



Asia-Pacific
Economic Cooperation

2004:

Realising Innovation and Human Capital Potential in APEC

A P E C E c o n o m i c C o m m i t t e e





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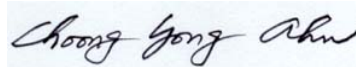
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FOREWORD

It is widely recognised that innovation and human capital are key factors of productivity and growth performance, and that properly designed economic policies can have a significant impact on innovation and human capital performance. The policy work in the APEC/OECD economies is now focusing on four growth drivers: seizing the benefits of information and communication technology, fostering innovation and technology diffusion, enhancing human capital and realising its potential and fostering firm creation and entrepreneurship.

The research contributions in this publication are along the same lines. They explore research and policy issues relating to two key drivers of growth in the new global economy – human capital and innovation. The first paper, “International Mobility of Highly-Qualified People in APEC” examines the key issues surrounding the international mobility of highly-qualified people (HQP). The second paper, “The Development of Industrial Clusters towards a Knowledge-based Economy” discusses the role of innovation and growth in the formation of an industrial cluster.

My special thanks go to Dr. Surendra Gera, Vice Chair of APEC Economic Committee and to Dr. Thitima Songsakul, who brought these contributions together, and to all contributing researchers. Dr. San Gee headed the team from Chinese Taipei, who produced the paper on the development of industrial clusters in the APEC region. A Canadian team consisting of Dr. Surendra Gera and Dr. Thitima Songsakul, with assistance from Dr. Samuel A. Laryea, produced the paper on the international mobility of HQP.



Dr. Choong Yong Ahn
Chair, APEC Economic Committee
Seoul, October 2004



INTRODUCTION

INTRODUCTION

REALISING INNOVATION AND HUMAN CAPITAL POTENTIAL IN APEC

“A Knowledge-based Economy is an economy in which the production, distribution and use of knowledge is the main driver of growth, wealth creation and employment across all industries.”

Towards Knowledge-based Economies in APEC

Report by APEC Economic Committee, November 2000

Entrepreneurs have always transformed ideas into new or improved products, production processes, services or trading opportunities. The process of turning knowledge into economic action is innovation, and, innovation has always driven economic and productivity growth. Innovation continues today and will drive economies of the future. The critical difference in today's world is the speed with which knowledge is transformed into economic activity and the speed with which this information is available around the globe.

Today's economy is worldwide and knowledge-based. Knowledge-based industries now account for around half of GDP in the world's key economies. Moreover, the importance of these industries, and of knowledge more generally, is rising quickly. The growth in the output from knowledge intensive industries has outpaced that of the total economy in almost all APEC economies since the mid-1980s. Firms are continually increasing their investment in knowledge in order to be competitive in the fast paced, global marketplace. For example, global knowledge investment, as reflected in patents granted in the U.S., grew by a compounded annual rate of 12.5 percent between 1995 and 1998. This rate is up substantially from the 3.3 percent annual pace reported between 1980 and 1995.

Transition to the Knowledge-Based Economy and Society

The transition to the knowledge-based economy can also be seen by looking at the changing skills and education mix of labour forces around the world. The shift cannot take place without knowledge workers. Knowledge-based economies have and continue to see job demand move away from low skilled, blue-collar workers, toward highly skilled and educated employees. The proportion of knowledge workers in the labour force is now

over 30 percent in the most developed economies and is rising quickly in the developing economies.

A knowledge-based economy is not an economy devoted exclusively to high-tech industries. The innovative use of knowledge is also creating competitive advantage, fuelling productivity and economic growth in all sectors – from mining to manufacturing to services.

All economies, no matter the stage of development, are being transformed in one way or another into knowledge-based economies. All economies are being drawn into the global marketplace and are becoming part of global production capacity. The world's most important economies are not only leading the way but are also shaping the process.

The transition to a global, knowledge-based economy is reshaping more than economic activity and the labour force. It is also changing the way we define our communities and the way we interact with each other. We now not only have a knowledge-based economy but also a knowledge-based society.

Innovation as the Agent of Change

The transformation into the global, knowledge-based economy (and society, for that matter) has been driven by rapid technological change; by heavy investment in new information and communication technologies; and by the international reduction of barriers to trade, investment and the flow of knowledge workers. However, the factor that has unleashed the power of these strong drivers has been innovation.

Technological change, from rail and steam power to computers, has always been key to economic growth. Important new technologies, those that have the greatest impact or

enabling properties within the economy and society, enhance the ability of the economy to be more productive. Innovative businesses within innovative economies use new technologies to change and improve products and production processes. The benefits to innovative leaders are enormous. For example, it is estimated that the innovative use of new technologies has raised U.S. productivity growth by a substantial 1.2 percentage points per year since 1995. This is all the more impressive considering that without this innovation U.S. productivity growth would have been around 0.2 percent per year.

The importance of innovation to the knowledge-based economy is not limited to the ability to apply new technologies to economic activity. An economy or a firm with a culture of innovation creates, adopts and adapts technological change, the pace of which is always quickly accelerating. The greatest benefits go to those first to market and first to create a competitive edge.

The rapid development and deployment of new information and communication technologies, from computers to fibre optics, have been instrumental in unleashing the forces of innovation – transforming economies and societies around the world into knowledge-based economies. The ability to communicate and to conduct business around the globe has never been easier than it is today. The impact of information and

communication technologies is clearly evidenced by the fact that today about three-quarters of Canadians believe that access to the Internet should be universal.

Information and communication technologies have been instrumental in making the production of goods and services truly global. The world's economies are increasingly becoming interlinked and co-dependent. Information, in the form of knowledge and ideas, now flows freely and rapidly around the world, and, businesses in all sectors are using information and communication technologies to increase productivity and reduce costs through more efficient and timely use of these inputs.

The reduction of barriers to the international flow of goods, direct foreign investment and the movement of knowledge workers have set the stage for a global, knowledge-based economy by creating a global marketplace and making knowledge in the form of new machinery and equipment, technical expertise and so forth available to all. The globalization of production has also given scope for the world's leading knowledge-based economies to continue to shift into high value-added services and away from low-end economic activities. High-end services are where knowledge tends to be created and transformed into economic activity.

INNOVATION AND HUMAN CAPITAL

“Innovation and technological change are without doubt the main drivers of economic growth.... More than before, innovation is now at the core of business activity...”
Science, Technology and Industry Outlook, OECD, 2000

Innovation is about people – their creativity and willingness to adapt, embrace and lead change. All individuals who are active in our economy – from the shop floor worker to the knowledge professional to the scientist and engineer to the corporate manager to the businessman – can contribute to the innovative performance of the nation. It is the entrepreneurial spirit within a firm and the entrepreneurial culture within a society that drive the innovation process of turning knowledge into economic and commercial activity. There is a direct link between the level

of entrepreneurial activity within a economy and economic activity.

Moreover, the relationship between the innovative use of knowledge and standard of living is strong and direct. Knowledge drives productivity through innovation. Productivity growth, in turn, is the primary mover of living standards. The world's wealthiest economies, those with the highest standards of living, represent its most innovative economies. Change comes through innovation. Economies are now competing on their innovative ability to quickly and efficiently

translate knowledge into competitive advantage – new and improved products, services, and production processes.

Innovation is, and has always been, the agent of change. In the past, from a nation's perspective, innovation was viewed as a fairly random event – left largely to individuals and to firms. Today, knowledge-based economies look at innovation as a national system, a collective process – one that links all of the key players involved in turning knowledge into economic activity within the economy.

Innovation is a complex and highly interactive process. It is heavily dependent upon the availability, exchange and integration of knowledge originating from every player in the national system. It involves direct and indirect, hard and soft linkages between firms, scientific and research communities, clusters, the financial communities, a skilled and educated labour force, and government. It requires organizational structures within firms conducive to innovation. And, it utilizes networks and alliances between firms and between the various players, both within and outside of the economy.

The nature of innovation is also changing. It is becoming much more market driven, and, its pace is accelerating. The need to innovate, to be competitive and productive in a global, knowledge-based economy, is permeating all sectors of that economy. Innovation is becoming much more intense and much more closely linked to the latest in scientific progress. An economy can gauge the

strengths and weaknesses of its national system of innovation by looking at a multitude of indicators covering the tangible and intangible elements of innovation.

Highly-qualified people (HQP) are indispensable to an innovative economy. A more innovative economy requires that the labour force include the right number and types of HQP. However, for some segments among HQP, the job market is now an international one, with the industrialized economies in APEC competing to attract individuals with the most in-demand skills and experience. This means that if APEC economies are to adjust to new skill requirements in order to support a more innovative economy, they must formulate policies to retain domestic talent and attract HQP from abroad. On the other hand, the mobility of HQP is a necessary condition for knowledge dissemination and absorption in the new global economy.

The two contributions in this report examine on innovation and human capital as drivers of growth. The first, "International Mobility of Highly-Qualified People in APEC" discusses the key issues surrounding the international mobility of HQP in order to help adopt the right policy approaches towards it. The second, "The Development of Industrial Clusters towards a Knowledge-based Economy" discusses the role of innovation and growth in the formation of an industrial cluster.

ORGANIZATION OF THE VOLUME AND OVERVIEW OF THE INDIVIDUAL PAPERS

1. International Mobility of Highly-Qualified People in APEC

In the knowledge-based economies of today, HQP are indispensable to an innovative economy. Reaching the goal of a more innovative economy requires that the highly qualified workforce is of sufficient quantity and quality to support the expansion of innovative activities by firms. Satisfying this key condition for the labour force poses challenges, as HQP have become increasingly mobile and the market for some segments of highly qualified workers has become more global. Many industrialized economies compete strategically in attracting these workers. Therefore, in adjusting to new skill requirements, APEC

economies must consider their performance in attracting HQP from the rest of the world and in retaining domestic talents.

The traditional view of international migration of HQP – the "Brain Drain" perspective, takes on migration of skilled workers as a zero-sum game among economies. A competing perspective on cross-economy labour movements – the "Brain Exchange or Brain Circulation" or "Globalization of HQP Labour Market" – examines the movement of human capital through the lens of labour mobility. This perspective argues that segments of the international mobility of HQP are linked to technology transfers, FDI, location of MNEs, and two-way flows of knowledge, ideas and

technology among trading economies. The highly talented workers are essentially becoming more globally mobile as goods, services and capital have become mobile over time. International mobility of skilled workers can generate global benefits by improving knowledge flows and satisfying the demand for highly qualified individuals where that demand is the strongest. This view suggests that greater HQP mobility may well lead to better economic outcomes among the economies participating in that labour exchange (Wildasin, 2003; Harris, 2003 and 2004a; and Harris and Schmitt, 2003).

Consequently, it has become increasingly important to understand key issues surrounding the international mobility of HQP in order to adopt the right policy approaches towards this movement of skilled labour. Attention must now turn towards improving our understanding of the issues such as what are implications of this new trend for the APEC economies? Would facilitating international mobility of HQP bring economic benefits to the participating economies?

This paper focuses on four key issues and identifies policy initiatives and potential directions for future research. First, it examines the global trends in the international migratory flows of HQP. Second, it discusses the fundamental (non-policy) drivers of the increased HQP flows in the new global economy. Third, it reviews the literature on the economic costs and benefits associated with cross-economy movement of HQP and the main factors conditioning these costs and benefits. Finally, we address the question: how policy has adjusted or should adjust to increased international HQP mobility in the new global economy?

In this paper, HQP refers to those individuals who are engaged in knowledge-intensive professions, such as physicians, nurses, science and technology (S&T) professionals, engineers, IT specialists, graduate and post-graduate students, scholars and researchers, and high-level administrators and managers. Our findings show that international mobility of HQP has increased significantly in the last decade, especially from Asia to major APEC/OECD economies. Three observations are particularly notable: First, the mobility of HQP has increased among industrialized APEC economies in the 1990s; Second, the increase in HQP migration is characterized mainly by temporary inflows as opposed to

permanent inflows; and Third, there is some evidence on return migration from APEC/OECD economies. The US has been the major recipients of temporarily flows of HQP while China, Mexico and India are major sending economies. Economies with highly active roles in both sending and receiving of HQP are Canada, Japan, and Australia.

Measuring the scale of the international movement of highly skilled individuals remains a challenge. There is a need to develop a better assessment of recent international skilled migratory flows, particularly in terms of their underlying skills/education, occupation, and the duration of their migration (temporary versus permanent). We need answers to questions such as are HQP, much like capital and FDI, becoming more mobile globally than in the past? Are global movements of HQP becoming more multi-dimensional (brain circulation) than in the past or do they tend to be one-way flows (brain drain)?

