the 2nd and 3rd years of a student's schooling. However, interviews showed that students' interest in sandwich programs were very low at all the universities in Hong Kong. Person 13 of Hong KongU best conveys the reasons described by many for the low popularity among students of the sandwich programs:

> *"Last year we had 7 students and this year we have 8 students in the sandwich program, however when the program was first introduced there were twenty students participating. We attribute this decrease in participation to several reasons--all of which revolve around the fact that the student must spend an extra year in college. First, because of the political uncertainty attributed to 1997, students want to finish with college as early as possible. Second, because of the delayed graduation, they enter companies a year later than their peers. Thus, a person who was once their peer in college is now in a relatively more senior position in the company since they have been there a year longer. That means they are first to get promoted to higher profile positions within that company."*

For those IT engineering students who are not in the sandwich programs and who are not required to do simulated industrial center training during their summers, the learning quality of their summer experiences is also questionable. Person 1, a former faculty member in Computer Science at Hong KongU, expressed deep concern for the types of work experience even his best students were able to get. According to person 1:

> *"the jobs they get are terrible and offer little educational experience. Even the good students that want to be hackers can't get a decent job. They don't get any network protocol or C programming experience. There should be a program created to allow good students to find good jobs."*

Person 1's IT engineering students at Hong KongU confirm that, in general, students in their department typically get little or no quality work experience during the summer. According to Person 1's students, computer science students at Hong KongU "might do freelance programmer jobs in small companies or vacation in Europe or China. They really don't get quality summer jobs because employers don't like hiring people for the summer." My trip to the Hong KongUST career office further confirmed the dearth of quality technical summer jobs available to students. In their summer job bulletin, only a few technical companies posted summer and part-time jobs. However, not one of the postings by the technical companies were for a technical position. They were all for very low level marketing and promotion type positions. Person 6 of the Chinese U computer science department agrees that "the problem is that [IT engineering] students work in marketing and sales during their summers." Overall, we heard few stories that IT engineers were participating in quality summer work assignments.

One reason for the lack of quality summer opportunities may stem from the hiring practices of Hong Kong's software companies themselves. Of the seven companies we talked to about summer hiring practices, six of them commented that they don't have formal summer internship programs because they don't think students could be productive during the 3 month long summer. When they do hire summer students, they typically do so because it is the child of one of their customers or partners. The issue of summer hiring practices by Hong Kong software companies will be discussed further in the next section. However it seems that

there is an opportunity for industry to do more to give students experience that may help to address, at least in a small way, the skill deficiencies that employers are most concerned about.

5.4.4 CONCLUSION

This section looked at how the Hong Kong education system and training opportunities could potentially be at the heart of the missing skills of IT engineers that Hong Kong software firms commented so frequently about. The research shows that both the education system and training opportunities are probably playing a role in creating the skill gaps cited. Strong evidence was found which connects the deficiencies cited by employers in all three areas, 1) problem solving and self learning 2) narrow knowledge base and 3) poor communication skills, with particular structural issues in the Hong Kong education system. Strong evidence was also found which would connect deficiencies in the quality and quantity of training opportunities with deficiencies 1) and 2) above.

5.5 ARE QUALITY PEOPLE BEING ATTRACTED AND RETAINED BY HONG KONG'S INDIGENOUS SOFTWARE INDUSTRY

5.5.1 OVERVIEW

While findings in the previous section showed that the way engineers are being educated and trained may be at the very root of the problems causing the concern by employers in the quality of the labor force, other issues may also be involved. Data shows that software firms are having a very difficult time attracting and retaining engineering talent. This section breaks the problem down into two parts. First, the ability of software firms to attract engineering talent and, second, their abilities to retain it.

5.5.2 THE ABILITY OF LOCAL SOFTWARE FIRMS TO ATTRACT ENGINEERING TALENT

Many local software firms in Hong Kong complain that it is very hard for them to find engineers, good or otherwise. This could be because there is a 12% shortage of IT personnel in the industry, and because average corporate MIS salaries average almost 19% higher than those of the average ISV[lxxxiv]. However, Hong Kong's local software firms also attribute their problem recruiting to the attitudes of these locally trained engineers, which they say focuses on getting big salaries and big titles. Person O is Managing Director of large Hong Kong software company which makes software for the financial services industry. The company is 20 years old is one of the few software firms in Hong Kong generating enough revenue to make it eligible to list on the HKSE. In terms of recruiting, person O says "we're one of the companies that has better access to universities because I know some of the university professors." However, when asked to describe the effectiveness of his recruiting program, person O was not positive:

> *"The job seekers don't want to take the time to send in a resume so I have them call in, but the response is not good. We (ABC Data) don't think about getting the best students, they wouldn't stay with us anyway. When you're hungry, you don't complain about the quality of the food you're getting."*

This has led person O to seek other sources of talent such as the Vocational Training Council's retraining program, which retrains people with non-engineering degrees to be software developers. However, according to person O, "the problem is that the people that replied sent in resumes that had job objectives like "manager" and not "programmer." They don't want to do what they've been trained for." Person H, founder of young Hong Kong software company, is even more direct about the attitude he finds among locally trained engineers. "Students are too materialistic-they don't look at the opportunity for personal growth," according to person H. Person J, managing director of a local software firm, furthers the view that monetary compensation is a key driving factor in being able to attract talented people. According to person J, "The top students go to top companies. The government gets good students, Hong Kong Bank gets the best student." According to salary surveys from the various university career centers, the jobs with the Hong Kong government consistently offer some of the highest entry level salaries for new graduates. Banks on the other hand offer attractive perks like low interest home loans. Person M also agrees that Hong Kong engineers "need to be more concerned with their professional growth than their pocket growth. People in Hong Kong just focus on money." In all, 5 of the 11 software companies interviewed commented that the desire for high salaries and quick promotions made it difficult for indigenous software companies, typically smaller companies, to recruit IT engineers[10].

[10] This includes the companies mentioned above plus TA Consultants.

Yet, the reasons why companies say students do not accept jobs with them are completely different from what students themselves say about why they do or do not accept job offers. The table below lists why students from different Hong Kong universities decided to take the jobs they did after graduation. The table lists the top 3 decision criteria. When the issues that employers think are important criteria to Hong Kong IT engineers (i.e. "high salary," "company status," or "prospects for promotion") are not among the top 3, the table also shows where students ranked those issues as well.

Hong KongUST		CITY University		Baptist University	
Rank	Criteria (multiple criteria can be chosen)	Rank	Criteria (only a single criteria can be chosen)	Rank	Criteria
1	62.5% Relevant to study	1	17% Good training and learning opportunity	1	Interesting/Challenging work
2	47.5% Interesting job nature	2	15.9% Relevant to course of study	2	Training/Learning Opportunities
3	37.2% Matching career goals	3	13.5% Interesting & meaningful job nature	3	Promotion Prospects
5	29.5% Attractive terms of	4	13.3% Attractive terms	4	Terms of Employment

	employment		of employment		
8	10.3% Status	9	4.2% Good promotion prospects	9	Name/Prestige of the Company
9	8% favorable promotion prospects	10	2.5% high status		

Table 8: Job decision criteria of Hong Kong university graduates

As can be seen from the table above, important criteria in choosing a job seem to be that the job is interesting and that it offers a chance to learn. This is further supported by data I gathered from a survey of IT engineers at Chinese University that found a high correlation between whether or not their previous summer job offered a learning experience and whether or not they were satisfied with the experience. On the other hand, the table also shows that issues such as compensation, opportunities for promotion, and status—the ones employers believe are important to new graduates—are actually ranked relatively low. The remarkable similarity of these results across very different universities lends support to their accuracy.

How can we explain these difference between why employers say they are having difficulty recruiting IT engineers and why students are taking the jobs that they are? To better understand the situation, it is important to understand the process students go through when deciding which job to pick. In this regard, we can apply a concept from marketing theory called the Hierarchy of Effects Model. This model defines a series of "steps" consumers typically go through when make a decision to adopt a given product. In this case, the "product" is a job with a local Hong Kong software company. The model has six distinct steps:

Step	Description	Example
1. Awareness	An individual must first be made aware that the given product does exist	Company A comes to campus to give a presentation to graduating seniors and potential summer interns. The presentation describes the company, the industry the company is in, and the roles the company has for the different students.
2. Interest	An individual must have an interest in the product after being made aware of it if that individual is to proceed to adoption.	A student finds company A's presentation interesting and wants to find out more about jobs with the company, and how those jobs compare with other companies the student is interested in.
3. Evaluation	An individual must have some way to evaluate the attributes of the product.	The student talks to friends who worked at company A or who know people who worked at the company to find out more about the type of work experience it offers. Also, the student can look at stock analyst reports to find out how successful company A has been. The student is

		able to compare company A against other companies the student is interested in.
4. Preference	An individual then must decide which product seems most preferable from a given product category.	Company A has been rated highly by the different sources consulted by the student and the students decides company A would be the best to work for.
5. Trial	An individual who has a positive, low-risk, first-hand experience with the product will be more likely to adopt the given product	Ideally, the student would have a low-risk/low-commitment opportunity to see what working at company A is like—like a summer internship.
6. Adoption	An individual makes the decision to adopt the product.	The student makes a decision based on the information from either step 4 or step 5 to work for company A.

Table 9: Hierarchy of Effects Model

Using this model for product adoption from consumer marketing theory, we can now ask: "are Hong Kong software companies doing a good job of marketing themselves to prospective job candidates?"

Generating awareness about a product is the first step in getting someone to adopt it. Similarly, it is the first step in getting someone to think about choosing a job in a particular industry or with a particular company. Generating awareness is also something that occurs on

several different levels. When getting someone to choose a particular job, at the most basic level that person must be aware that a particular industry exists. Then, they must be aware of the particular companies in that industry, and finally they must be aware of the particular jobs with the different companies.

In Hong Kong, the problem may very well start with the fact that many coming out of college don't know that an indigenous software industry even exists. When questioning Person 1's former computer science students from Hong KongU about the Hong Kong software industry, their response was "It's funny that you say "software industry." That's the first time we've heard those words used in connection with Hong Kong." According to person 1, these were some of the most serious computer science students at Hong KongU, and the fact that they were unaware of a domestic industry makes one wonder just how aware others are.

Further study was done of how aware other IT engineering students in Hong Kong are about the local software industry and about the firms that compose it. The survey I conducted presented seven local software companies including ABC Data, Magic, Integrated Solutions, TA Consultants, Prima Design Systems, Future Solutions, and Turbo Soft. Students were then asked to rate their awareness of the company by putting a check mark in the appropriate place on the scale. The scale was composed of qualitative categories including "Never Heard About Them," "Heard Something, but Not Much," "Familiar With Them," and "Very Familiar With Them." I used a relatively generous criterion to determine whether or not a student was "aware" of the indigenous software industry. If the student had at least "heard something, but not much" about two companies of the seven, they were considered "aware." The surveys done at Chinese U and Poly U revealed remarkably similar results. 22.2% of IT engineering students at Poly U and 22.4% of IT engineering students at Chinese U were

"aware" of indigenous companies in the Hong Kong software industry. What makes the similarity of these numbers from these two different schools even more interesting is the difference in the age demographics of the people who responded from the two universities. At Poly U, 20% of the respondents were first year students while 70% were 2nd year students. At Chinese U, 20.9% of respondents were 2nd year students and 76% were 3rd year students. This could imply a few things. First, it seems that students don't become "more aware" of the indigenous software industry as they go through college. Second, and perhaps more importantly, in a survey in which 76% of respondents were final term, final year IT engineering students who were getting ready to enter industry, only about 1 in 5 was aware of the local software industry.

This naturally leads to the question of how the local software industry tries to generate awareness. While all software companies weren't asked specifically about how they recruit, 4 of the 11 software companies interviewed commented that their primary method of recruiting was to place an ad in the South China Morning Post (SCMP) newspaper. This corresponds well with channels students use to find jobs. According to career office surveys, students from all the major universities use the South China Morning Post as their primary source of job information, even more than their own university career office. However, given the low level of awareness of these companies by students as indicated by the survey, it is clear that advertisements in the SCMP have not been an effective method of generating awareness. The interesting issue is that companies that have bigger reputations to start with, like Hong Kong Bank or Motorola, actually do more to generate awareness on college campuses then the less well known software companies in Hong Kong. Mr. Dennis Lo, the recruiting manager at Motorola, states that his company has "strong ties and student programs with virtually every local university." Person G of Hong Kong Bank's IT department states that they "get almost

100% of [their] people out of colleges." They get these people by going "to give talks during the recruiting days at the campuses-about 2 times per year." Person G, the results of their recruiting programs are very strong. "One year, we were looking to get 100 fresh grads and we got 500 responses," says person G. This is despite the fact that they only use the SCMP to get experienced hires who have skills that are hard to develop in-house.

The key issue is that even the most famous companies have to spend significant amounts of time generating awareness about themselves and the jobs they offer in order to get the best people. This is true not only in Hong Kong but also in the US. Companies like Cisco Systems and Microsoft believe their success hinges on getting the best people in the industry. Even though they both have tremendous reputations in the computer industry, they both spend a significant amount of time trying to generate awareness about the types of positions they offer. Cisco Systems developed the Cisco Friends program to make potential candidates aware of the types of jobs Cisco offers and the work environment it provides. This program pairs current Cisco employees who are in a given job function with potential Cisco employees who may be recruited into a similar job function. Using the framework of the Hierarchy of Effects Model, this allows Cisco to generate awareness, cultivate interest, and help the candidate to evaluate the job in a way that requires very little risk on the side of the potential employee. Furthermore, companies like Cisco and Microsoft assume that the best people are not looking for jobs because good people are probably treated very well by their current employer. However, both Cisco and Microsoft make aggressive efforts to generate awareness among top talent at other companies. According to Mr. David Pritchard, Microsoft's director of recruiting, they "will get an org chart and start calling" in order to make top talent in other companies aware of job opportunities with Microsoft[lxiv]. One might expect that only big companies like Microsft or Cisco have the resources to be aggressive at generating awareness.

However, evidence suggests that companies of all sizes looking for top talent on campuses are aggressive at generating awareness. In the US, medium size software companies like Trilogy or Microstrategy may visit a given campus three or four times a year. They also have their CEO or other top executives come to campuses to talk about issues of interest to students such as emerging technologies, trends in the industry, or how to start a high-tech company. They do this all for the sake of generating awareness about their company among potential employees. Even software startups are active in trying to generate awareness on campuses where they expect to find top talent. During the 1998 spring semester at MIT (from January through early May), over 30 software start-ups sent e-mail to electrical engineering and computer science mailing list in order to attract potential employees. There were also many that came on-campus to recruit students.

Besides being more active on campus in recruiting full-time employees, another tactic that was found to be underutilized by all software firms interviewed in Hong Kong was that of having an active summer recruitment program. An active summer recruitment program impacts many important parts of the Hierarchy of Effects Model. It generates awareness and interest in the company, and it creates a opportunity for students evaluate and try out the jobs at the company with minimal commitment. It also allows the company to scout for top talent, get relatively inexpensive summer labor, and test out potential full-time hires with much less risk. However, none of the indigenous software companies interviewed had an active summer recruitment program. If they did take any summer students, firms mentioned they took them because the intern was related to customers or partners of the company. One might expect that these firms don't have an active summer program is because they are small and don't have as much need for manpower. However, according to Motorola's recruitment manager, Dennis Lo, "for other companies to initiate these kind of [summer and co-op]

programs [like Motorola's] with universities is not a matter of company size, but a matter of company desire." The most frequently mentioned reason for not having an active summer recruitment program was that companies felt that students could not be productive during the summer. This reason was mentioned by six of the eleven software companies interviewed. This seems to point out that local software companies are taking a very short term view with their human resources strategy. They are looking at a summer intern program as something which should produce an immediate return on investment as opposed to seeing it as a strategy which could increase likelihood of top students taking jobs with them after graduation.

Indigenous software companies repeatedly talk about the difficulty of getting talented students to chose a job with them as opposed to a job with a multinational or the IT department of a bank. These local software companies complain that good students choose the jobs with the larger companies because students are "money-oriented" or because they want quick promotions. However, when students are asked why they took the job they did, they give very different explanations. They say they are looking for learning opportunities and interesting jobs. The Hierarchy of Effects Model was used to understand how students go about choosing a job. The model suggests that local software companies spend their time focusing on the very last step of the model—the adoption phase. Their argument is that "top students adopt top companies." However, if we look at the process which students must go through when deciding which company to adopt, we find that local software companies lose out for the most fundamental reason of all—students don't know about them.

5.5.3 THE ABILITY OF LOCAL SOFTWARE FIRMS TO RETAIN ENGINEERING TALENT

While the ability of a firm to attract a talented employee is one thing, keeping that employee is another. This section seeks to understand the impact of employee turnover on Hong Kong software firms and how that level of turnover can be better managed.

According to the 1996 Manpower Survey of the IT industry, of nine different industrial sectors, software vendors had the highest level of turnover of IT people, at 30.1% of their IT staff. In comparison, the finance sector was the third lowest with 16%. In one year, there was close to 45% turnover of applications programmers and 40% turnover of R&D people in the software vendor sector. In the 25th anniversary yearbook produced by the Hong Kong Computer Society, both Paul Chow, the CEO of the Hong Kong Stock Exchange, and John Strickland, former chairman of the Hong Kong Bank, independently criticized the high turnover rate in Hong Kong's IT profession. According to Mr. Strickland "Too many job-hoppers looking for short term rewards makes it difficult to have trust in hiring local companies for large IT projects. It also makes it difficult to make Hong Kong a development base."[lxxix] A survey of human resource professionals confirms that turnover is the number one problem they face[lxxxv]. To put the percentages above in perspective, average labor turnover for all of Hong Kong is 18%. In East Asia, this is second only to Thailand which has 20% turnover. The lowest turnover rate in East Asia is in Japan with 9%[lxxxvi]. Silicon Valley, known as a hot bed for job-hoppers, has an average turnover rate of 16%[lxxxvii]. Thus, as the numbers show, both in an absolute sense and a relative sense, turnover of software developers in Hong Kong software companies is extremely high on average.