A recent European report points out that international mobility of HQP is becoming increasingly important to business as they are expanding their production and marketing activities globally (PWC, 2002). Our findings seem to be broadly consistent with this view. Our analysis suggests that the mobility of HQP has increased parallel to an increasing importance of technological change, globalization of production and integration of markets through international trade and FDI, location of MNEs, strategic alliances and networks with high-technology global firms and clusters of research and innovation, opportunities for high-technology entrepreneurship and the internationalization of R&D activities of national firms. Our findings also seem to suggest that increased income and employment opportunities, and career prospects and attractiveness of the education and research system coupled with the changing preferences of highly qualified personnel towards working abroad are also key drivers of international mobility of skilled workers in the new global economy.

Overall, there still remain significant knowledge gaps, and more research on the fundamental drivers of international mobility of skilled labour is clearly warranted. For example, we need to better understand the underlying fundamental factors driving the international mobility of HQP. How have these factors changed over time? How do they vary

across different groups of HQP or by sector of activity?

A review of the literature on welfare economics of labour mobility suggests that the globalization of the market for HQP yields positive impacts on the sending economy due to increased human capital acquisition, increased specialization and international knowledge spillovers. A brain circulation could lead to higher growth rates through increased specialization and transfer of knowledge spillovers generated by the HQP movements. Participation in global knowledge industries enables global knowledge workers to acquire access to international science and technology networks through which knowledge is shared and transferred. Overall, convergence of income level under free mobility of workers could be a result. Initiatives to improve cross-border mobility for HQPs could prove to be quite important for long run growth of a smaller economy.

However, the distribution of benefits is likely to be uneven. Some sending economies may incur costs in the short run and possibly also in the long run. The potential costs may include loss in human capital spillovers, loss in human capital recipient capacity that could lead to widening of the innovation gap. Yet, there is not much literature on the impact of labour mobility on economic convergence/divergence. The existing empirical studies show mixed results. The experience from the US demonstrates that where labour mobility is high, income levels have converged but the pattern of industrial development is relatively uneven. In contrast, the evidence from the EU, where labour mobility is considered low, suggests that income levels across economies vary but industrial patterns are more balanced. More empirical evidence is clearly needed on the costs and benefits associated with cross-economy movement of HQP. Further investigation on mechanisms or channels through which increased HQP mobility may contribute to convergence is also warranted.

The push towards innovation in APEC economies and the emphasis on human capital are likely to increase international competition for HQP further. Economies are likely to face an increasingly global and competitive market for HQP. There are two inter-related, but somewhat conflicting, objectives of policies regarding international mobility of HQP. One aims to attract and retain

HQP and the other aims to facilitate their cross-border mobility. The attraction policies are generally unilateral initiatives including policies in the areas of immigration, domestic labour market, science and technology, taxation, and education.

Many developed APEC economies, notably the US, Japan, Australia, and Canada have adjusted or introduced various policies, especially those related to immigration and work permit application and approval procedures, in order to compete in the global market for HQP. In the area of domestic labour market policies, in Canada for example, there is a recognition that the harmonization of regulatory standards in the domestic labour market is the key step in improving the mobility of HQP both domestically and beyond. The facilitation policies are mainly in the realm of multilateral initiatives between the integrated economies. Generally, integrated labour market initiatives originate from the product market integration policies. Examples include provisions on temporary movement of skilled workers under NAFTA, and APEC policies on business mobility.

A review of the policies in the integrated labour market economies suggests that greater harmonization of policies and adoption of common licensing standards are key to reducing barriers to cross-border mobility. On the international trade front, policies affecting trade in services, particularly business services, will certainly influence the movement of HQP internationally. Further liberalization of the service supply modes under GATS will reduce barriers to international mobility of HQP.

2. The Development of Industrial Clusters Towards a Knowledge-based Economy

Over recent decades, an ever-increasing level of attention has been paid to the role played by industrial clusters in facilitating regional economies and in driving high technology industries. By examining the development of industrial clustering within the APEC region, the two-year study, which is led by Chinese Taipei, began in 2003. The project aims to: (i) explore the factors contributing to the successful formation of industrial clusters and the overall effects of industrial clustering on productivity; (ii) gain an understanding of the organization and networking of industrial clusters; and (iii) highlight the

interrelationships that exist between industrial clustering and innovation.

In part (i), drawing on the empirical evidence from the Hsinchu Science-based Industrial Park (HSIP), the study finds that outsourcing is generally adopted by firms within the clusters since this enables them to access the major markets and to save on R&D costs through production specialization. The experiences of HSIP also support the assertion that entrepreneurship, skilled labor and market access are essential ingredients for the formation of a cluster. To determine whether common mechanisms exist in binding together these three ingredients in order to produce a winning formula, we have attempted to compare the experiences of HSIP to those of Silicon Valley in the US, as well as the experiences of the industrial clusters in Penang and the Kelang Valley in Malaysia, Hamamatsu in Japan, and Shanghai in China.

Furthermore, these case studies indicate that in terms of developing industrial clusters, human resources are indispensable to the build-up of innovation capability. Indigenous skills are the core of location advantage that underlies the formation of an industrial cluster, and they are pivotal in leveraging foreign-based skills. When the economy develops more, it may even attract skilled labor from overseas. This could bring benefits from the human resources investments made by other economies. In other words, human resources that are repatriated or borrowed from abroad are always insufficient to support the operations of an industrial cluster, as they have to be complemented by indigenous skills. In part (ii), the study looks at the technological linkages between clusters from the viewpoint of networking. Firms can learn from other firms through global production networks within which they operate, collaborating to offer products in the global market. It is clear that cluster is an important facilitator for such learning. Clusters form a 'learning region' within which knowledge flows, and is diffused, amongst the residing firms. Clusters also provide a bridge between different learning regions to facilitate the effective transfer of knowledge.

We have made an investigation into the state of human resource development within the HSIP, from which we find that industrial output expanded exponentially between 1990 and 1995, along with the infusion of high-skilled labor from overseas. There has been a slowdown in the rate of the so-called 'reverse brain drain' since 1995, with foreign workers now accounting for a substantial proportion of labor movement. This suggests that the HSIP is becoming increasingly integrated with the global market because its high-skilled labor has increasingly shifted away from production toward research and development.

In addition, the study makes an inquiry into the intra-cluster division of labor and networking relationships. Using the HSIP as an example, we find that the most prevalent modes of interaction between firms in the HSIP are subcontracting and outsourcing of components and parts, implying a vertical disintegration of production within the HSIP. In addition, the duration of subcontracting contracts increases positively with the distance between the partners. Subcontracting allows firms in the cluster to realize economies of scale while maintaining the flexibility of production. As horizontal differentiation is an important characteristic of a cluster, which allows for product competition and knowledge sharing, subcontracting also allows for vertical disintegration within the cluster, which in turn, brews specialized suppliers.

In part (iii), the study suggests that industrial clustering occurs not only in high-tech industries, but also in the so-called traditional industries. It appears that innovation and growth are the two most important elements in the formation of an industrial cluster. Innovation provides the dynamics for competition and restructuring. Innovation also underlines the benefits of knowledge sharing, which is the basic reason for firms to congregate. Meanwhile, growth is important both in terms of inducing new entry and facilitating a division of labor within the industry. Growth in most cases is demand-driven and therefore linking (or access) to the major market is the key to the formation of an industrial cluster.

The study has also showed that industrial clustering improves the productivity of individual firms. We have been able to gather statistical evidence to support the role played by Porter externality and Marshall-Romer in industrial clusters. Although these two externalities differ in nature, they can exist simultaneously in a cluster. If firms in a cluster are more productive than those outside the cluster, it naturally follows that firms that locate too distant from the cluster will be driven out of the industry by competition. This, of course, is the main driving force for agglomeration.

Finally, in terms of policy implication, industrial clustering can be a useful policy for national economic development of various scales. However, there is no one-size-fits-all formula for successful industrial clustering and an economy should allow its comparative advantage to determine what industries to grow into a cluster. Having said that, investment infrastructures and human resources, building innovation capabilities, linking sources of growth, promoting vertical disintegration and subcontracting, and enhancing productivity can be the key ingredients of industrial cluster policies.



**INTERNATIONAL
MOBILITY OF
HIGHLY-QUALIFIED
PEOPLE IN APEC**

INTERNATIONAL MOBILITY OF HIGHLY-QUALIFIED PEOPLE IN APEC*

INTRODUCTION

There is a wide recognition that today's economy is being fundamentally transformed via globalization, economic integration, new technologies and a shift to more knowledge-intensive activities. The skill intensity of production, both in manufacturing and services, has risen so that the demand for highly-qualified people (HQPs) has increased in all countries. An important aspect of this global knowledge-based economy (KBE) is the emergence of a new trend where segments of the highly-qualified labor force are becoming increasingly mobile. Key features of this new trend include a growing focus on temporary migration, as opposed to permanent migration, and an increase in the share of HQPs moving across industrialized countries. These globally mobile skilled individuals generally comprise those who participate in high-tech industries, manage multinational enterprises (MNEs), and occupy scientific and technical professions. These individuals participate in industries that are largely knowledge-based and global in scope.

Some argue that the greater international mobility of HQPs may well be the by-product of globalization.¹ As the argument goes, the new trend, which became more noticeable in the 1990's, is driven by the information technology revolution, the proliferation of regional trade and investment agreements, the general economic integration of product markets (e.g. the increased globalization of corporations) and the rapid industrialization of Asia. The swift growth in foreign direct investment (FDI) by multinational enterprises, outstripping the growth in international trade, has increased the demand for managers and technical experts at the foreign subsidiaries. The increased scarcity of HQPs is being reflected worldwide by the higher premium paid for these individuals. Not only is international mobility of HQPs on the rise, so also is the migration of high-skilled jobs. Although outsourcing in manufacturing has been occurring for a long time, a relatively new development is the outsourcing of white-collar skilled jobs, such as basic data entry, telemarketing and claims processing (Mann, 2003; McKinsey Global Institute, 2003).

At the same time, business is becoming increasingly international in its outlook and activities. Doing business in a global world has implications for the mobility of HQPs. Exports of products, technology transfers and R&D investment across operations worldwide require the movements of highly skilled professionals. Seeking ways to draw upon scarce specialized resources, firms are shopping for HQPs across continents. Individuals' attitude to mobility are changing as they become better qualified and increasingly seek opportunities to work internationally to improve their incomes and to work in premier global organizations. More people, particularly those in the younger age groups, regard international mobility to be an important part of their skills and career development.²

National policy makers increasingly view nations as competing to attract internationally mobile workers in order to improve their innovation performance through R&D investments, the adoption of advanced technologies and the application of knowledge-intensive processes throughout the economy. Head and Reis (2003) note that until recently, the most sought after internationally mobile resource (IMR) has been foreign direct investment (FDI), particularly new manufacturing facilities of MNEs. The desired set of IMRs has now widened to include a variety of activities of MNEs such as R&D and access to highly skilled professionals. The authors argue that the

* The study was completed by a team led by Dr. Surendra Gera, Senior Policy and Research Advisor, and Dr. Thitima Songsakul, Economist, Micro-Economic Policy Analysis Branch, Industry Canada. The authors would like to thank Dr. Samuel A. Laryea, Senior Economist, Human Resources and Skills Development, Canada for providing assistance on an earlier version of this paper. Thanks are also due to Richard Roy for helpful comments and suggestions and Patrick Taylor for technical research assistance. Views expressed in this study do not necessarily reflect those of Industry Canada nor Human Resources and Skills Development, Canada. Comments may be addressed to Surendra Gera (email: gera.surendra@ic.gc.ca)

¹ See, for example, Harris (2003) and European Economic Advisory Group Report (2003), henceforth referred to as EEAG (2003).

² PriceWaterhouseCoopers (2002). Henceforth, in the rest of the paper, this study is referred to as PWC (2002).

location decisions of FDI, R&D and skilled professionals are jointly determined: success at attracting one resource draws more of each.

Indeed, evidence suggests that the international mobility of HQPs increased during the 1990s. Data show an increase in migration flows during this period, particularly among temporarily migrating HQPs, from Asia to the US, Canada, Australia, and the UK. The mobility of HQPs is also on the rise among OECD countries but appears dominated by personnel with specialty occupations such as IT specialists, advanced students, researchers and managers. Part of the rise in the international mobility of these individuals is related to deliberate policies by national governments of advanced industrialized countries. Strong demand for information technology (IT) and other technical professionals in advanced APEC economies has been a key driver of reforms toward migration rules easing the movements of HQPs. Harris (2004b) argues that advanced industrialized countries now seek to strategically attract the highly-qualified migrants through adjustment of immigration controls in face of a very large, but highly differentiated, queues of potential migrants. The US H-1B temporary visa program for highly-qualified individuals and the Canadian and Australian point system for immigrants which emphasizes skills are examples of these reformulated immigration policies.