There are many potential causes of this high turnover. However, one clue as to why engineers are so dissatisfied on average when working for local software vendors may be found

in the data describing why people pick jobs in the first place. The data from the career offices of various local universities describing the key criteria students used to make their job decision points to the importance of learning opportunities and the importance of the job being interesting. In terms of learning opportunities, the data suggests that software companies might not be training their employees as much as other sectors who utilized IT personnel. The same 1996 manpower study mentioned above shows that, in terms of providing IT training courses to its IT employees, software vendors have the lowest percentage of companies offering various types of formal training. For the software vendors sector, the maximum percentage for a given type of formal training is 68% whereas the second lowest is 73% in transport storage and communication. On average, in 1995, while software vendors trained 31.6% of their employees, finance companies trained 41%.[lxxxi]. The reasons they give for this low level of training are simple. Software vendors were the second most likely sector, behind the restaurant and hotel sector, to say that they don't train people because they don't have a budget for it. However, of these 9 sectors, they were only the 5th most likely to say that they didn't offer training because they already saw their employees as well trained. Thus, one potential issue that the data shows is that, while IT engineers value training, Hong Kong software companies typically do not have the financial resources to provide that training.

The reason why many indigenous Hong Kong software companies believe turnover is so high is because they believe their employees are looking for more financial benefits or bigger titles at bigger organizations like the IT department of a bank. Three of the larger software companies in Hong Kong that we interviewed, ABC Data, WOCS, and ISL all brought up this issue. According to person J, "After several years, our employees jump to the banks so they can get these [low interest housing] loans." Person O feels similar pressure from the banks, especially since his programmers work so closely with them already. According to person O,

"After 2 years of getting experience with us, [my employees] can get a big jump in salary if they go to our customers [the banks]. . .[Hong Kong people] want to get bigger titles and more money "

Another reason for the high turnover could be the lack of financial incentives available to the indigenous firms. When we look at the US to understand how firms help control turnover, one mechanism that has taken on greater importance recently is the use of restricted stock option grants. The value of shares set aside for options grants in the US was about $59 billion in 1985 and by 1996 the figure was about $600 billion. Currently, 90% of public US companies have stock option programs[lxxxviii]. While some might believe this high percentage could be misleading given that many companies grant options only to executives, a study done of 197 companies in the manufacturing, utilities, finance, and trade sectors show that 88% of companies extend options eligibility down through middle management[lxxxix]. In a study of why companies grant stock options, the number one reason cited was said to be "retention of employees."[xc] Options act as "golden handcuffs" in retaining employees because of the restrictions typically placed on them. For example, 86% of US companies had an exercise period of 10 years and 70% had a waiting period of 1 year[lxxxix]. Small high-tech firms especially find the use of restricted option grants as important in helping them retain key talent. One study on high tech firms that recently did an IPO found that the second biggest advantage of going public described by the sample companies was the ability to create employee incentive plans which help retain talent. According to the study "going public clearly demonstrates the potential value of the company to employees and creates liquidity for their equity. These types of incentive plans are hard to implement if the company is private."[xci]

Unfortunately, for many indigenous firms in Hong Kong's software industry, giving equity doesn't seem to have the same retention effects. One major reason for this is that going

public is difficult for many software companies given the current listing regulations on the Hong KongSE (see chapter on capital markets for more detail). Person O tried to offer equity as means of retaining people when his company was far from being able to meet the Hong KongSE listing requirements. However, when ABC Data "tried to offer shares in 1985. . .it was a disaster," according to person O. "The company had no possibility of being listed at that time, so equity in the company didn't mean anything to the employees." Thus, without the ability to create "golden handcuffs," one might expect that reducing turnover in Hong Kong's software industry will be difficult.

There are several possible explanations for why turnover is so high in local software firms. We found that the indigenous software industry can't invest as much in formal training as some of the other sectors which it competes with for IT manpower, and we found that the "golden handcuffs" so effectively employed by many firms in the US is not an option for the typical Hong Kong software company. Finally, many in the local software industry believe people just go to a small software companies to get some experience so that they can get a better paying job at the IT department of a bank. One way to gain insight into which of tehse factors is most important is to look at high-tech firms in Hong Kong with low turnover rates and try to understand if they have anything in common. Six high-tech companies in Hong Kong were interviewed whose employee turnover ranged from "virtually no turnover" to about 10%. The companies include Motorola, Johnson Electric, Wong's Circuits, Goldpeak China, Prima Design Systems, and Future Solutions. The reason mentioned by all six companies as to why turnover was low was the effort they put into helping their employees to develop professionally. According to person D, "I provide lots of training. . .I have people come in and lecture on special subjects. . .[and] I send people to universities." Person N comments that "we don't have trouble keeping people because they learn a lot with us. We've

had people that have been with us for 5 to 6 years." Of all the companies interviewed by the MBHong Kong team which have plants both in Hong Kong and China, only one, Goldpeak, had lower turnover in China than in Hong Kong. Goldpeak's statistics show 14.29% turnover among engineers in Hong Kong while only 7.2% turnover among engineers in the PRC. When looking at the different human resource practices in Goldpeak China versus Goldpeak Hong Kong, we found that Goldpeak China has a well-defined training program in Shenzhen called the "Clipsal China Apprentice Training Center" which is a program jointly offered with Shenzhen University. However, no such training program exists in Hong Kong.

While all six companies pointed to the effort they put into professional development of their staff as a major factor contributing to their low turnover, only 2 of the 6 made reference to financial incentives as another factor. Johnson Electric mentioned that it gives low-rate housing loans and other financial incentives for people who stay with the company a long time, and Prima Design commented that they give people equity and profit sharing. However, financial incentives as a reason for low turnover were not mentioned at all by the other 4 companies.

The six companies that have such low turnover can provide an important lesson to Hong Kong software companies. The lesson is that people will stay with your company if they feel you are playing an important role in their development. This is not only supported by the anecdotal evidence of the six companies above, it is also supported by what Hong Kong college students say are the most important criteria for choosing a job.

5.5.4 CONCLUSION

This section looked at two major influences on the quality level of people in Hong Kong firms; first, the ability of the firm to attract quality people, and second, the ability of the firm to retain them. In terms of being able to attract quality people, the Hierarchy of Effects Model presented a series of steps someone must go through before "adopting" a job. Data show that students are probably not looking at working for indigenous software companies for the most fundamental reason of all—they don't know about them. In terms of retaining people, local software companies were found to have extremely high turnover rates by any standard. While many in the local industry say that people leave in order to get more money or bigger titles, anecdotal data from firms with very low turnover seem to show that the most important factor is investing in the development of employees.

5.6 CONCLUSION

Quality people are of tremendous importance to the growth of a software industry. Data from a recent survey of MIT related software companies describes it well. The most important reason by far for contact with universities by these software companies, above faculty consulting, doing joint R&D, and other potential reasons for contact was the need to do recruiting. The most important determinant for a software company to locate where it did was because of access to skilled professionals. Besides the limitations provided by the capacity of the present location of the company, access to skilled professionals was the most important factor affecting a software company's expansion.

Because of the vital importance of people in driving software companies, this chapter took an extensive look at the ways in which human resources issues could potentially be affecting Hong Kong's indigenous software industry. A model was proposed in order to provide a

framework for understanding the importance of the quality level of people in the software industry in driving its growth, and the different ways in which that quality can be affected. Secondary data collected on the US, Israel, India, and Ireland suggest that the successful firms in these economies consider the quality level of local people to be very important to their success. Thus, not only did quality seem to be present in the labor pool for high-tech in our comparison economies, but that quality level was cited as an important driver of growth.

The next step was to understand the quality level of IT engineers in Hong Kong firms, and the key factors that could be affecting that level of quality. Consensus from the interviews showed that domestic software companies were not happy with the quality of engineers they were getting. Fundamentally, this quality was found to be affected by problems in the way IT engineers are educated and trained. The quality level of IT engineers working in Hong Kong's indigenous software sector is further impacted by the difficulties that sector has in attracting and retaining quality engineers.

What this overall analysis tell us is that quality people are fundamental to driving the growth of a software industry. There are no examples of a successful software industry in which the quality of people is not rated highly by some third party. This result has important implications for Hong Kong's long term priorities if it wants to build a competitive software industry

APPENDIX A: SURVEY INFORMATION

The survey taken at Polytechnic University had the following statistics:

36 respondents all of whom are IT majors. The survey was handed out during classes and, according to the faculty who handed them out, the response rate was near 100%.

The breakdown by year is as follows:
20.% 1st year students
75% 2nd year students
5% 3rd year students

The survey taken at Chinese University had the following statistics:

67 respondents all of whom are IT majors. The survey was handed out during classes and, according to the faculty who handed them out, the response rate was near 100%.

The breakdown by year is as follows:
0% 1st year students
21% 2nd year students
79% 3rd year students

6. SOURCE ORGANIZATIONS

6.1 INTRODUCTION

The term "source organization" has been used by Prof. Edward Roberts of the MIT Sloan School to refer to an organization which provides the technological base for a start-up company[xciii]. This base may be provided through the physical transfer of technology or simply through the specialized training that the founder of the start-up gets while at the source organization. My definition of a "source organization," is slightly broader than that of Roberts. I define a source organization as one which provides the technological and the managerial base for a start-up. This expanded definition reflects the importance of sound management as well as sound technology in creating a successful new venture.

This chapter takes a closer look at the role source organizations play in helping to create an industry. Specifically, I look at two main types of source organizations, universities and large companies, and try to understand their impact in providing the technological and managerial base for new companies in the software industry. I then look at the Hong Kong economy to understand how their presence (or lack thereof) my be a factor in affecting the growth of Hong Kong's indigenous software industry.

This chapter is divided into four main sections. Section 2 presents an overview of the theory of source organizations developed by Roberts. While focusing mainly on the issue of

technology, this section characterizes source organizations and presents conditions which promote or inhibit the transfer of technology from the source organization to the start-up. Section 3 examines the role universities have played in high-tech industry formation both in the US and in our other comparison economies, and then compares this with the role universities are playing in Hong Kong. Section 4 looks at the other major category of source organizations, large high-tech companies. While the chapter on universities mainly focuses on their role as a technological source organization, section 4 considers the role of large companies in helping to form both the technological and managerial base of new enterprises. Section 5 concludes by comparing the role of source organizations with the other macro-variables looked at elsewhere in this thesis.

6.2 OVERVIEW OF THE THEORY

The research conducted by Roberts provides a solid basis for understanding the link between source organizations and the formation of new enterprises, especially in the high-tech sector[xcii]. Roberts' work finds that source organizations are important because they provide a low risk opportunity for potential entrepreneurs to learn about problems and how they can be solved with particular technologies or skills. For example, of 125 companies started by MIT affiliated people, only 13% had no technical dependence whatsoever on the MIT lab where their founders had gained experience. Roberts' research finds that large high-tech corporations also play an important role in acting as the source of the technological base of new enterprises. Evidence from one major electronics manufacturer showed that 40% of the companies that were started by its former employees used technology which either "directly" or "partially" came from the electronics manufacturer[11]. The results Roberts' collected from a large diversified technology company presented even greater evidence. In this case, 48% of the new companies started by the diversified technology company's former employees were "direct" spin-offs while a further 17% were "partial" spin-offs. Roberts' study of Route 128 firms was paralleled by a study of Silicon Valley firms. In 1984, a survey showed that 75% of 182 Silicon Valley firms' founders, while at their previous position, had already been working on the technologies that formed the core of their new firm's knowledge base. Furthermore, 54% had even been working on similar products.

[11] The definition of "direct" is that "the company in its present form wuld not have been started without the source-learned technologies. It now utilizes or utilized at the beginning mostly what the founder(s) learned at the source." The definition of "partial" is that "an important aspect of the company's work originated with source-learned technologies. The individual who transferred the technology might have supplemented the source-learned technologies at other employment between the laboratory and the new enterprise."

Roberts went further to understand what factors contribute to the technology transfer from source organization to new firms. His research finds the following four factors important to the transfer of technology from a source organization to a new enterprise:

- The opportunity to work on development as opposed to pure research projects
- The longer the employment with the source organization, the more direct the technology transfer from the source organization to the new enterprise was.
- An ability to work part time away from the source organization
- Personal aptitude at about the Master's level of education

Thus, the basic idea surrounding the importance of a source organization is that it is a low-risk place to learn and get experience before starting a company. While Roberts' work focuses specifically on the importance of the source organization with respect to the technological base of new enterprises, the same logic can easily be extended to understand why they form the managerial basis of new enterprises as well. While working at an MNC might not necessarily teach someone the best way to operate a business, it gives them experience with what works and what does not..

6.3 UNIVERSITIES AS SOURCE ORGANIZATIONS IN THE COMPAIRISON ECONOMIES

6.3.1 INTRODUCTION

Data shows that universities have played an extremely important role in high-tech industry formation by providing the technology base of new enterprises. This technology base is not only provided through the physical transfer of technology, but also through the quality of the specialized technical training that the university provides. This section looks at how innovation and training in universities has the potential to affect a software industry. First, the case of the US is examined in depth, then followed by an examination of the other comparison economies.

6.3.2 UNIVERSITIES IN THE US

This subsection will look at the role several universities have had on building high-tech industry in the US.

MIT

As mentioned earlier, research by Ed Roberts showed that, of 125 MIT related companies surveyed, only 13% had no tie with the technologies that the founders worked on while at MIT[12]. On the other hand, 53% had very important or important ties[xcii]. One important aspect about MIT that led to the tremendous number of companies which share a technological base with the university's research is the extremely high level of investment in research at the university.

[12] MIT related companies as defined by Roberts as companies which were founded by former employees of MIT major laboratories and engineering departments.

Beyond the advanced technology, there were several factors that made MIT important to the development of many new firms. First, leaders at MIT encouraged faculty, staff, and students to start their own companies with the technology they had been working on at MIT. This encouragement started at the top by successive presidents of MIT including Karl Taylor Compton and James R. Killian. Respected faculty also created important role models for others. These early faculty-entrepreneurs (and the companies the started) included Doc Edgerton (EG&G), Bolt and Beranek (BBN), and John Trump (High Voltage Engineering). Charles Stark Draper, long-time head of MIT's Instrumentation lab was also instrumental in encouraging numerous people at his lab to start their own companies. In this environment, there was never any question when somebody wanted "moonlight" on an outside project or with an outside company. Researchers were even allowed to take home research equipment during the weekends without any question. According to Roberts, "approximately half of all spin-off enterprises, including essentially all faculty-initiated companies and many staff founded firms, are started on a part-time basis, smoothing the way for many entrepreneurs to 'test the waters' of high-tech entrepreneurship before making a full plunge." It is as though every part of MIT was working in concert to encourage the transfer of technology from MIT to new firms. Even the Technology Licensing Office (TLO) was making it easier to commercialize MIT technology. In 1988, the TLO's head, John Preston, initiated new policies which would allow MIT to license technology in exchange for stock instead of for a fee. In the first year of the policy, 6 new companies were started based on that practice, and 16 were started the second year.

STANFORD

The roots of Silicon Valley can be traced to the efforts of a Stanford faculty member named Frederick Terman. He encouraged his students, William Hewlett and David Packard, to start a company based on their PhD research[xciii]. Like MIT's Compton and Killian, Terman created an atmosphere that encouraged the commercialization of research and the strong links between faculty and industry. More recently, the research in Margaret Jacks Hall at Stanford, former home to the university's computer science department, led to such companies as Cisco Systems, Sun Microsystem, and Silicon Graphics. Like MIT, the involvement of faculty in starting companies has been extremely important. Jim Clark, as a professor at Stanford, developed the technology which became Silicon Graphics. Prof. David Cheriton co-founded a networking company named Granite which was subsequently sold to Cisco Systems for $220 M. Also, both the former dean of the school of engineering and the chairman of the computer science department are involved with companies they helped start. As Fortune magazine describes it, "Stanford is the *cause* of Silicon Valley."[xciv]

UNIVERSITY OF CALIFORNIA BERKELEY

The importance of UC Berkeley on the growth of the software industry in Alameda County California (just outside of Silicon Valley) was confirmed by the research of Anna Lee Saxinian. According to her, "UC Berkeley professors or graduate students have participated in virtually every major regional software start-up." She goes on to say that "much more than capital or any physical resource, knowledge is the most important commodity in software production. . . .To this end, UC Berkeley and related institutions . . .[are] primarily responsible for the breadth and character of the regional software industry."[xcv]

UNIVERSITY OF CALIFORNIA AT SAN DIEGO (UCSD)

Universities and related research institutions were not only important to the development of the information technology industry in the US, there were also an extremely important technology source for spawning the biotechnology industry[13]. San Diego was made one of the leading biotechnology centers in the world mostly because of it's universities and related research centers. According to one study, 51% of the 90 biotechnology firms that were established in San Diego between 1971 and 1991 can trace their roots to UCSD and related research institutes. As with the information technology industry, those researchers employed by UCSD played a very important role in company formation. Probably one of the most famous companies started by UCSD researchers was named Hybritech. Hybritech's early success lead to the formation of a number of other biotechnology companies in the area. In all about 15% of the companies established between 1971 and 1991 can trace their roots to the company started by Hybritech.

These different examples of US universities helping to spawn industries or important segments of industries have three important implications. First, Roberts' research on the importance of university R&D in forming the technological base of new enterprises seems to be supported by many other cases outside MIT. Second, it seems to be important for the new industry to cluster around the university. This is because the geographical proximity allows ready access to important technologies and people. Finally, in every case described above, an important form of technology transfer was not by the university licensing its research to an already established company, but instead was the transfer of that technology through companies initiated by university faculty or staff.

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[13] Related research institutions include Scripp's Clinic, the Salk Institute of Biological Studies, and the La Jolla Cancer Research Foundation.

6.3.3 UNIVERSITIES IN IRELAND, ISRAEL, AND INDIA

Evidence was gathered on the role of universities in our comparison economies outside of the US. While evidence was found on university technology being spun-off and having impact on the local industry, data as detailed as that gathered on the US was difficult to come by.

IRELAND

IONA is arguably the most successful software company coming from Ireland. It's product is the CORBA standard object request broker which lets different types of computers better talk with one another. Furthermore, its product is the world leader in that product category. IONA was founded as a result of experience in distributed systems and object technology gained by researchers at the department of computer science at Trinity College Dublin[xcvi].

Audio Processing Technology (APT) of Belfast is a spin-off company founded from the R&D work at Queen's University in Ireland. This company created the first digital soundtrack for a Hollywood motion picture. The movie to first employ APT's technology was Stephen Spielberg's Jurassic Park[xcvii].