Over many previous years industrial country immigration policies have been attacked as promoting a 'brain drain' from a poor South to a rich North. However, more recently, industrial countries have become alarmed about the migration of their highly-qualified individuals. The 'brain drain' is now an industrial country issue (Harris, 2004b). The emigration of skilled professionals from Canada to the US, for example, has often received particular attention from Canadian media and policymakers, in part because of a periodic concern about a "brain drain". Finnie (2001) estimates that 178,000 people left Canada for the US between 1991 and 1996, 30 percent higher than from 1986-91; permanent emigration increasing by 15 percent and temporary emigration doubling. The most striking change is the increase in the number of Canadians entering the US under TN (Treaty National) visa in the late 1990s, reaching an average of 73,000 entries per year during the 1998–2002 period. While weak business conditions in Canada relative to the US, and special factors in sectors such as health services have played a role in the outflows of Canadians, the increase also reflects the growing economic integration of the North American economies under the FTA and the NAFTA (Globerman, 1999). The globalization of firms has also helped fuel the temporary flows to the US; intra-company transferees in the mid-1990s accounted for 5-10 percent of the total flows of Canadian HQPs to the US (OECD, 2002b).

The traditional view of the international migration of HQPs was the "brain drain" perspective, whereby highly-qualified individuals migrated from poor to rich countries, motivated by expected wage gains in the receiving country. The migration of HQPs in this perspective is largely viewed as a zero-sum game with winners and losers. The benefits of the receiving country being, by and large, equal to the costs born by the sending country. Even in models where there are dynamic externalities associated with human capital, the magnitude of the cost-benefit calculations changes, but the migration of highly-qualified workers is still largely viewed as a zero-sum game for participating economies.

A competing perspective on cross-country movement of highly-qualified individuals—"brain exchange or brain circulation" or "globalization of HQP labour market" perspective—holds that movements of HQPs across countries must be studied in the context of globalization. This perspective argues that segments of the international mobility of highly-qualified individuals are linked to technology transfers, FDI, location of MNEs, and two-way flows of knowledge, ideas and technology among trading countries. The highly talented workers are essentially becoming more globally mobile as goods, services and capital have become more globally mobile over time. According to this perspective, the international mobility of HQPs can generate global benefits by improving knowledge flows and satisfying the demand for highly-qualified individuals where that demand is the strongest. This view suggests that greater HQP mobility may well lead to better long-term economic outcomes among the countries participating in that labour exchange (Wildasin, 2003; Harris, 2003 and 2004a; Harris and Schmitt, 2003).

Harris (2004b) argues that deeper integration between economies (regional or bilateral) through trade and FDI may encourage productivity and income convergence across countries over time,

so it is possible that mobility of HQPs might also have this effect. According to this view, the economic policy discussion surrounding the cross-border movement of HQPs must take into account the wide variety of ways the migration of labour affects the economy. In particular, attention must now turn towards the links between these movements, and the institutions regulating them, and the performance in the trade of goods and services; foreign direct investment; human capital formation and MNE location; and income convergence among countries. Harris argues that labour market integration initiatives within free trade areas may carry large benefits to small economies. Addressing these and related key knowledge gaps is required to develop appropriate policy approaches on the migration of HQPs.

This study discusses the key issues surrounding the international mobility of HQPs, while identifying knowledge gaps and directions for policy-relevant research. The paper focuses on four key issues in each of the subsequent section:

- How mobile is the highly-qualified labor force in APEC?
- What are the fundamental (non-policy) drivers of international mobility of HQPs in the global knowledge-based economy?
- What are the costs and benefits associated with cross-country movement of HQPs, and the main factors conditioning these costs and benefits?
- How policy has adjusted, or should adjust, to increased mobility of HQPs in APEC?

Finally, the summary and conclusions are presented in the last section.

1. HOW MOBILE IS THE HIGHLY-QUALIFIED WORK FORCE IN APEC?

Getting a firm grip on the magnitude, direction and the composition of the international flows of HQPs is imperative to inform and fashion appropriate policy responses. The increasing globalization and the importance of knowledge-intensive activities is changing skill needs across all industries, and business is placing higher premiums to access internationally mobile talents. A recent European report points out that international mobility of highly-qualified individuals is becoming increasingly important to business as they are expanding their production and marketing activities globally (PWC, 2002). Additionally, a number of recent empirical and theoretical contributions provide support for the linkages between doing business in a more integrated world and requirements for a highly-qualified labour force.³

Our aim in this section is to use data to illustrate how international mobility of HQPs has evolved over recent years. First, we define and identify different forms of HQPs mobility that we consider in our discussion. Second, we document trends of recent migratory flows of HQPs in APEC – magnitude, direction, and the nature (temporary versus permanent) of recent aggregate flows and their composition in terms of underlying education/skills. We examine these trends at three different levels: global patterns of HQPs mobility; patterns of HQP mobility in APEC; and the patterns of HQP mobility in the integrated labor market economies such as Canada and the US; Australian and New Zealand and the European Union (EU).

1.1 Defining HQPs Mobility

In this study, HQPs are defined as those individuals who are engaged in knowledge-intensive professions such as physicians, nurses, science and technology (S&T) workers, engineers,

³ See, for example, Harris and Schmitt (2003) and Globerman (2001).

information technology (IT) specialists, graduate and post-doctoral students, scholars and researchers, and high-level administrators and managers.⁴

International mobility of HQPs is multi-dimensional. The PWC report (2002) for the European Community argues that it can take many different forms depending upon whether it is motivated by an employer or an individual and whether it is temporary (i.e. lasts for a few months) or permanent (lasts for several years).⁵ In the subsequent discussion, we document the following forms of HQP mobility:

- The ‘traditional’ permanent migration – highly-qualified individuals move on a permanent basis from one country to another
- Temporary migration of HQPs – such as admissions to the US based on H-1B visa, and TN visa;
- Intra-company transferees generally associated with MNEs
- Foreign students at higher educational levels and temporary visiting scholars and researchers.

1.2 International Mobility of HQPs: Global Trends

The readily available data on the global mobility of HQPs is rather limited. Most of the data measures only inflows to the advanced APEC/OECD economies and, as such, provides only an incomplete story of the international mobility of HQPs.

The data show that HQP migration, especially from Asia to major OECD/APEC economies, rose substantially during the 1990s (OECD, 2002b). Furthermore, the increase in HQP migration among APEC/OECD economies was characterized by temporary inflows as opposed to permanent inflows (Guellec and Cervantes, 2002). International mobility of HQPs is also on the rise amongst APEC economies. Table 1.1 shows that APEC economies such as the US, Japan, New Zealand, Canada, and Australia have been major recipients of temporary inflows of HQPs.

Table 1.1 ‘Permanent’ and ‘Temporary’ Inflows of HQPs, Selected APEC Economies

		Permanent ('000)	Temporary ('000)
Canada ^a	1998	81.2	38.0
	2001	137.1	49.9
	2002	123.3	41.5
United States ^b	1998	63.5	754.2
	2001	165.8	1,148.0
	2002	163.5	1,083.5

⁴ This definition is broader than the definition suggested in the “Canberra Manual” (prepared by OECD’s Group of National Experts in Science and Technology Indicators). The Canberra manual defines skilled human resources in science and technology (HRST) as personnel with a tertiary education level in science and technology study or currently employed in a S&T occupation. See OECD (2002c).

⁵The PWC (2002) report identifies eight key types of worker mobility from the business perspective in the EU. Some notable new forms of recent worker mobility include the cross-border commuter, whereby an employee commutes from their home to a place of work in another country (on a weekly or bi-weekly basis); the rotational assignee in which an employee commutes from their home country to work in another country for a few months without changing their home; a virtual assignee who assumes business responsibilities which span several countries and works as part of a team located in several countries but does not need to relocate; a virtual assignment often involves extensive business travel to work with colleagues and supported by ICTs; and teleworking whereby an employee, supported by ICTs, works from any location, especially his or her home.

Australia ^c	2000/1	43.4	37.0
	2002/3	56.8	43.0
Japan ^d	1996	n.a.	191.0
	1999	n.a.	240.9
Korea ^e	1996	n.a.	13.4
	1999	n.a.	12.6
New Zealand ^f	2000	5.0	49.2*
	2003	7.8	85.6*

Notes:

- (a) Permanent flow to Canada shows the number of skilled immigrants admitted under the skilled focus program, principals and dependents. Temporary workers are movers with managerial, professional, and technical skilled levels. *Source: CIC (Facts and Figures, various years)*
- (b) Permanent flows to the US are immigrants with employment preferences, including professionals, executives, skilled workers and their dependents (1st, 2nd, and skilled workers in the 3rd employment preferences). Temporary inflow is in terms of admissions, not persons, under the following visa arrangements: NAFTA-TN, H-1B, Exchange visitors (J1), and intra-company transferees (L1). *Source: US-CIS (Statistical Yearbook, various years)*
- (c) Australian data on permanent flow reflect the number of people admitted under the skilled migration program. Temporary numbers are in terms of persons admitted under long-stay business visas for skilled workers (3 months to 4 years), and independent executive visas, excluding New Zealand citizens. *Source: Population Flows: Immigration Aspects, DIMIA (2004)*
- (d) Figures include 12 temporary visa occupation categories associated with high-skilled workers (entries). *Source: NSF (2002), Science and Engineering Indicators*
- (e) *Source: OECD (2001a) Trends in International Migration, Table 1.2*
- (f) Skilled permanent-migrants are those with administrative, managerial, and professionals occupations. *Temporary data refer to the number of work permits and work visas issued to unskilled and skilled workers. *Source: New Zealand Tourism and Migration (2000, 2003)*

We use three additional indicators to gauge the extent of international mobility of HQPs in the APEC/OECD area.

The first relates to scientists and engineers in the US with a doctorate qualification, who are not US citizens. Chart 1.1 shows the number of non-US OECD/APEC citizens with science and engineering (S&E) doctorates in the US. The data shows that the largest number of foreign-born scientists and engineers come from the UK and Canada; relatively few are from Germany and Japan (OECD, STI Scorecard 2003b). The report points out that if non-OECD countries are taken into account, there are three times as many foreign-born scientists from China and twice as many from India as from the UK. The corresponding shares of foreign-born women scientists vary greatly across countries.⁶

The second indicator looks at the international mobility of PhD student as an indicator of internationalization of both higher education sector and the research system (OECD, STI Scoreboard 2003b). The available data shows that the US has the highest number of foreign PhD students among the APEC/OECD economies (about 79,000), followed by the UK with some 25,000. European students represent 19 percent of foreign PhD students enrolled in Canadian universities. These shares reach 50 percent in Austria and 77 percent in Switzerland (Chart 1.2).

The third indicator shows the movement of intra-company transferees among selected APEC/OECD economies. Temporary migration of intra-company transferees increased sharply in the US as compared to other OECD countries (Table 1.2). These movements are usually for short periods, but may be for several months or reoccur at frequent intervals. Intra-company transferees in the US (L-1 visas) virtually tripled in magnitude between 1995 and 2002. It increased from 112,100 in 1995 to 313,699 in 2002.

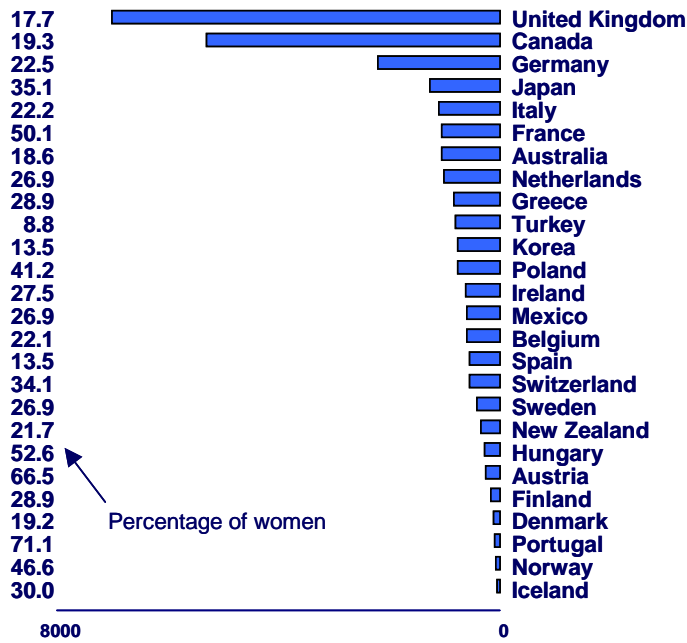
⁶ The OECD, STI Scoreboard 2003 notes two important points. First, internationally comparable data on international flows of scientists and researchers are extremely **scarce**; and second, the available **data** only covers inflows and thus provides only part of the picture of international mobility.