As Roberts discussed, it's not only the physical transfer of a particular technology that is important, but it is also the training that people get with technologies that is important to forming the technological base of enterprises. In Ireland, the managing director of pharmaceutical company mentioned that 50% of the people on his staff were from UCC (a major research university in Cork, Ireland). Furthermore, the managing director was planning to raise this number to 60%. What is the reason for this enthusiasm about the graduates of

UCC? According to the managing director of the pharmaceutical firm, the graduates are of such high quality because the university is active in research, enabling its graduates to keep up to speed with developments around the world[xcviii].

In general, it seems that the transfer of technology and technical know-how to the private sector from universities is encouraged in Ireland. In addition to the above examples, another small, by interesting tell-tale sign of this encouragement is a Web site set up by Ireland's National Software Directorate. This Web site contains a database of continuously updated information on current research projects being undertaken by the universities. The database is searchable via key word searches and by research area, college, deliverables, and sources of funding[14].

ISRAEL

The segment of the Israeli electronics industry which produces components (including semiconductors) netted $860 million in sales or 14.6 percent of the entire sales of the Israeli electronics industry. This industry was directly impacted by Israeli universities, namely, the Technion. The motivation for the Technion to do research in component electronics was a result of the Yom Kippur war in 1973. During that war, the Israelis were taken by complete surprise by the night vision capabilities of the Egyptians. However, Israel responded by developing their own imaging capabilities. This started when the late Professor Yitzhak Kidron set up a plant at the Technion to design and produce infra-red night vision equipment for the military. According to Yael Nemirovsky, associate professor of electrical engineering at the Technion who worked with Kidron until his death, "Professor Kidron was the father of microelectronics in Israel. . . in the beginning he defined a very specific niche - infrared

detectors which were required for the defense of Israel. One success brought another and that is where it all began."[xcix] Prof. Kidron's work lead to a plethora of people from the Technion developing skills in imaging. In the late 1970s, this specialization in imaging led to the first two civilian companies which soon became world leaders in their market. These were Scitex in digitized pre-press systems and Elscint in computerized tomography. They were also very noteworthy in that they helped set some of the earliest examples for others to follow 5of Israeli high-tech companies going public in the US[c].

INDIA

The role of Indian universities has been to impart software development know-how into its graduates. As described in detail in the chapter on human resources, Indian educated engineers are described as extremely capable and their skill is an important reason for the growth of the indigenous industry. However, detailed data about the connection between the technical education in universities and the technical expertise of Indian software engineers was difficult to find, and presents an area where more research needs to be done.

6.3.4 CONCLUSION

Strong evidence from three of our four comparison economies show that universities play an important role in providing the technological base for new enterprises in the high-tech industry. Furthermore, in these economies, it has been the new enterprises, as opposed to more established ones, which have played an important part in the growth of the industry. The two key attributes of universities as source organizations seem to be their extensive

[14] The Web site can be found at http://www.nsd.ie/cgi-bin/ResearchQuery

investment in R&D and the opportunities they create for transferring technology and technical know-how into the commercial sector. As was seen in the case of the US, a particularly important method of technology transfer was when university faculty or staff took the their technology or technical expertise and created a new company. The ease with which this method of technology transfer could occur seems to be facilitated by the culture of the various universities.

6.4 UNIVERSITIES AS SOURCE ORGANIZATIONS IN HONG KONG

6.4.1 INRODUCTION

In the sections above, we identified two main factors that have allowed universities to have an important impact on the respective indigenous high-tech industries in three of our four comparison economies. First, research done at the universities created a source of technology or technical know-how that was important to the formation of firms and even industries. Second, transfer of the technology by faculty, students, and staff was facilitated in various ways by the university. Using this two-factor framework, we can examine the extent of the impact Hong Kong universities are having and potentially can have on the indigenous high-tech industry.

6.4.2 INNOVATION IN HONG KONG UNIVERSITIES

Research shows that innovation in Hong Kong's university system is fettered. In the two years including 1995 and 1996, data from 4 of Hong Kong's 5 research universities shows that there were only 9 patents received across all disciplines. This is despite the more the almost $100 million that was invested in technological research[ci]. Interviews with those in the Hong Kong university system suggest there might be several reasons for this.

One issue stems from the lack of space to do research. Several universities mentioned that it was lack of space, not money, that prevented them from doing more research. According to person 6 of CU, "Funding is not a problem to get a program going, the greatest problem is lack of lab space. . .computer science is the worst off, or as some like to say, the most

efficient." Person 4, a senior faculty in the computer science department at Hong Kong U, said that "before we moved last September, we were very tight on space. University policy is that graduate students don't get offices, so this impacted the amount of lab space we had." Speaking more generally about the situation of universities in Hong Kong, the president of one of Hong Kong's leading universities said that "universities really need some low grade space where we can do some activities." He went on to speak of his university's situation in particular saying that "our professors are hard-pressed for space to do their research." Inspired by the technology transfer created by MIT's Lincoln Labs, the dean of the engineering department of one major Hong Kong university wanted to create a similar lab at his university. However, as with the situation mentioned by the other universities above, he said the major barrier to creating such a lab is that there is no space. The only university that we asked about the space issue where it didn't seem to be a problem was at HKUST. However, at the time of the interview, that university was only about 5 years old.

The second major issue that seems to be effecting the quality level of research being done has to do with people. Specifically, the issue raised by many is that Hong Kong research assistants (RAs) and graduate students are not interested in research and consequently do not do good research[15]. Person 2, a computer science professor at PolyU, describes PolyU's situation:

[15] In Hong Kong, RAs are individuals who have already received their undergraduate degree and who are currently doing research at a university. However, RAs are not in a degree program

> *"Most of the good Hong Kong undergraduates go to graduate school abroad. As for research assistants (RAs), most stay 9-10 months and then leave, especially in computing. This is because it's easier to find a job once they work here for a little while. We have 10 RAs, but their quality is not that good. Most of the people from Hong Kong that apply to be RAs are the ones who couldn't get a job after their undergraduate degree. That is why most faculty here like to get their RAs from China. We have 25 grad students. The problem is that we can't use the money allocated for RAs to attract good grad students. Another problem is that the government limits the number of non-local grad students to about 25%. However, we're fighting to increase this number to 40%."*

The difficulties that result from not being able to attract good researchers is told best by the numbers. During the two years including 1995 and 1996, PolyU did not produce any patents in any fields of research[ci].

Person 4, a professor at Hong KongU's computer science department, describes a similar situation:

> *"About 10% of grad students [in his department] were the better undergrads when they were in college. However, we have to bring in a lot of people from China. We rely heavily on RA's from China to get our research done. In terms of graduate students, there is a limit to the number that we can have from China. The grad students from China are usually of better quality than the Hong Kong ones. The students from China also work much harder than the Hong Kong ones. A student who comes from China to be an RA or regular grad student makes Hong Kong$15,000 per month. A professor in China makes Hong Kong$1,000 per month. So they come here and try to save as much as they can. Besides just being hardworking by nature, when you don't want to spend your money on recreation you don't have too many other things to do besides work.*

The same story is told yet again by person H, a former lecturer in computer science at Chinese University: According to person H:

> *Grad students don't go to grad school to do research, they go there to job hunt and get a good salary while they are hunting. This is not my personal opinion, it is a fact. Many grad students never finish their degree because they get a job offer first. For example, I knew a student in computer science getting his Ph.D. He was very good, but he quit a year before he got his degree to go to Hong Kong Bank's IT division to do source code control[16]. Because of this problem, professors don't require a lot of work out of their grad students. Grad students get good pay for doing mediocre work because most funding is restricted to personnel usage. Professors don't dismiss these grad students because the norm is that grad students don't do work. Also, if they dismiss grad students, that means they get less money for their research because they have a smaller head-count in their lab. The result is that not too many good papers get published. The people that do publish are usually outsiders who brought their work to Hong Kong.*

Between the lack of research space and the lack of quality student researchers, universities face major challenges to becoming sources of innovation for the local high-tech industry.

Finally, a third issue brought up by several is that it may just be an issue of time. That is to say, many believe that real research in Hong Kong universities only started in the early 1990s. Person 6, a computer science faculty member at Chinese University, mentioned that "about 3 years ago, we were asked to emphasize research even more." The dean of one of the engineering departments at a major Hong Kong university further concurred that "local university research just developed in the last 5-6 years." According to person 2 of PolyU's computing department, PolyU's older faculty in his department were all trained in the data processing centers of large companies, not in academia. However, it is important to keep in mind that, while it might just be a matter of time before Hong Kong universities start generating more innovation, current problems such as space constraints and lack of research oriented graduate students and RAs points to the fact that more has to be done than just waiting.