Table 1.2 Intra-Company Transferees in Selected APEC/OECD Economies, 1995–1999

	Thousands				
	1995	1996	1997	1998	1999
Canada ^a	na	na	2.1	2.8	2.9
France	0.8	0.8	1.0	1.1	1.8
Japan	3.1	2.8	3.4	3.5	3.8
Netherlands	Na	1.6	2.3	2.7	2.5
United Kingdom	14.1	13.0	18.0	22.0	15.0
United States (visa L-1)	112.1	140.5	na	203.3	234.4

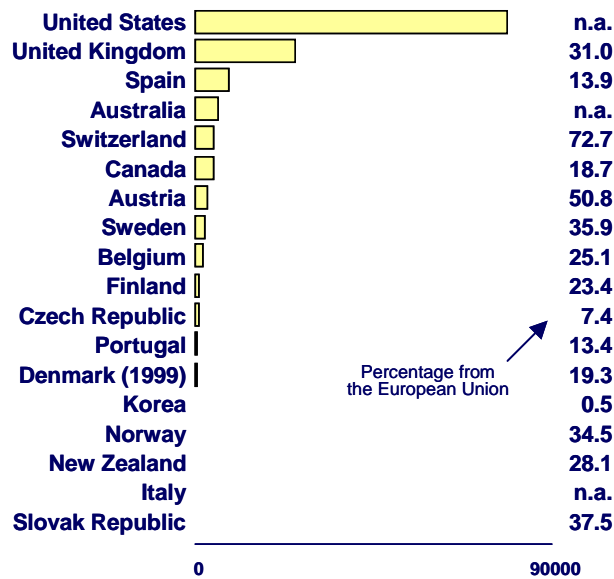
a) Including Mexican and American intra-company transferees entering under NAFTA.
 Source: OECD-DSTI/STP (2002b)

Chart 1.1 Non-US APEC/OECD Citizens with S&E Doctorates in the US, 1999



Source: OECD, based on data from National Science Foundation/SRS, SESTAT database, May 2003.

Chart 1.2 Distribution of Foreign PhD students in APEC/OECD Economies, 2000



Source: OECD, Education database, May 2003

Recent Patterns of HQP Mobility within the EU

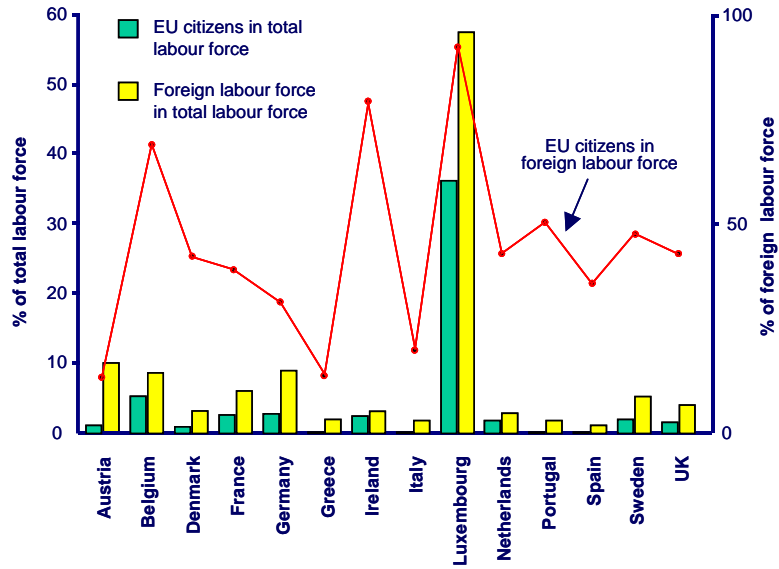
The data that measures the flows of workers between EU countries on a consistent basis is not available. The available data rather focuses on the share of foreign-born work force. A recent report by PWC (2002) notes that historically, the level of worker mobility in the EU has been low compared to that in the US; and the rate of migration has changed little during the 1990s. Based on the estimates by the European Commission, the PWC report (2002) notes that the annual mobility of EU nationals within the EU is less than 0.4 percent of the resident population (some 1.5 million people) whereas in the US it is about six times greater.

Chart 1.3 shows the share of foreign-born workers in the labor force of the European economies. The relative shares are higher in Luxembourg, Austria and Germany and lower in Spain and Italy. The chart also shows that mobile EU citizens (from other Member States) are more important in Luxembourg, Belgium and Ireland and least important in Greece and Italy.

The PWC (2002) report argues that the way in which these data are collected excludes workers on short-term assignments. Their survey of business firms' expatriate staff suggests that there has been an overall increase in mobility of workers within organizations, and, more importantly, the relative importance of virtual and short-term assignments has increased most significantly (Chart 1.4).⁷

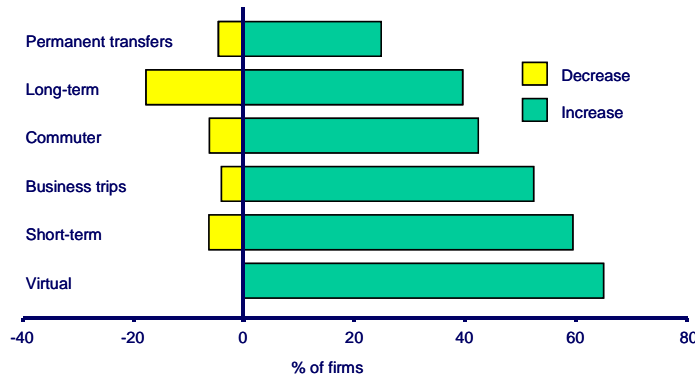
⁷ The PWC report (2002) defines a virtual assignee "who assumes business responsibilities which span several countries and works as part of a team located in several countries but does not need to relocate: a virtual assignment often involves extensive business travel to work with colleagues (rather than to develop new client or supplier relationships) and is supported by wide use of ICTs".

Chart 1.3 Size and Composition of Foreign Labor Force in the EU, 1998



Source: PricewaterhouseCoopers (2002) based on OECD data and OECD Employment Outlook (2001)

Chart 1.4 Changes in International Assignment Type over the Last Two Years



Source: PricewaterhouseCoopers, IAS Survey 1999/2000

1.3 International Mobility of HQPs in APEC

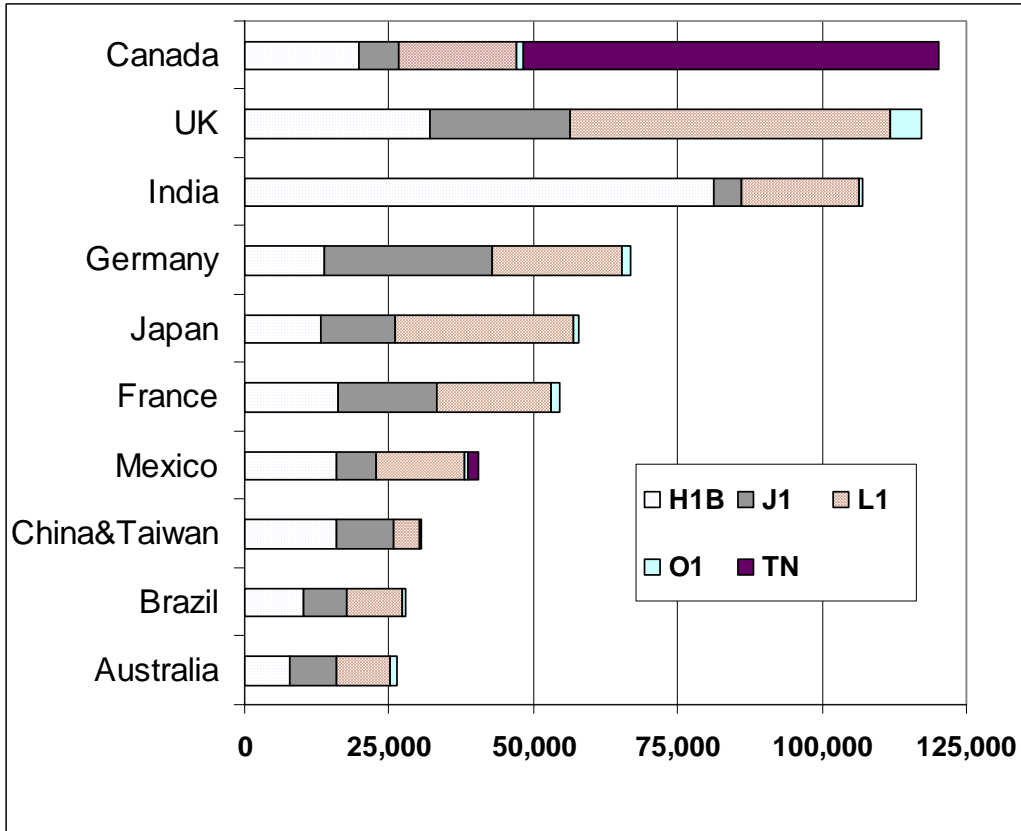
Experience of the Selected APEC Economies: United States

Inflows of HQPs: Temporary Migrants

The US is the main destination for internationally mobile HQPs. A strong demand by US technology-intensive firms in service-related occupations such as architecture, engineering, surveying and computer-related occupations and the demand by universities for academic faculty and researchers led to increased temporary inflows of HQPs into the US. The data shows that in fiscal year 2002, there were 1.1 million entries of HQPs to the US (the US Citizenship and Immigration Services; US-CIS). The main source of temporary HQP migrants have been APEC economies such as Canada, Mexico, Japan, China, Chinese Taipei and Australia, and non-APEC economies including the UK, India, Germany, France and Brazil. APEC economies (other than the US) contributed 33.3 percent of temporary HQP migrants to the US. Europe, however, has been the main contributor of temporary HQP migrants to the US (43 percent), followed by Asia (26 percent), and North America (Canada and Mexico, together 15 percent).

Chart 1.5 shows top source countries for HQPs admitted on temporary visas into the US for the fiscal year 2002 by country of citizenship. These include H-1B temporary HQPs with specialty occupations such as computer scientists, engineers; exchange visitors including researchers and professors (J1); intra-company transferees (L1); individuals with extraordinary ability or achievement (O1); and NAFTA workers (TN). Canada and the UK are the top two source countries of HQP inflows to the US, followed by India. More than half of HQPs inflows from Canada are via the NAFTA-TN channel, whereas about half of HQPs from the UK enter as intra-company transferees. For India, most of HQP entrants are under H-1B visas.

Chart 1.5 Temporary Inflows of HQPs into the US by Visa Type, Fiscal Year 2002



Note: H-1B visa is for workers with specialty occupations, J1 refers to exchange visitors' visas, L1 is for intra-company transferees, O1 visas are for individuals with extraordinary ability or achievement, and NAFTA workers are admitted under TN. The data are in terms of entries and exclude dependents.

Source: US-CIS, 2002 Yearbook of Immigration Statistics

In 2002, three APEC economies—Canada, Japan, and Mexico—were the biggest contributors of HQP inflows into the US; they together made up almost 60 percent of HQP entrants from APEC economies (Table 1.3). Other main sending APEC economies were China and Chinese Taipei, Australia, Korea, and Russia; each contributing more than 20,000 entrants.

Table 1.3 Temporary Inflows of HQP Migrants from APEC Economies into the US by Visa Type, Fiscal Year 2002

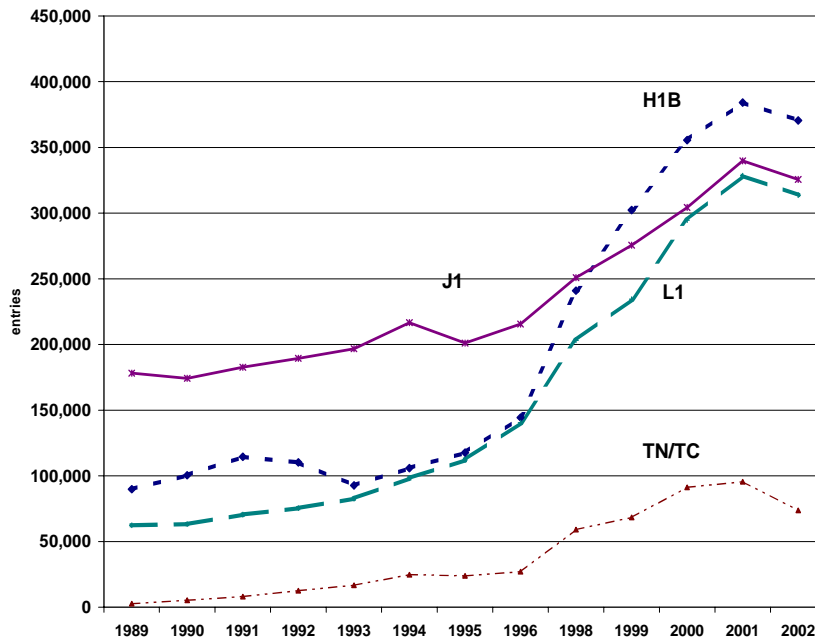
Economy	Total	Workers with Specialty Occupations H-1B	Exchange Visitors J1	Intra-company Transferees L1	Workers with extraordinary ability O1	NAFTA-TN visa
Canada	120,190	19,866	6,748	20,320	1,378	71,878
Japan	57,756	13,287	12,684	31,044	741	-
Mexico	40,534	15,867	6,894	15,283	669	1,821
China and Chinese Taipei	30,487	15,838	9,795	4,572	282	-
Australia	26,286	7,761	7,990	9,323	1,212	-
Korea	22,947	8,000	9,951	4,769	227	-
Russia	21,506	4,560	15,605	829	512	-
The Philippines	9,110	5,509	1,333	2,077	191	-
New Zealand	7,192	1,980	2,935	2,014	263	-
Peru	6,924	2,990	2,351	1,392	191	-
Chile	5,718	1,978	1,488	2,096	156	-
Thailand	5,476	1,671	3,365	382	58	-
Malaysia	4,908	2,479	871	1,533	25	-
Singapore	4,092	1,938	651	1,468	35	-
Hong Kong, China	2,910	2,005	497	364	44	-
Indonesia	2,514	1,488	591	409	26	-
Viet Nam	917	96	744	77	-	-
Brunei	32	13	6	13	-	-
Papua New Guinea	12	1	8	3	-	-
Total APEC percent of all nations	369,511 33.3 percent	107,327	84,507	97,968	6,010	73,699

Source: US-CIS, 2002 Yearbook of Immigration Statistics, Table 27

Chart 1.6 shows the trend in inflows of temporary HQPs to the US over the period of 1989 to 2002. The admissions on H-1B and intra-company transferee visas increased sharply in the last five years while the NAFTA-TN and exchange visitors' visas also rose, albeit with a relatively slower pace. In all categories, the entrants declined in 2002 mainly due to the impact of the September-11 incident.⁸

⁸ The impact of the shock is clearly acknowledged in the 2002 Yearbook of Immigration Statistics.