6.4.3 ABILITY TO TRANSFER INNOVATIONS FROM THE UNIVERSITIES TO INDUSTRY

An important factor in allowing technologies developed at universities to have impact on an industry is the ease with which those technologies can be transferred. As we saw from our comparison economies, one important way that this manifests itself is through the degree to which universities encourage their faculty and staff to interact with industry and even the degree to which they encourage their faculty to leave academia and form new companies. While I do not have in-depth data for Hong Kong, various pieces of anecdotal data suggests that there are a variety of barriers that impeded the transfer of technology in this way from Hong Kong universities. Probably first among the various issues is the cost to a faculty member if he or she wants to leave the university. Since universities provide subsidized housing for many of their faculty, leaving the university would not only mean the disappearance of one's salary, but also the corresponding difficulty in finding an affordable place to live that meets the faculty member's standards. Interviews suggested that challenges associated with housing discouraged faculty from taking their technology or technical know-how and leaving to start a new company. A second issue seemed to be the limited interaction the faculty had with the local software industry. Interviews with the computer science department of one of Hong Kong's top three universities uncovered the fact that only one faculty member in the entire computer science department consults with industry. A third issue is the availability of space to setup a new company once one gets an idea. Unlike Stanford's Industrial Park, and the area around MIT, faculty who want to leave the university will find it difficult to find low cost office space. A final issue that was raised by interviewees

[16] Source code control basically involves ensuring that, when different people are working on the same piece of software, that the newest version doesn't get overwritten by something older. In general it involves little innovation or R&D.

was that some universities don't have efficient technology transfer programs. A CEO of one of Hong Kong's largest software companies mentioned that he wanted to license a technology from a university to put into a new product. However, because the technology was created with government money, the CEO would have to repay the full cost of developing that technology before he could develop a product around it.

It is clear that more in-depth data is needed on the ease with which technology can be transferred from Hong Kong universities. However, there does seem to be effort in the area of facilitating technology transfer via generating more awareness about Hong Kong technology. For example, the Hong Kong Industrial Technology Center Corporation publishes the Business and Technology Information Quarterly and they also have various seminars which also try to promote technology in Hong Kong to the private sector. Hong Kong's newest university, Hong KongUST, has also been active in promoting technology transfer to corporations via its RandD corporation. However, as we saw with many examples from our comparison economies, technology transfer by university faculty and staff going off to start their own companies has been an extremely important method of technology transfer to the private sector. When identifying opportunities for technology transfer, Hong Kong universities cannot forget to take this method into account.

6.4.4 CONCLUSION

Evidence from our comparison economies suggests that universities play an extremely important role in contributing to the growth of various high-tech industries. They play this important role because they allow people to work on innovative technologies and because they a way for actual technology or the technical know-how to be transferred to the industry.

However, evidence from our comparison economies show that an important method of transfer was not simply the sale or licensing of the university's technology to an outside corporation, but instead an important method of transfer was that people from the universities actually left to form new companies with their technologies. Given this, the challenges for Hong Kong universities seem to be two fold. First, due to space and human resource constraints, Hong Kong universities do not seem to be the same sources of innovation that their foreign counterparts are. Second, due to a variety of factors, the transfer of the technology from Hong Kong universities to the private sector seems to be constrained. The result is that the indigenous industry is missing an important variable for growth.

6.5 CORPORATIONS AS SOURCE ORGANIZATIONS IN COMPAIRSON ECONOMIES

6.5.1 INTRODUCTION

Large corporations were also identified by Roberts as important sources for forming the technological base of new high-tech enterprises. However, while Roberts solely focuses on the importance of technology transfer from corporations to new enterprises, my definition also incorporates the transfer of managerial know-how. Managerial know-how is a catch-all for the experience one gets by working in large high-tech firm that goes beyond the technology. This is important because spending time in a corporate environment gives potential entrepreneurs a perspective on how a high-tech organization is run. The following sub-sections describes the impact of corporate source organizations for each of our comparison economies.

6.5.2 THE US

Evidence showing that large high-tech organizations in the US provide important managerial and technical know-how to new firms is numerous. Unlike Route 128, Ed Roberts finds that Silicon Valley and "the resulting proliferation of firms there came from multiple spin-offs of other companies, and did not follow the dominant greater Boston pattern of direct fostering of new firms from university labs and departments."[xciii] For example, Fairchild Semiconductor gave birth to such industry giants which include Intel, National Semiconductor, and Advanced Micro Devices (AMD)[cii]. Xerox PARC was the source of the ethernet technology that started 3Com as well as technologies that were the base of a number of other companies.. Tracor, an electronic warfare equipment manufacturer in Austin Texas is responsible for creating 16 new firms in the Austin area. Similar to universities, these large companies provide people with a low-risk opportunity to learn about various technologies and

the problems which those technologies can solve. However, they also provide and added dimension of learning where potential entrepreneurs get exposed to dealing with high-tech products in the market.

6.5.3 IRELAND

In Ireland, engineers' training both abroad and domestically in (mainly US) MNCs was cited as an important factor in helping the indigenous software industry to grow[ciii]. Heavy investment in educating engineers by the Irish government created a surplus of labor who mostly went to the US to find work. Data shows that between 10 and 20% of Irish computer science graduates emigrate within one year of graduation. Anecdotal evidence suggests that 50% to 70% emigrate at some point in their career thereby creating a significant brain drain[lxx]. However, the experience they gain working in MNCs (whether abroad or domestically) gives them the experience to start their own firms and the credentials to obtain VC funding. For example, RFT is Irish firm which makes software for the manufacturing industry. As described in the chapter on capital markets, the Irish venture capital firm ICC invested in RFT when it was three years old. This was one of the youngest companies that ICC had invested in and they only did so because RFT's products were "highly innovative and because their directors were all very experienced in the industry." Where did the directors of RFT get this experience? According to one of the founders of RFT, "All of us were senior managers with US manufacturing organizations in Ireland before we set up our own business."[civ]

6.5.4 INDIA

The growth of the software industry in India also seems to be strongly affected by the contributions of Indians who were trained in US high-tech MNCs. Specifically, researchers sight the contributions of expatriate Indians as one of three key factors leading to the success

and growth of the Indian software industry[cv]. According to this research, "Indian engineers and technicians who migrated to the west, mostly to the US, during the sixties and the seventies appear to be a source of finance, technical assistance, and market intelligence to the Indian companies."[cv] Some very successful Indian software companies like Wipro Limited, Infomart, and BPL systems were started by return migrants. One of the unique aspects of the Indian software industry compared with other industry's in India is the management system used by most indigenous software firms. The management style in many software firms is said to be an important part of what makes the industry competitive in export markets. According to researchers:

> *"the communication channels between the top management and the young software engineers appears to be free of the hierarchy and bureaucracy typical of the traditional industries. The managers are acutely conscious of the need for training and the promotion of job satisfaction for their employees. . .it is the training and life styles which the managers have acquired abroad. . .[which] explains [this] enlightened style of management."*[xv]

6.5.5 ISRAEL

High-tech in Israel was affected by a similar "brain drain and return" phenomena that both India and Ireland experienced. According to one business article:

> *"Throughout the state's half century, Israeli universities trained engineers in the latest technologies for the country's defense. But, with no internal commercial market, until a decade ago, the supply of graduates far exceeded the demand. Many left, mostly for the United States, in search of greener pastures and higher education. Dov Frohman developed the original EPROM at Intel. Yaron Shamir, general manager of Microsoft's R&D lab in Israel, was Microsoft's development manager for networking and OS. Joseph Raviv managed groups at IBM's Thomas J. Watson Research Center. They sold their American bosses on the potential of Israel's plentiful technical brain power, and returned to head the investment. Most such ventures succeeded and grew."*[xvi]

The experience working in MNCs that the individuals mentioned in the quote above got gave them the opportunity to return to Israel to start the Israeli subsidiary of their respective parent MNCs. Essentially, they came back and started new companies which have been important contributors to the Israeli high-tech industry. While much of the attention in Israeli high-tech goes to the indigenous industry, figures from 1994 show that subsidiaries of foreign MNCs play no small role. The Intel subsidiary that Dov Forhman started had 451 people and was designing next generation processors for Intel. The Microsoft's R&D center started by Yaron Shamir had 26 people and was responsible for designing MS Proxy Server—Microsoft's network firewall software. Finally, Joseph Raviv's IBM subsidiary had 240 people working on a variety of technologies[cvii].

6.5.6 CONCLUSION

The type of corporations that seem to make the most effective source organizations are those which invest heavily in R&D and which in turn have internationally competitive high-tech products. However, the data from our various comparison economies shows that corporate source organizations are not only important for the technical know-how they impart in people, but also for the managerial know-how. In essence, the provide a "complete" training experience for those who might one day want to start their own firm. Finally, we find that corporate source organizations do not necessarily have to be domestically located for them to have an impact on the domestic high-tech industry. Since high-technology is very knowledge intensive, the value of the experience one gets from working at an MNC can easily be brought to whatever location a person chooses to call home. These lessons learned from our comparison economies will all have important implications for understanding the role of corporate source organizations in Hong Kong in the next section.

6.6 COMPANIES AS SOURCE ORGANIZATIONS IN HONG KONG

Hong Kong is not without examples of corporate source organizations helping to spawn new companies. Motorla, Hong Kong's best example of a large high-tech MNC doing R&D in the territory, led to the formation of a company called Group Sense Limited (GSL). GSL develops hand-held electronic dictionaries for the Asian market, and, in 1995, was a public company on the Hong KongSE with revenue of approximately US$53 M. One of the founders of GSL, Samson Tam, had worked at Motorola in Hong Kong before starting the company. Mr. Tam started GSL because he knew early on about a chip that Motorola Hong Kong was developing that would improve the performance of various types of personal digital assistants like hand-held electronic dictionaries. An important part of GSL's success comes from building one of the first products that took advantage of Motorola's new technology. However, stories such as this are few and bar between in Hong Kong. According to Mr. C.D. Tam, the General Manager of Motorola's Asia Pacific Group, "the weakest link in Hong Kong is the entrepreneur's link to the big developers like Motorola. . .there needs to be more opportunities for people like Samson Tam of GSL." Corporate source organizations in Hong Kong which provide exposure and training to the latest information technology R&D are scarce. It is not only that there are very few large high-tech corporations doing R&D in Hong Kong, there are simply very few large high-tech corporations in Hong Kong period. Appendix A shows that there are only 18 companies on the Hong Kong stock exchange that might be considered high-tech. This lack of corporate source organizations, in terms of sheer numbers, simply creates a dearth of people who have the necessary training and experience to start their own high-tech companies..

One main issue seems to be that companies in Hong Kong, MNC or otherwise, for the most part don't do R&D. As the case of GSL and the evidence in the previous section showed, technologies coming from source corporations play a very important part in forming the technological base of new high-tech enterprises. The table below compares the amount of R&D done in Hong Kong with the amount of R&D being done in the comparison economies (all as a percentage of GDP).

Country	R&D as a % of GDP
USA	2.28%
Israel	2.11%
Ireland	1.31%
India	.69%
Hong Kong	.26%

Table 10: R&D as a % of GDP[cviii]

As table 1 above shows, there is significantly less R&D being done in Hong Kong than in any of the comparison economies. In fact, using the April 1998 rankings of the World Competitiveness Report published by IMD, Hong Kong ranks as number 40 out of 45 countries in terms of total R&D expenditures as a percentage of GDP (with the country ranked #45 spending the lowest on R&D as a percentage of GDP)[cviii]. Also, according to the data, nine 3rd world countries (out of the eleven 3rd world countries in the group of 45) actually

spend more on R&D as percentage of GDP than Hong Kong[17]. (Appendix B provides a detailed ranking of R&D expenditures for each of the 45 countries).

Despite this low level of R&D in Hong Kong, many take comfort in the vision that Hong Kong will provide the business know-how while China provides the technical know-how. However, China is not much better off than Hong Kong. It only spends .43% of GDP on R&D. This is still well below our four other comparison economies, and this level of spending places China as number 35 out of the 45 countries compared. However, even this level of .43% is misleading. The reason why is best explained by Dr. Raymond Ch'ien, chairman of the Hong KongITDC. According to Dr. Ch'ien, "China has a lot of talented people trying to reinvent the wheel—the problem is that it doesn't always turn out round. The problem stems from the fact that the Chinese are reluctant to let their best and brightest become familiar with foreign cultures."[cix] Research has shown that, at the end of 1995, only 5% of Chinese R&D could be characterized as advanced technology and that only 20% of their advanced technology was on par with international industrial technology standards. Thus, only 1% of all Chinese R&D was considered to be internationally competitive[cx]. Whether it is in Hong Kong or China, sources of advanced technology that can be transferred to new firms are scarce.

Complementary to the missing component of innovation in Hong Kong companies, there is also the missing component of training opportunities. Since companies in Hong Kong do not work on researching and developing innovative technologies, there are few places domestically where Hong Kong engineers can get experience developing, and managing the development of an advanced technology product—skills critical to initiating a high-tech start-

[17] 3rd world countries are classified as those countries identified by the World Bank publication, "Trends in Developing Economies" (1994), as Less Developed Countries (LDC's).

up. Dr. Olin Shivers, a lecturer at Hong KongU and now a lecturer at MIT describes the impact this is having:

> *"Some of my most talented students went to MIS [management of information systems] jobs in banks. The result is that a lot of talent gets wasted. Hong Kong doesn't put its top students into jobs where they can really strengthen the software development industry. Also, once you graduate with a PhD, there won't be job opportunities that meet you educational level. Companies here don't understand the value of a Ph.D."*

This lack of an outlet for those who want to do research causes faculty members to discourage top students from pursuing graduate work. Prof. Irwin King of Chinese U says "I don't encourage students to get PhD's because all the top jobs are taken by outsiders. Also, most companies don't have research centers here so there is not outlet for PhDs in terms of careers for people who want to stay in Hong Kong." The fact that there are very few source organizations where people can get the training that will prepare them to launch a technology oriented company affects Hong Kong in a variety of ways. One way is that the territory's best engineers are not being taught design work, but instead they are being taught how to be system administrators. According to person 9, a senior faculty member in the electrical engineering department of HKUST, "the difficulty is that there is not a job market for design engineers. The demand is for system administrators and IT administrators, both of which pay more than design engineers." This has led Hong KongUST, Hong Kong's premier technical university, to implement a mandatory training program for it's IT engineers which involves them spending several weeks studying how to become a UNIX system administrator. The lack of work experience opportunities which provide development experience can be directly seen from the statistics. In Hong Kong, there are less than 10 R&D personnel for every 10,000

people in the workforce. This is as compared to 40 in Singapore, 75 in the US, and 80 in Japan[cx].

In the end, the fact that source organizations are not providing the technology or the training means that individuals in Hong Kong have very little base with which to start new high-tech companies. In a recent interview, Mr. Loo Hock Voon, Vice President of Walden International Investment Group, a major VC firm focusing on Asian high-tech companies, describes the importance of corporate source organization. Mr. Voon commented that employees of MNCs who wish to set up their own businesses are attractive potential investment prospects since they generally have the necessary knowledge, contacts, and management skills to establish themselves and prosper in their chosen field. When talking in general about the types of people he backs who are starting companies in Asia, Mr. Voon comments that "the returnees we back are invariably between 35 and 45 years old because they are still hungry for success and are prepared to work for it. They have also gained 10 to 15 years experience of working overseas." However, he adds that in Hong Kong, "there are not enough of these people."[cxi] Dr. Christopher Leong, president of Transpac Capital, another VC firm focusing on high-tech in Asia, iterated similar feelings. According to Mr. Leong, "Taiwan built their technology on returning engineers from the US, but in Hong Kong, the students go abroad to study business."[cix]

6.7 CONCLUSION

This chapter identified two main types of source organizations and the types of impact they have on driving a high-tech industry. While the relative weight of the importance of the two types of source organizations may vary from economy to economy, when taken in aggregate, they seemed to play an important role in the development of the high-tech industry in each one of our comparison economies. The fact that, in aggregate, source organizations seemed to play an important role in each of the comparison economies, despite the very different reasons for the success of the software industries in each of the economies, seems to distinguish this variable in importance from those covered in most of the other chapters in this thesis.

One significant form of impact that both universities and companies have in contributing to the growth of a high-tech industry is that their R&D plays an important part in forming the technological base of new enterprises. This was found to be the case not only in the US but internationally as well. Research on Hong Kong showed that there were extremely low levels of innovation and R&D at both universities and in the private sector. In the case of universities, there is a complementary issue of the ease with which technology transfer can be done. While there are various ways with which technology can be transferred, one of the most dominant patters in the US has been where a faculty or staff member takes a leave of absence from the university to start the new company. Due to housing issues, among others, the ease with which this type of technology transfer can happen in Hong Kong is of serious doubt.

A second important contribution of source organizations is the training they provide. They provide a low risk place where people can learn how to develop an advanced technology

product, and manage that product in the market. These are both skills that are very important to new companies. Evidence suggests that the high-tech industry in India, Ireland, Israel, and Taiwan all benefited from people who got training in high-tech MNCs for a number of years before starting their own company in their homeland. Maybe more importantly, venture capitalists feel more comfortable backing people who have significant work experience at MNCs.

APPENDIX A

The following describes the only "high-tech" companies listed on the Hong KongSE

Name of Company	Turnover (Hong KongDm)	Notes
Asia Satellite		
ASM Pacific	1,255.849	Makes and markets machines, tools and materials used in the mfg of semiconductors.
Capetronic	2,189.412	design, development, and mfg of computer monitors and TVs.
Elec &Eltek International	1,052.080	Makes and sells PCBs, fax machines, and liquid crystal displays. PCB mfg facilities in Hong Kong, PRC and Thailand. Listed PCB business on S'pore stock exchange and opened business there. Started by Professor Loh Shiu-chang of the Chinese University of Hong Kong
Founder		Probably the largest software company indigenous to China.
Gold Peak	2,257.097 (mar '94)	Mfg and marketing operations in 15 countries. Makes batteries, audio equipment, and other electronics. Does OEM and own brand name. Exclusive distributor for Onkyo and NAD hi-fi in PRC, Hong Kong, and Macau.
Goldtron	2.392	Mfg , markets, and assembles blank video tapes.
IDT	631.730 (mar '94)	Make LCD consumer electronics, cordless phones, and LCD video doorphones. Subsidiaries produce electronic translators too. Does both OEM and private-label. Sales offices in US and Europe.
Johnson Electric	1,506.806 (mar '94)	Design, mfg, and mktg of micromotors. Sales to US, Europe and Asia. Development centers in US, Asia, and Europe.
Legend	2,427.057 (mar '94)	Does OEM comp mfg for HP, IBM, Appel, and has own brand in PRC. Sales subsidiaries in US and Europe.
QPL	1,682.172 (apr '94)	Mfg ofIC leadframes, and assembly of Ics, and silicon-wafer fabrication. Factories in Asia, US, and Europe.