Chart 1.6 Trend in Temporary Inflows of HQP Migrants into the US by Visa Type, 1989–2002



Source: US-CIS, 2002 Yearbook of Immigration Statistics

Profile of H-1B entrants

The admissions on H-1B visas increased sharply from 144,458 in 1997 to 370,490 in 2002, at a growth rate of 23 percent per annum (Chart 1.6). Under the H-1B program, foreign professionals are permitted to work in their field of expertise for as long as three years initially, with extensions not exceeding three years. H-1B petitions must be submitted by domestic employers and their representatives on behalf of non-immigrant workers seeking temporary employment in the US. The maximum stay is six years. Specialty occupations include computer systems analysts and programmers, physicians, professors, engineers, and accountants.

In the fiscal year 2002, there were 197,537 petitions approved (the number exceeds the number of individual workers because of possible multiple petitions). Tables 1.4 and 1.5 show the profiles of H-1B entrants. The typical H-1B beneficiary had the following characteristics: born in India; 30 years old; holding a bachelor's degree; working in a computer-related occupation; and receiving an annual compensation of US\$53,000.

Table 1.4 Profile of H-1B Beneficiaries by Country of Birth Top 10, FY2002

Country of birth	No. of approved petitions	Median Age (years)	Median Income (dollars)	Bachelor degree or higher (percent)	Master degree or higher (percent)	Computer related occupation (percent)
All countries	197,537	30	53,000	98	48	38
India	64,980	29	60,000	99	43	73
China (PRC)	18,841	32	48,000	100	85	28
Canada	11,760	34	70,000	94	39	24
The Philippines	9,295	32	38,000	99	15	17
United Kingdom	7,171	33	68,000	92	36	17
Korea	5,941	34	42,000	98	59	14
Japan	4,937	31	38,000	97	37	9
Chinese Taipei	4,025	31	42,000	99	71	24
Pakistan	3,810	31	50,000	99	50	39
Colombia	3,320	32	38,000	98	29	9

Source: US-CIS, 2002 Yearbook of Immigration Statistics

Table 1.5 Profile of H-1B Beneficiaries by Occupation, FY2002

Country of birth	No. of approved petitions	Median age (years)	Median Income (dollars)	Master degree or higher (percent)	Leading Country of birth (percent)
All occupations	197,537	30	53,000	48	India (33)
Computer-related	75,114	29	60,000	38	India (63)
Architecture, engineering, And surveying	25,197	31	57,000	48	India (23)
Administrative specializations	21,103	30	41,000	34	India (13)
Education	20,613	34	36,000	75	PRC (17)
Medicine and health	12,920	32	46,000	68	India (20)
Managers and officials	10,610	33	59,000	34	India (11)
Life sciences	6,910	33	38,000	85	PRC (28)
Social sciences	5,547	29	44,000	42	India (13)
Mathematics and physical Sciences	5,443	32	55,000	80	PRC (26)
Miscellaneous professional, Technical, and managerial	4,940	30	53,000	48	India (14)

Source: US-CIS, 2002 Yearbook of Immigration Statistics

Inflows of HQPs: Permanent Migrants

The discussion in this section considers only the “employment-based preference immigrants” and ignores other categories such as family-sponsored and diversity programs.⁹ In particular, the discussion focuses on HQPs such as the priority highly-qualified individuals including people with extraordinary ability, outstanding professors or researchers, and multinational executives or managers (Class 1); professionals with advanced degrees or with exceptional ability (Class 2);

⁹ There are five classes under the employment-based program: priority highly-qualified individuals including people with extraordinary ability, outstanding professors or researchers, and multinational executives or managers; professionals with advanced degrees or with exceptional ability; skilled workers and professionals (without advanced degrees) and needed unskilled workers; special immigrants (e.g. religious workers, foreign employees of the US government); employment creation immigrants or “investors”.

and skilled workers and professionals with bachelor degrees (part of Class 3). During the years 2000 and 2002, on average, 140,000 HQPs immigrated to the US under these categories (Table 1.6).

In terms of the source countries, Asia contributed more than 60 percent of *all* employment-based immigrants to the US in FY 2002, followed by Europe (15 percent). The leading countries were India (24.5 percent), China (11.8 percent), The Philippines (7.2 percent), Canada (5.4 percent), Korea (5.3 percent), The UK (4.3 percent), and Mexico (4.3 percent).

Table 1.6 HQP Immigrants Admitted to the US by Selected Classes, FY 2000–2002*

	FY2002	FY2001	FY2000
Class 1	34,452	41,810	27,706
Class 2	44,468	42,620	20,304
Class 3			
Subclass- Skilled and Professionals	84,574	81,363	45,167

* persons, including dependents

Source: US-CIS, *Yearbooks of Immigration Statistics, various years*

Of all the permanent immigrants to the US in the year 2002, more than 45 percent of those who had jobs were in the professional and executive occupation groups (US-CIS, 2002). Guellec and Cervantes (2002) make two interesting observations. First, while the temporary migration of HQPs into the US increased in the latter part of 1990s, the permanent migration of engineers and computer scientists to the US has decreased substantially since 1992. Second, at the same time there is a surge in inflows of skilled migrants in occupations such as physicians, nurses, and health-related technicians.

Experience of the Selected APEC Economies: Canada

Although the U.S. is the major beneficiary and destination of global highly-qualified migrants, Canada is also a major recipient of HQPs from the rest of the world. The migration of HQPs into Canada occurs primarily through three distinct but related channels—permanent immigrants admitted under the skilled-focused program, temporary migrants with work permit visas¹⁰ and foreign students in tertiary educational institutions.

The economic principal applicants constitute the bulk of the international highly-qualified migrants to Canada (permanent migrants), because they are selected on the basis of their labor market attributes through the points system. They include highly-qualified individuals and business immigrants.¹¹ In 2002, 123,379 people were granted skilled-worker immigration and 11,041 people admitted as business immigrants (CIC, 2002). Together they account for more than 60 percent of the total inflow of permanent immigrants admitted in the year. The annual growth rate of skilled immigrants over the period 1998-2002 is about 10 percent, higher than the overall growth of permanent immigration (8 percent).

Data on the profile of skilled immigrants show that the majority of them are highly educated and at their prime working age. In 2002, the skilled immigrant category includes principal applicants (44 percent) and their dependants (56 percent). For principal applicants, 83 percent have a bachelor's degree or above (25 percent with master and/or doctoral degrees). This remarkable increase in

¹⁰ Note that persons visiting Canada under short-term business arrangements are not included as part of national employment, but may reflect a small part of temporary movement of high-skilled workers.

¹¹ These also include individuals nominated by the provinces and fast tracked through the system to meet urgent labour market shortages within that province.

education attainment of permanent immigrants to Canada reflects a response to structural shift in demand for higher skills. In addition, more than half of their adult dependants (15 years and older) hold at least a bachelor's degree. In terms of language ability, more than 85 percent of the principal applicants can speak English or French or both, while 56 percent of their dependants cannot speak either of the Canadian official languages. About 60 percent of all skilled immigrants are 25–44 years old. Seventy-five percent of principal applicants are male while 63 percent of dependants are female.

Skilled immigrants into Canada are also classified by 'occupational skill levels' according to their previous employment (which can be different from their actual jobs when they settle in Canada). In 2002, more than 80 percent of skilled immigrants were holding managerial, professional, skilled and technical jobs¹² prior to their landing. More than 55 percent of these skilled immigrants were professionals.

The majority of immigrants to Canada in the last decade came from Asia. For several years, China has been the leading source country of immigrants admitted under the skilled-focus program to Canada, accounting for over 20,000 or 16 percent of the total immigrants in 2002. During the same year, the second, third and fourth largest source countries were India (11 percent), Pakistan (7 percent) and the Philippines (5 percent).

The second source of HQP migrants into Canada includes temporary foreign workers. Temporary foreign workers are in Canada primarily to work, although they may have other permits or authorizations (including NAFTA-TN professional work visa). Temporary inflows of HQPs include workers with professional, executive, and technical skill levels. An annual average of 48,000 HQPs were admitted during 1999–2002, out of which 70 percent are with exceptional skills (i.e. executives and professionals). In contrast to the surge in permanent inflow as described above, the number of temporary inflow of HQPs has been fluctuating in the last couple of years. According to the CIC record, there were 46,063 foreign skilled professionals admitted to work in Canada in 1999. The number increased to 52,446 in 2000, before reducing to 41,488 in 2002. The main source countries in 2002 were the NAFTA partners – the US (23 percent) and Mexico (13 percent) – and the UK (7 percent) and Australia (6 percent) in 2002. Over 70 percent of temporary workers are male.

Thirdly, student migration constitutes a significant part of international mobility.¹³ As one of the main players in globalization of education services, Canada receives substantial number of foreign students. Their number has risen substantially in recent years, more than doubling between 1995 and 2001. In 1999, there were about 25,000 foreign students admitted to Canadian universities and colleges (for post-secondary education); the number rose to 29,000 in the year 2000 then levelled to approximately 36,000 in the two subsequent years (CIC, various years). The leading source countries were Korea (20 percent), China (17 percent), Japan (8 percent), and the US (6 percent). In the international arena, 80 percent of all foreign students for higher education study are in the US, the UK, Germany, France and Australia. The number of foreign students per 1000 students enrolled in Canada is 27.9, considerably lower than the OECD weighted mean (37.1). The respective numbers are, 32.4 in the US, 73 in France, and 125.9 in Australia, and 12.4 in Italy (Tremblay, 2002).

Canada-US patterns of HQP mobility

Canada is heavily integrated with the US on both the trade and investment front. Moreover, Canada-US labor markets are integrated to a great extent for a sub-set of the labour force. The issue of measuring the migration of HQP in the North American context will continue to be important in the near future. An improved understanding of the magnitude, direction and the composition of the migratory flows between Canada and the US is essential to estimate the longer-term cross-border mobility trends of HQPs.

¹² Levels O, A, and B according to the Canadian National Occupational Classification (NOC) system

¹³ Tremblay (2002) argues that student migration to higher education can be a precursor of subsequent migration of qualified workers particularly in the field of science and technology.

In terms of inflows from the US to Canada, on average, about 5,400 permanent migrants entered every year into Canada over the 1997–2002 period (Table 1.7). However, the inflows of skilled permanent (principal) migrants were quite insignificant - less than a thousand people per year. In comparison, the total temporary inflows from the US have been quite significant over this period – on average, about 23,000 people per year. Temporary inflows of HQPs from the US, on average, are around 20,000 per year. This comprises both NAFTA-TN workers and the non-NAFTA workers in managerial, professional and technical skills categories.¹⁴

The outflow of highly-qualified professionals from Canada to the US has always been of great interest to Canadian policy makers, particularly because of periodic concerns over brain drain. Data quality is one of the main problems in estimating outflows from Canada. In recent years, a number of efforts have been made to improve these estimates. Statistically Canada has employed three different data sources to provide estimates of the magnitude of the total outflows of HQPs from Canada. These include personal income tax data, the Canadian Census Reverse Record Check (RRC) and the US Current Population

Table 1.7 Inflows of HQPs from the US to Canada, 1997–2002

Year	Temporary Inflows ^a					Permanent Inflows ^b	
	From all countries		From the US			From the US	
	Total	Skilled	Total US	NAFTA Skilled	non-NAFTA Skilled	Total	Skilled (principal)
1997	75,452	na	23,453	8,194	11,971	5,043	764
1998	79,788	na	23,760	9,073	11,322	4,773	680
1999	85,932	46,063	23,751	7,921	12,368	5,528	712
2000	94,893	52,446	26,407	8,752	13,819	5,815	692
2001	95,555	49,945	23,227	8,080	11,959	5,902	658
2002	87,910	41,488	19,700	6,923	9,766	5,288	556
Average	86,588	47,960	23,383	8,157	11,868	5,392	677

(a) Numbers of foreign workers are in terms of persons. Skilled workers from all countries are temporary workers with managerial, professional and technical skill levels (i.e., Levels O, A, and B). Temporary inflows from the US, are workers with American citizenship. Skilled workers from the US are NAFTA-TN workers and non-NAFTA workers in skill categories O, A, and B (source: CIC unpublished data).

(b) Total numbers include all skilled levels. Skilled permanent immigrants are principal applicants admitted under the skilled focus program. Source: CIC, various years

Using sample data from the Canadian census (RRC), Zhao, et al (2000) estimate that half of all permanent emigrants and a third of all temporary emigrants chose to move to the US during the period 1986–91 and 1991–96.¹⁵ Similarly, Finnie (2001) estimates that 178,000 people left Canada for the US between 1991 and 1996, 30 percent higher compared to the 1986-91 period; permanent emigration increasing by 15 percent and temporary emigration doubling. Furthermore, Finnie (2001) and Zhao, et al (2000) estimate that the annual emigration to the US in the 1990s was in the 22,000 -35,000 range, or approximately 0.1 percent of the Canadian population.¹⁶ Helliwell (1999), using the US Current Population Survey (CPS) for the years up to 1998, concludes that there is little evidence of a surge in the *net* outflow of Canadians during the 1990s. In fact, both Finnie and Helliwell conclude that there is little evidence of a substantial outflow of Canadian workers to the US through most of the 1990s.

¹⁴ The number somewhat understates the amount of skilled workers due to the fact that almost 10% of temporary workers from the US did not declare their skill levels.

¹⁵ Similar trends in the outflow of skilled migrants to the US can also be observed for countries such as Germany, the United Kingdom and France (See Guellec and Cervantes, 2001).

¹⁶ Interestingly enough, while the share of migration to the US has remained approximately constant between 1986-91 and 1991-96, temporary emigration to other countries has risen just as fast as that to the US in the 1990s. Canadian emigration flows (both temporary and permanent) have shifted from Europe towards Asia in the past decade.

However, recent numbers reported by McHale (2002) do not support the joint Finnie-Helliwell contention that the Canada-US outflows were small. McHale extends Helliwell's CPS estimates to include data for the 1999 to 2002 period. McHale's key findings are: (1) by 2002, the stock of Canadians resident in the US approached 935,000 which represented approximately 400,000 or an 80 percent increase in 5 years (1997-2002); (2) the *net* annual outflow to the US appears to be around 50,000 per year; and (3) more importantly, between 1997 and 2002, 116,000 more university trained Canadians aged 25–64 moved to the US, which represented an average outflow of 23,000 annually during the period.

We also look at the outflow data that comes from the US Citizenship and Immigration Services (US-CIS). Chart 1.7 below shows the quantitative importance of the permanent and temporary emigration of skilled Canadians to the US during the period of 1997-2002. The number of Canadians granted permanent residency in the US has been small despite sharp increases in 2000 and 2001. In contrast, the temporary outflow of highly-qualified Canadians is relatively large and has been sharply on the rise during 1997–2002, with a striking rate of 26.6 percent per annum.

The trend illustrated in Chart 1.7 appears consistent with CPS data reported by McHale.¹⁷ A significant part of the recent increase in emigration is accounted for by temporary migrants (i.e. intra-company transfers, NAFTA-TN visa holders, H-1B visa holders and exchange visitors). Table 1.8 shows temporary flows of Canadians to the US under these temporary visa arrangements. An important change is the increase in the number of Canadians entering the US using the TN visa in the late 1990s. Between 1998 and 2002, the average number of TN visa admissions to the US was around 73,000. The temporary outflow of HQPs drops in 2002, part of an overall decline in the migratory flows to the US during this year due to the external shock of the September 11 event.

Intra-company transferees have also been rising rapidly. The other major group of professionals entering the south is under the H-1B program – a nonimmigrant visa issued to foreign professionals in occupations such as computer system analysts and programmers, physicians, professors, engineers, and accountants. The annual flow is smaller in magnitude (about 11,000 annually) than the flow under NAFTA-TN but grew fastest at the rate of 38 percent per annum during the same period (Table 1.8).

The evidence presented above shows that out-migration of highly-qualified Canadians to the US increased in the 1990s and sharply so since 1997. Clearly, there appears to be an upward trend, and a steep one.

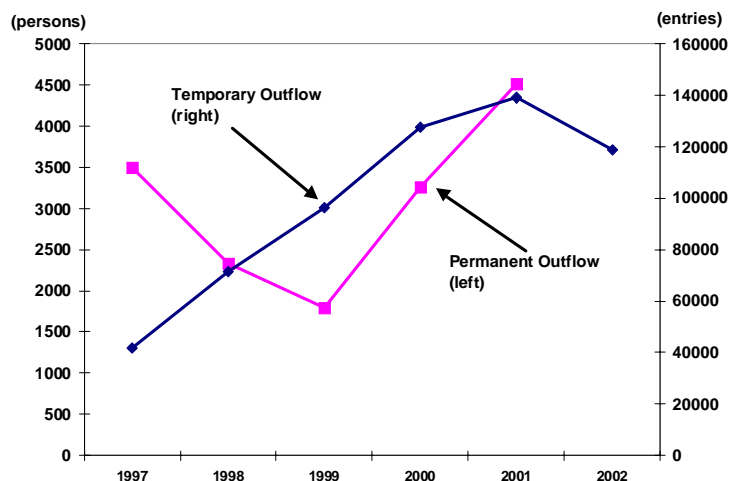
Table 1.8 Entries of Canadian-born to the US on Temporary Basis, Selected Classes, 1997–2002

Year	NAFTA-TN	Specialty Occupations (H-1B)	Intra-company Transferees (L1)	Exchange visitors (J1)
1997	26,794	4,192	7,037	3,698
1998	47,060	7,595	12,001	4,792
1999	67,076	10,235	13,603	5,470
2000	89,220	12,929	19,221	6,322
2001	92,915	16,454	22,838	6,872
2002	71,878	19,866	20,320	6,748

Source: US-CIS, various years

¹⁷ McHale's study is drawn from stock data while US-CIS data reports annual flows. The unit of temporary flows is in terms of entries, therefore, it is difficult to compare the figures from US-CIS and McHale's numbers literally. Nevertheless, both sources indicate that there has been a surge of outflows of Canadians to the US in recent years.

Chart 1.7 Outflows of HQPs from Canada to the US, 1997-2002



Note: Permanent outflows to the US are Canadian-born emigrants with professional and executive skills, principals (exclude dependents). Temporary flows are in terms of admissions (entries) of Canadian-born working in the US under the following visa arrangements: TN, H-1B, intra-company transferees, and exchange visitors.

Source: US- CIS, various years.

The Composition of the Outflows from Canada to the US

First we look at the composition of such migrants in terms of skill levels. Table 1.9 shows that Canadian emigrants to the US have always had above-average education levels relative to those who stayed home (Card, 2003). Card's analysis shows that currently Canadian men living in the US are 2.7 times more likely to hold a university degree than men in Canada. Even more striking is that about 8 percent of Canadian immigrants in the US have an advanced degree (MA, PhD, law and medical degree), compared to just over 1 percent of Canadian men. The data suggest a possible sharp increase in the quality of migrants in the 1980s and 1990s. Similar conclusions hold for women.¹⁸

Frank and Belair (1999) report that a survey of 1995 Canadian university graduates found that 1.5 percent of the respondents were residing in the US by 1997, which is fairly consistent with the proportion of Canadians living there. The figure for PhD graduates in the same survey was even much higher – 12 percent of them were living in the US by 1998.¹⁹

Secondly, in terms of income, the estimates from Zhao, et al (2000) and Finnie (2001) show that Canadian tax filers who moved to other countries, including the US, are more likely to be high-income earners. To illustrate, almost 1 percent of 1995 tax filers who earned \$150,000 or more ceased to reside in Canada in 1996. The fractions are smaller for the lower income earners.

Lastly, the evidence on occupational profile shows that in 1996-97, permanent outflows to the US tend to be concentrated in certain knowledge-intensive professions (Table 1.10). Emigrants in professions such as physicians, nurses, natural scientists and engineers had higher-than-average emigration rates. In particular, for physicians and nurses, the number of permanent emigrants to

¹⁸ The data shows the distribution of measured educational levels among emigrants and misses a potentially important dimension of skill, that is unmeasured ability. The loss of human capital would be underestimated if, at any given education level, those who migrate from Canada have a higher ability than others. Card (2003) notes that the issue of unobserved skill differences is complex, and ultimately difficult to resolve.

¹⁹ Helliwell (2001) makes some interesting observations on inflows and outflows of PhDs from Canada. He argues that the high numbers of exiting PhDs reflect most of all the global reach of the recruiting for PhD programs.

the US exceeded the number of such immigrants to Canada from all countries (OECD, 2003a). The higher emigration rates of these medical professionals were probably related to the health spending cutbacks enacted by most provinces in those years. Barrett (2001) argues that for physicians, the outflow seems to have abated toward the end of the decade.

Table 1.9 Outflows of HQPs: Percentage Canadians with a University Degree

	Canadians in US.		Canadians in Canada	
	Women	Men	Women	Men
1940	3.3	5.8	2.0(est.)	3.0
1970	7.6	15.0	---	---
1980	12.7	24.9	7.5	11.8
1990	22.7	33.3	---	---
2000	36.7	44.3	15.2	16.0
2000*	5.0	8.1	0.5	1.1

* percent with advanced degree

Source: Card (2003)

Table 1.10 Emigration to the US and Total Immigration, Selected Professions

Annual averages, in percent of 1996 labour force by occupation

	Emigration to the United States ¹			Immigration (total) ¹		
	1986-89	1990-95	1996-97	1986-89	1990-95	1996-97
	Physicians	0.25	0.45	0.78	0.69	0.70
Nurses	0.13	0.31	0.33	0.34	0.39	0.16
Teachers – post-secondary	0.13	0.17	0.13	0.38	0.49	0.35
Teachers – except post-secondary	0.06	0.07	0.06	0.25	0.32	0.23
Computer scientists	0.06	0.08	0.07	0.55	1.53	4.11
Engineers	0.27	0.31	0.27	1.01	2.11	5.21
Natural Scientists	0.22	0.30	0.39	1.28	2.32	6.49
Managers	0.09	0.13	0.12	0.44	0.56	0.70
All other occupations²	0.06	0.05	0.03	1.23	0.92	0.72
All occupations	0.07	0.08	0.06	1.06	0.86	0.80

1. Permanent migration

2. Includes cases where occupation was not identified.

Source: OECD Economic Surveys: Canada (2003)

One obvious question would be whether the patterns of HQP migration across countries different much compared to those within a national labour market such as the US or Canada? What is the historical perspective of HQP migration in an integrated labour market such as the European Union and Australia?

Experience of the Selected APEC Economies: Australia

In post-war Australia permanent immigration has clearly been the dominant thinking and policy regarding international migration. However, in the increasingly knowledge-based Australian economy, internationalization of labor markets and globalization forces more generally, there has been a major shift in policy towards recruitment of HQPs with particular occupational skills, outstanding talents or business skills via temporary entry programs (Hugo, 2002).

Inflows of HQPs: Temporary Migrants

Temporary residents in Australia include persons approved for non-permanent entry, e.g. top managers, executives, specialists and technical workers, diplomats, business persons, working holiday makers, occupational trainees, entertainers, etc. Their stay is usually longer than three months but not more than four years. In this section, we focus on the “long-stay business” entry, which can be considered “highly skilled”. These people include independent executives, intra-company transferees, and professionals.

The business long stay categories include managers and skilled specialists who are sponsored by their companies to work in Australia. These skilled temporary residents must satisfy the requirement for minimum skill and salary levels they receive in Australia. Table 1.11 shows that there were on average about 35,000 persons granted long-stay temporary business visas each year. Major occupation groups are professionals (64 percent), managers and administrators (14 percent), and associate professionals (12 percent). The top five source countries were the UK (31 percent), India (10 percent), the US (8 percent), Japan (6 percent), and South Africa (6 percent). In terms of stock of business long stay residents, there were 56,000 persons as of June 30, 2003. The median duration of long stay business entrants was just over six months. The median age was 30 years.

An independent executive stream of business long stay visa is a non-sponsored visa that enables a person to enter for the purpose of establishing or buying into a business and managing that business. In 2001–02, more than 4,000 independent executive visas were granted. The number increased to almost 5,000 in 2002–03.