Star Paging	670.996	In telecom and Internet access. Busienss in Asia and India.
Stone Electronic	1,462.185	One of the largest none-state owned hgh-tech companies in the PRC. Mfg and sale of integrated word processords. Distribution rights for OKI printers in US.
Tricom	382.943	Marketing, sale, and tech support of telecom products. Products are typically mfg by US or Japanese companies, but trying to develop their own name products.
Ultronics	162.385	Mktg and distribution of technologically advanced medical products in PRC, Hong Kong, and Macau. Also mkts and distributes scientific equipment.
V-Tech		Designer and manufacturer of various electronic and communication devices. Most recently 900MHz phones.
Vanda	317.092 (mar '94)	The group is principally a systems integrator for computer systems projects as well as a distributor of PCs and peripherals in the PRC. Head office in Hong Kong, offices in PRC, wholly owned subsidiary in Singapore.
Varitronix	601.215	Design, mfg, and sale of LCD products for customized industrial applications and for the consume market. Network of distributors in over 30 countries. Sales offices in US and Europe.

APPENDIX B

The data in the table below comes from the April 1998 World Competitiveness Report rankings published by IMD. The table below shows GDP, total R&D expenditures, and R&D as a percentage of GDP for 45 countries. There is also a column that shows whether the country is a Less Developed Country (LCD), also known as a 3rd world country. The table is sorted in descending order by R&D as a percentage of GDP.

The following variables are used in the table below:

GDP: Gross Domestic Product in US dollars

R&D: Total R&D Expenditures in US dollars

%GDP: R&D Expenditures as a percentage of GDP

LDC: Indicating whether or not the country is considered as "less developed" by the World Bank.

Rank	Country	GDP	R&D	%GDP	LDC
1	Sweden	2.26E+12	8.30E+10	3.673893805	
2	Japan	4.19E+13	1.53E+12	3.659364548	
3	Korea	4.42E+12	1.35E+11	3.059276018	
4	France	1.38E+13	3.56E+11	2.580942029	
5	Switzerland	2.51E+12	6.47E+10	2.575697211	
6	Germany	2.08E+13	5.36E+11	2.573320537	
7	Finland	1.15E+12	2.96E+10	2.572173913	
8	Netherlands	3.54E+12	8.25E+10	2.33079096	
9	USA	8.083E+13	1.85E+12	2.284609675	
10	Israel	9.80E+11	2.07E+10	2.112244898	
11	Denmark	1.57E+12	3.31E+10	2.108280255	
12	Belgium	2.41E+12	4.33E+10	1.797925311	
13	Taiwan	2.83E+12	5.05E+10	1.783745583	
14	UK	1.29E+13	2.26E+11	1.75321955	
15	Austria	2.04E+12	3.44E+10	1.687254902	
16	Norway	1.50E+12	2.51E+10	1.674	1
17	Canada	6.18E+12	9.61E+10	1.554368932	
18	Iceland	7.40E+10	1.10E+09	1.486486486	

19	Australia	3.94E+12	5.43E+10	1.379187817	
20	Singapore	9.60E+11	1.27E+10	1.323958333	
21	Ireland	6.90E+11	9.04E+09	1.310144928	
22	Italy	1.13E+13	1.36E+11	1.200441306	
23	Czech Rep.	5.08E+11	5.99E+09	1.179133858	
24	Spain	5.22E+12	4.87E+10	0.932375479	
25	New Zealand	6.40E+11	5.84E+09	0.9125	
26	Russia	4.61E+12	3.76E+10	0.815618221	1
27	S. Africa	1.26E+12	9.42E+09	0.747619048	
28	Hungary	4.50E+11	3.28E+09	0.728888889	1
29	India	3.16E+12	2.19E+10	0.692405063	
30	Chile	7.10E+11	4.85E+09	0.683098592	1
31	Poland	1.35E+12	8.80E+09	0.651851852	
32	Portugal	1.00E+12	6.08E+09	0.608	
33	Brazil	7.49E+12	4.07E+10	0.543391188	1
34	China	9.02E+12	3.93E+10	0.436031042	1
35	Greece	1.19E+12	4.38E+09	0.368067227	
36	Argentina	2.97E+12	1.03E+10	0.346801347	1
37	Turkey	1.90E+12	6.44E+09	0.338947368	1
38	Venezuela	8.75E+11	2.87E+09	0.328	1
39	Hong Kong	1.54E+12	4.03E+09	0.261688312	
40	Malaysia	9.90E+11	2.26E+09	0.228282828	
41	Mexico	4.02E+12	8.86E+09	0.22039801	1
42	Columbia	9.50E+11	2.06E+09	0.216842105	1
43	Philippines	8.30E+11	1.15E+09	0.138554217	
44	Thailand	1.84E+12	2.08E+09	0.113043478	
45	Indonesia	2.27E+12	1.87E+09	0.082378855	

7. CONCLUSION

This research looked at the role of five key variables in affecting the development of Hong Kong's software industry. These five variables, intellectual property protection, domestic market size, capital markets, human resources, and source organizations, were all factors that seemed to be impacting the development of Hong Kong's software industry as indicated during the original research done as part of the MBHK project. However, what the MBHK research did not provide was a context with which we could evaluate the importance of these variables relative to each other.

This thesis built on the MBHK research by providing such a context. The context was developed by looking at the role of these key variables not just in the Hong Kong software industry, but also in the software industries of four comparison economies—the US, Ireland, India, and Israel. The comparison economies were chosen because they all have what many consider to be successful software industries, and because the route to success for each of the software industries in the comparison economies was very different. Independent of the path to success, this allowed us to understand which variables are more fundamental than others in contributing to a software industry's growth.

Without re-stating the conclusions of each of the previous chapters, we found that only two variables of the five played important roles in the development of the software industries in all of our comparison economies. The first of these was human resources. Having well-trained and well-educated engineers going into the software industry was a feature common to each of the comparison economies. Furthermore, if we look at each of the five variables as an

area for "investment" by the government (where "investment" is defined as any activity by the government which would promote the positive impact of that variable on the software industry), then in each of the comparison economies the original investment in the software industry was made in human resources. The second variable that was important to each of the comparison economies was the one defined as source organizations. Source organizations were important because they provided a low-risk environment where potential entrepreneurs could develop both technological and managerial know-how. Like human resources, strong source organizations seemed to play a key role in each of the comparison economies from the very beginning of their respective high-tech industry's formation.

When the industry reaches a certain critical mass, capital markets then become important in fueling the further growth of the industry. This was seen clearly in the case of the US, Israel, and India and also seems to be true of Ireland (but more data is needed to confirm this).

The two remaining variables, domestic market size and intellectual property protection, are certainly helpful to a software industry, but evidence suggests that they are not critical to an industry's growth. Ireland, Israel, and India have rapidly growing software industries yet they also have relatively small domestic markets and very poor domestic intellectual property protection. The reasons for the lower importance of these two variables seems to be because, when an industry has strong human resources and source organizations, they are able to be competitive in export markets. Thus, the importance of the domestic market is diminished.

Taken in aggregate, the data on how each of the five variables affects a software industry suggests a model for the way high-tech industries develop. The first step is the education and training of people. This primarily begins with the domestic university system. India, Ireland, Israel, and the US all had made important investments in the university systems long preceded

the significant growth of their respective high technology industries. The investments had an important impact on the quality of the labor force. A factor which those in each of the comparison economies sight as being a key reason for the success of the high-tech sectors in the respective economies. Once there were well educated engineers being produced, those engineers need a place to go to continue to learn and challenge themselves. Whether domestically or abroad, these engineers went to source organizations which allowed them to work on leading edge technology and business problems. In the case of Ireland, Israel, and India, we saw a similar pattern of a "brain drain" followed by a flux of return migrants whose experience at MNCs abroad helped play an important role in the formation of their respective domestic technology sectors. In the US, we had data which showed the importance that a new enterprise's founder placed on his or her experience with the previous employer. We also saw an important role for universities as source organizations in the case or the US, Ireland, and Israel. In these economies, technology being developed at the universities played an important role in forming important indigenous high-tech companies and even industries. Once there was a critical mass of well educated people with experience in source organizations, the next issue became the flow of people from source organizations to start-ups. Reasons for this flow seemed to point to a variety of factors that ranged from the tangible (such as layoffs in the case when the Israeli military cut back jobs), to the intangible (such as the culture created at universities like Stanford and MIT). Once there is a critical mass of well educated and trained people who are interested starting and growing companies, then venture capital becomes important to the long term growth of the industry. Venture capital provides the needed resources for companies at different stages in the their growth to expand faster than simple organic growth might allow them to. Evidence from the US, Israel, India, and Hong Kong showed how venture capital had impact only after there was a critical mass of well trained people, source organizations, and a compelling reason for people to leave the source

organizations to start new companies. Finally, characteristics of the domestic market such as its size, sophistication, or level of intellectual property protection certainly affect the domestic industry, but they don't seem to be critical to the industry's success or failure.

The research on Hong Kong and the various comparison economies has important implications for where industrialists and policy makers in Hong Kong should place their efforts. While many in Hong Kong are spending a lot of time trying to address the issues of capital availability, domestic market size, and intellectual property protection, the results of this thesis suggest that other variables are in need of greater attention. Specifically, the problems associated with human resources and with the scarcity of source organizations seems to be the most fundamental barriers to the growth of Hong Kong's domestic software industry. These findings have added urgency given that the impact of investments in overcoming these two barriers will not become evident for some time.

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