Table 1.11 Annual flows of Visas Granted for Long Stay Business and Independent Executives

	2000–01	2001–02	2002–03
a) Long-stay business	37,000	34,000	38,000
b) Independent Executives	na	4,093	4,943

Note: that there are occupation-specific visa classes for medical practitioners -2,496 principal applicants in 2002-03, a 30 percent increase over 2001–02. For academics and researchers in educational or research institutions, 1,315 visas were granted in 2002–03, down from 1,819 in the previous year. However, this stream of entry was recently reclassified as subclasses of long-stay business visas in the new legislation introduced in March 2003.

Source: a) *Figure 5-23 Long stay temporary business grants*, b) numbers given on p.64, from *Population Flows: Immigration Aspects*, Department of Immigration and Multicultural and Indigenous Affairs, March 2004.

In terms of overseas students in Australia, there were 162,575 visas granted to overseas students in 2002–2003 (a 7 percent increase from 151,894 in 2001–2002). Of these, 32 percent enrolled for higher education and 19 percent went for master and doctorate degrees. The top source economies were China (13 percent), the US (10 percent), Malaysia (7 percent), Korea (7 percent), and Hong Kong, China (6 percent). The stock of overseas students as of 30 June 2003 was almost 73,000.

Inflows of HQPs: Permanent Migrants

The majority of skilled migrants who immigrated to Australia were those admitted under the skill program – a points system based on skill evaluation. The skill program is specifically designed to target migrants who have skills or outstanding abilities that will contribute to the Australian economy (DIMIA, 2004). In the fiscal year 2000, there were about 43,000 skilled migrants. The skilled inflows continued to increase to above 57,000 in 2002 (see Table 1.12). Among these people, almost 30 percent of them are considered high-skilled professionals. They consist of

people who were employed as managers, administrators, and professionals. The top three sending countries were the UK, India, and South Africa.

In addition to the skill stream, skilled migrants can enter and settle in Australia via the family migration. During 2000–2002, an annual average of approximately 5,000 individuals in highly-skilled occupations were admitted to Australia under the family migration program. In 2002, 3,500 high-skilled New Zealanders entered and settled permanently in Australia under a different program designated specially to New Zealand citizens.

Table 1.12 Settler Arrivals (As Permanent Additions to the Resident Population)

	2000-01	2001-02	2002-03
Total persons	131,161	121,174	125,860
Top 3 source countries	NZ (27%) UK (10%) China (9%)	NZ (18%) UK (10%) China (8%)	UK (13%) NZ (13%) China (7%)
Skill Program	43,363	51,671	56,782
Top 3 source countries	na	na	UK (21%) India (11%) South Africa (10%)
Occupation Highly-skilled (i.e., managers and administrators, and professionals)	28,305 (22%)	24,858 (21%)	25,532 (20%)
- Family program	4,034	4,770	6,035
- Skill program	15,359	15,486	15,667
- NZ citizen	na	na	3,494

Source: DIMIA, Immigration Update (Report on FY 2003)

The top occupations of migrants on the basis of employment prior to their arrivals in Australia as reported in (DIMIA, 2004) included computer professionals (3,338 persons, in 2002), accountants (2,568), general managers (1,475), managers and administrators (1,647) and registered nurses (1,374).

Inflows from New Zealand

The Trans-Tasman Travel Agreement introduced in 1973 allows both Australian and New Zealand citizens to enter and visit freely, live, work and remain indefinitely without any visa requirements. However, New Zealand citizens are still required to apply for formal permanent residency in Australia if they wish to access certain social security payments.

The 'net' permanent and long-term (longer than 12 months) movement of New Zealanders tends to follow relative economic conditions such as differences in relative real incomes and employment opportunities (DIMIA, 2004). The movement increased steadily until reaching a peak in 2000–01 (Table 1.13).

Table 1.13 Net and Permanent and Long-Term Arrivals of New Zealand Citizens

	Net (persons)	Arrival (persons)
1999–00	30,000	42,000
2000–01	38,949	52,368
2001–02	16,817	30,068
2002–03	11,591	25,179

Source: *Population Flows: Immigration Aspects*, Department of Immigration and Multicultural and Indigenous Affairs, March 2004.

As of 30 June 2003, stock estimates show that 460,000 New Zealand citizens were present in Australia. New Zealand citizens coming to Australia permanently do not enter the migration program but are included in settler arrival statistics (see the discussion on permanent migrants).

Outflows of HQP migrants

As much as Australia is an immigration country, it is also a country of emigration (Hugo, 2002). There have been substantial departures on a long-term and permanent basis. In 1999-2000 there were 197,846 permanent and long-term departures. The number reached 219,568 in 2002-03. About half of these emigrants are Australian born. (DIMIA, 2003).²⁰

The UK is the most popular destination of more than 30 percent of Australian-born permanent and long-term departures, with the US in the second place accounting for about 15 percent. The movement to the two main destination countries is dominated by the highly qualified. Almost 60 percent of those leaving for the UK are in the manager, administrative, professional and associate professional categories, while 72.8 percent of those going to the US are in these occupations (Hugo, 2002).

Table 1.14 provides the total numbers of permanent and long-term departures of Australian-born working in skilled occupations during 1994-2000. The main destinations were the UK, the US, followed by New Zealand; Singapore; Hong Kong, China; and Japan.

²⁰ Permanent departure refers to out-migration of Australians and residents of Australia for indefinite periods of time (with no intention of returning). Similarly, permanent arrivals are movements of Australians or foreigners entering Australia with the intention of staying indefinitely. These arrivals and departures data relate to the movements of travellers rather than the number of travellers. Long-term movement refers to a change of residence that lasts longer than 12 months. Long-term departures refer to Australian residents and overseas visitors (who had stayed in Australia for 12 months or more) departing temporarily with the intention of staying abroad for at least 12 months. Long-term arrivals are the incoming movement of temporary visa holders and the return of Australian residents (who had stayed abroad for 12 months or more) with the intention of staying in Australia longer than 12 months. (DIMIA, Immigration Update FY2003)

Table 1.14 Long-term and Permanent Departures of Australian-born to Selected Top Countries By Occupation, 1994–2000

Country	Total workers over 1994-2000*	Skilled occupations**
UK	121,256	57,361 (59.8%) Manager, administrators 9,782 Professionals 39,341 Associate professionals 8,238
US	50,818	22,686 (72.8%) Manager, administrators 4,914 Professionals 15,063 Associate professionals 2,709
New Zealand	17,303	10,329 (59.7%)
Singapore	7,876	6,566 (83.4%)
Hong Kong, China	6,423	5,362 (83.5%)
Japan	7,418	5,855 (78.9%)
Malaysia	3,727	3,002 (80.5%)
Germany	2,677	1,933 (72.2%)
France	1,934	1,369 (70.7%)
Other Europe	14,845	9,127 (61.5%)
Other Asia	19,786	15,190 (76.8%)
Other rest of the world	35,491	24,720 (69.8)

* Note that the numbers are in terms of movement, not persons, and that they are aggregated over the period of six years.

** Skilled occupations refer to manager, administrative, professional and associate professional categories.

Source: Modified from Tables 12 and 13 in Hugo (2002)

Like other advanced APEC economies, Australia faced skill shortages in the information technology and telecommunication industries in the second half of the 1990s. Consequently, Australia experienced a substantial increase in the inflow of IT professionals during 1995–2000 although the outflows increased as well (Hugo, 2002). In part, this was due to the high degree of turnover in the global IT work force. Table 1.15 shows the permanent and long-term movement of IT professions between 1995–96 and 1999–2000. The net migration increased substantially during the period mainly due to large number of newly recruited IT personnel from countries like India. In addition, Australia also experienced a significant return of Australian resident IT professionals.

Table 1.15 Arrival and Departure of Permanent and Long-Term Migrants with Information Technology and Telecommunication Occupations, 1995–2000***

Year	Arrivals	Departures	Net Gain
1995–96	5,946*	3,318*	2,628*
1996–97	6,062*	3,912*	2,150*
1997–98	6,189*	4,477*	1,712 *
	4,708**	3,743**	965**
1998–99	5,507**	3,934**	1,573**
1999–2000	7,007**	4,227**	2,780**

* Based on wide definition, which includes data processing managers, electrical and electronics engineers, computing professionals, electronic engineering technicians, communications equipment trades, office equipment computer services and sales representatives.

** Based on narrow definition, which is more restrictive and includes information technology managers, computing professionals, and computing supply technicians.

*** Note that the numbers include both Australian residents and foreigners.

Source: Hugo (2002), Table 18

Experience of the Selected APEC Economies: China, Japan, Korea, and Mexico

Japan

In Japan, the 1989 revision of Japanese immigration laws made it easier for high-skilled workers to enter Japan with 'temporary' visas, which allowed employment and residence for an indefinite period (NFS, 2002). Fuess (2001), as reported in NFS (2002) examines 12 categories of temporary visas associated with highly-qualified individuals in Japan, and notes the growing importance and acceptance of the foreign skilled labor force in Japan. In 1999, 240,936 workers entered Japan under high-skill visa categories – a 75 percent increase since 1992. To compare, this number is roughly 40 percent of the number of Japanese university graduates entering the labor market each year and is about 80 percent of the H-1B entries to the US in the same year.

Korea

Data on permanent inflows of skilled foreigners to Korea is limited. Most information is available in terms of temporary workers. According to OECD (2001a), there were 12,600 temporary workers entering Korea in 1999, a 6 percent decrease from three years earlier.²¹ HQPs in Korea are classified by visa types – highly-qualified temporary migrants are, for example, professors, language instructors, researchers, special technology instructors. Stock data reported by Jang (2004) show that there were more than 8,000 high skilled foreigners (under visa type E1-E7) and close to 20,000 temporary business people²² working in Korea in 2004. Almost 40 percent of these skilled workers are from Asia and about 28 percent and 22 percent are from North America and Europe, respectively.

People's Republic of China (PRC)

Since its economic opening and reforms in 1978, the People Republic of China has engaged in exchanges and relations with other countries. This has contributed to an increase in international mobility of highly-qualified Chinese. The migration flows are mainly to North America, Europe, Japan, Australia, and New Zealand. Studying abroad has been the main form of migration of skilled Chinese, although there is evidence of an increased trend in outflows of technical and professional individuals as well. The main destination Chinese students, has been the US, which absorbs about half of the stock of 400,000 persons studying abroad during the years 1978–1999 (Zhang and Li, 2002). Additionally, APEC economies such as Japan (17 percent), Canada (7 percent), and Germany (7 percent) have also attracted Chinese individuals for higher studies.

In recent years, the Chinese government has actively encouraged the recruitment of foreign experts to work in China as well as the returning of highly-qualified Chinese from abroad. According to the State Bureau of Foreign Experts (SBFE) of China, a total of 834,000 foreign experts were working in China temporarily and permanently during 1978-99. The inflows of experts increased at an annual rate of 4.3 percent. In 1999, there were 84,000 foreigners working full-time in China; they include people who are management experts sent on contracts or by foreign investors, and experts in education, science, culture and public health (Zhang and Li, 2002).

Mexico

Flows of highly-qualified individuals from Latin America tend to go towards European economies and the US. The data show that Latin Americans make up almost 10 percent of the registered foreigners in Italy and 18 percent in Spain in the late 1990s (Solimano and Pollack, 2004).

²¹ The shortage in manual workers in Korea means that the majority of foreign workers in Korea are likely to be less-skilled and unskilled. As pointed out by an official in the Ministry of Labor, in 1987 a shortage of manual workers was estimated at 100,000. Sixteen years later in 2004, the number of foreign workers in Korea has climbed to more than 400,000. (IPF, 2004)

²² Intra-company transferees (visa D7), investors (D8), and traders (D9).

Since NAFTA, Mexico has emerged an important source of highly-qualified temporary migrants to the US. In 2002, there were more than 40,000 entries of skilled Mexican to the US, almost 40 percent of those entries were workers with specialty occupations (H-1B) and more than 30 percent were intra-company transferees (US-CIS, 2002). Solimano and Pollack (2004) note that there has been a two-way exchange of HQPs, which in part has been the result of foreign investments from European companies who have brought in a number of foreign executives, professionals, and investors working with global corporations and international banks in Latin American economies.

1.4 Return Migration of HQPs in APEC

In this section, we focus on the return migration of HQPs. The recent economic downturn that had hit the global IT sector hard, set off a kind of reverse migration – migrants with technical skills either returning to their native countries or moving to jobs in many new Silicon Valleys in India; China; Hong Kong, China; and Chinese Taipei and other fast-growing Asian economies. In North America, many of these reverse migrants were engineers, computer analysts and programmers who were brought to work in expanding high-tech industries in Ontario, British Columbia in Canada, and California and Massachusetts in the US during the peak of the dot com boom in the 1990s. They typically were recruited under special visa arrangements – such as fast-track work authorization for IT foreign workers in Canada and the H-1B program in the US – that aimed to make up for critical skill shortages facing North American companies at the time. Other than returning to their homelands, some of these mobile talents also found jobs in a third country. This pattern of mobility facilitates the international exchange of skills and blurs the notion of sending and receiving countries widely used in the brain drain literature. In other words, mobile HQPs are no longer a country-specific resource.

An empirical study on return migration by DeVoretz et al (2002) shows some evidence on the return of Hong Kong-born people from abroad. Using 2001 Hong Kong, China census data, they show that there were about 86,000 returnees who lived abroad before 1996 and had returned to Hong Kong, China between 1996–2001, out of which almost 40 percent were returnees from Canada and 20 percent from the US. In general, these people are young and recent graduates from overseas institutions. Returnees from Canada were more heavily concentrated in entry-level professions (34 percent), and higher-level professions or managers (40 percent) than those who returned from the US and other APEC/OECD economies.

The evidence on return migration from other countries is quite scattered. Anecdotal evidence reveals cases of HQPs from developed countries returning to India; China; Hong Kong, China; Chinese Taipei; and Russia. A well-known example is India's hi-tech cluster in Bangalore, which attracted about 35000 Indian tech professionals returning from abroad (The Economic Times, 27 July 2004; Siliconindia, June 2003).

A rapidly growing Chinese economy since the 1990s has increasingly attracted foreign-educated and western-trained Chinese nationals back home. These returnees are highly educated, with 90 percent holding a master or doctoral degree from abroad. While some of them go into academic and government careers, most returnees opt for jobs in the business sector, either joining multinational firms or state-owned enterprises, or setting up their own business. The Chinese government established more than 70 business parks to provide more attractive business opportunities for those who returned to set up their enterprises. A successful business cluster situated in Beijing proximity, Zhongguancun, is also known as China's Silicon Valley. Returnees can receive several incentives in setting their companies in these areas, including tax breaks, cheap office space, start-up loans and advice on dealing with the local bureaucracy. In Beijing alone, there are 3,300 new enterprises started by returnees, including some of the economy's largest firms such as UTStarcom (IT equipments) and Sohu (an internet portal). (The Economist, 11 August 2003)

In Chinese Taipei, the immigration laws and regulations on working visas for the high-tech talent were being revised and relaxed in order to attract high-tech skilled workers from overseas.²³ The return home of Chinese Taipei engineers to take up positions at home is also recognized as one of the successful tools in building up effective business networks in the Hsinchu Science-Based Industrial Park (Liu, 2004). The box below gives an overview of the return migration of HQPs from abroad.

BOX 1.1

Return Migration of HQPs in Chinese Taipei

There has been a significant movement of former emigrants returning to Chinese Taipei since the late 1980s. It is estimated that 33 percent of students graduated from abroad had returned. The return rate is three times higher than that in 1980. According to a survey based on the Chinese Taipei 1990 population census, around 50,000 emigrants returned during the period of 1985–90. About 43 percent of them have at least a college education and more than 30 percent are employed as managers and professionals.

The success of the Hsinchu Science-based Industrial Park (HSIP) has attracted returnees, especially those who are highly educated in science and technology fields. The number of returnees working in HSIP was merely 27 in 1983, 223 in 1989, but rose sharply to 3,265 in 1999 and 4,108 in 2000. With the large concentration of R&D researchers, returnees with doctorate degrees constitute an important part of R&D manpower in the HSIP. During 1990s, US-educated students returned to Chinese Taipei to start new companies or take positions in existing companies in HSIP. By 2000, there were 113 companies (out of the total of 289 companies) established by mainly US-educated engineers, often with professional experience in Silicon Valley.

Many returnees work in Chinese Taipei on a temporary basis. They are characterized as “temporary returnees” or “trans-national workers”. This group mainly consists of managers, engineers, investors, and venture capitalists, who often travel between Silicon Valley and Hsinchu. They play a very significant role in business, investment, and research networking between Chinese Taipei and the US. A total of 70 HSIP companies have offices in Silicon Valley, with executives and managers working on both sides of the Pacific.

Source: Luo and Wang (2002)

In Russia, anecdotal evidence reveals many of the highly-qualified Russians who left home to work in the US, especially under the H-1B visas, have returned. A recent media report indicated that Russian expatriates are more than welcome by the homeland high-tech companies as they bring back a unique set of skills, including team working, project management and knowledge of how to work and deal with Westerners. Working experience from abroad is viewed as crucial by the technology companies because most Russian tech firms depend primarily on sales to North America and Europe. (Moscow Times (Russia), 4 June 2003)

2. FUNDAMENTAL DRIVERS OF INTERNATIONAL MOBILITY OF HQPS IN THE GLOBAL KNOWLEDGE ECONOMY

The traditional migration literature in the labor economics tradition treats international migration as driven by “push” and “pull” factors. “Push” factors are the supply side factors affecting the incentives and willingness to migrate; and “pull” are demand side factors that affect the demand for migrants in the receiving country. On the supply side, higher relative incomes in the host country is a key factor influencing migration decisions while the demand side factors include the use of less expensive migrant workers and skill shortages in specific sectors of the host country. In the most basic migration model, labor is assumed to be fairly homogeneous, and the net out-migration of skilled educated workers is treated as a “brain drain” in which there is a transfer of

²³ In addition, the Chinese Taipei government has successfully organized a recruiting mission since 1995 to recruit high-tech talent in the US and Canada. The same operation was repeated in 1997, and 2000 to 2004. (Details at <http://hirecruit.nat.gov.tw/english/index.asp>)

skilled workers from one country to another, leading to benefits for the country gaining these talents (brain gain) and costs for the sending country (brain drain). The migration of highly-qualified workers is largely viewed as a zero-sum game for participating countries.

In a competing perspective – “globalization of the HQP labor market” perspective – international mobility of HQPs is considered as “Brain Exchange” or “Brain Circulation” where the increased mobility contributes to increased two-way flows of knowledge, ideas and technology (OECD, 2002a,c; Harris 2003). This perspective suggests that a number of important factors have contributed to the recent rise in the international mobility of HQPs. These are: technological change, in particular the developments in ICTs, globalization of production and integration of markets through trade in goods and services and FDI, location of MNEs, access to leading clusters of research and innovation, opportunities for high-technology entrepreneurship, technology transfer and the internationalization of the R&D activities of national firms.

Guellec and Cervantes (2002) argue that these factors are important for migratory flows of HQPs among advanced countries, although they also play a role in the case of flows from developing countries. Furthermore, factors such as differences in labor market conditions, skills premium, job opportunities and career prospects, and attractiveness of the education and research systems continue to be the key drivers of the mobility of highly-qualified individuals in the new global economy (OECD, 2002b). Table 2.1 below, based on the OECD (1998), provides a summary of the key factors that drive the mobility of different occupational groups in the new global economy.

Interestingly, a study on European mobility patterns suggests that individual’s attitude to mobility are changing in the new economy as they become better qualified. They are more interested in living and working in another country, particularly those people in the younger age groups (PWC, 2002).

We organize our discussion of the key drivers of the mobility of HQPs under five main headings: technological change, globalization through trade and FDI, research and innovation, increased income and employment opportunities, and changing individual preferences. In order to assess the likely importance of these inter-related factors for the mobility of HQPs what key analytical issues would need to be addressed? To answer these questions, we turn our attention to both theoretical and empirical work in the area.

Table 2.1 Factors Explaining Mobility of Different Occupational Groups

Occupations	Major Factors
Managers and executives	Takeovers and mergers FDI Process
Engineers and technicians	Economic opportunity in host country Immigration policies R&D activities Personal factors
Academics and scientists	Networking, R&D activities International mobility within academic institutions
Entrepreneurs	Economic opportunity Immigration and taxation policies Capital markets and availability of venture capital
Students at higher education	Job market R&D (postdoctoral research) Financial supports Immigration policies

Source: Harris (2003) based on OECD

2.1 Technological Change

Technical change is considered as one of the most fundamental sources of productivity and economic growth in the new global economy (OECD, 2000). Developments in ICT are clearly the most important source of technological change in the 1990s. Most observers agree that the pace of technological change has accelerated and nations that develop and adopt the latest technological innovations can achieve competitive advantages and, eventually improve their productivity performance.²⁴ Evidence from a number of OECD countries shows that technological change, both “disembodied and “embodied” in capital equipment, especially in ICT have been a key factor in recent growth in total factor productivity (TFP). The evidence from the US, for example, shows that over the 1990-2001 period, investment in IT and transformation of business activities in response to IT investment accounted for 50 percent or more of the rise in labor productivity growth (Stiroh, 2002).²⁵

How does technological change affect the international mobility of HQPs? This is a complex question and also an area of uncertainty. It is important to note that the different potential roles of internationally mobile HQPs will be affected in different ways by technology.

First, technological change may shift demand towards highly-qualified workers relative to the less skilled, and raise returns to skill. Higher returns to skills, in turn, act as a significant pull factor in attracting globally mobile HQPs. Much of the recent empirical evidence confirms that the technological change associated with new computer technologies has been skill-biased (SBTC); it has caused a rise in demand towards highly-qualified workers relative to the less skilled (see, for example, Katz and Murphy, 1992; Card and Lemieux, 2001; Boudarbat, Lemieux and Riddell, 2003).²⁶ OECD (2002b) argues that in recent years, an increased demand for HQPs, driven by the rapid expansion of technology-based activities, has played a major role in the rise of cross-country HQP mobility for some countries. The observed higher returns to education in a number of countries over the last two decades or so, including the US and the UK, also seem to be a major pull factor in stimulating cross-country mobility of HQPs.

Second, technology, especially ICT, may reduce the demand for internationally mobile highly-qualified individuals. The argument goes that the ICT may transform the business activities and open up new possibilities that are cost-effective and do not involve interaction between worker and jobs. For example, the need for virtual labor mobility and telemobility may increase in importance and act as a substitute for physical HQP mobility in many areas. Examples include software engineering, data entry, translation services and distance teaching. According to Harris and Schmitt (2003), call centers in various Canadian cities that serve the entire NAFTA market provide, in essence, a form of mobile labor service. Inexpensive high-bandwidth communications make it feasible for large workforces located and effectively managed anywhere, giving rise to the vision of a continental e-labor market. The need for HQP mobility to facilitate skill transfer could decline if technology is used to deliver new forms of learning, such as, e-learning. Two common examples include university professors who deliver lectures via distant learning technology and doctors located in one city perform surgery in another.

A survey of businesses in the EU countries argues that although the use of new technology will allow greater flexibility for employers and workers, it will not reduce the need for mobile HQPs. Moving forward, a great majority of businesses believe that ICT developments enhance worker mobility. Innovations such as video conferencing facilitate ‘virtual’ meetings across countries. Yet personal contact remains the optimum way to develop business relationship. Only 18 percent of

²⁴ See Hanel and Niosi (1998) for a comprehensive survey of the relationship between technology and economic growth.

²⁵ Enabling technologies with broad applications throughout the economy offer considerable benefits over the longer term. What Richard Lipsey has called General Purpose Technologies, “Fifth-wave” technologies include ICTs, bio, nano and environmental/energy technologies.

²⁶ In contrast, Haskel and Slaughter (2002) have shown that for ten OECD countries over the period 1970s and 1980s, sector bias, and not skill bias, was a more important determinant of changes in relative wages. Other studies such as Card and DiNardo (2002) fail to support the SBTC hypothesis for the US.

the all businesses think that advances in technology will mean less need to have mobile workers (PWC, 2002).

2.2 Globalization through Trade and FDI

The last few decades have seen a stunning integration of the global economy through trade, FDI and technology. Rapid advances in ICTs accompanied by the sharp drop in transportation and communication costs, and increasing competition for markets, capital and skilled workers have accelerated the pace of globalization of business throughout the world.

The 1990s witnessed a significant increase in global trade. Global FDI flows have grown at a pace that exceeds even the growth in trade. In the 1990s, the nature of FDI has changed markedly, with mergers and acquisitions (M&A) now accounting for more than 85 percent of total FDI (Kang and Johansson, 2001). Over the 1991-99 period, M&A grew more than tenfold mainly in response to the rising importance of economies of scale and technology.

ICTs have been instrumental in making the production of goods and services global. The world's economies are increasingly becoming inter-linked and co-dependent. Mann (2003) notes that looking back, global integration of IT production accounts for about 10 - 20 percent of the dramatic decline in IT hardware prices. These price declines supported additional investment in IT and transformation of businesses, which together contributed to higher productivity and GDP growth in the US.²⁷

Interestingly enough, it is suggested that the rising global integration of world markets has brought with it increased mobility of HQPs. The EEAG report (2002) suggests that rising mobility of HQPs is a natural outcome of the increased globalization process. The PWC report (2002) argues that going forward, developments in technology will accelerate globalization, as more and more businesses will be looking to operate on an international basis. This can only lead to an increased demand for internationally mobile highly-qualified workers.

International Trade and HQP mobility

According to theory, trade may be either a substitute or complement to international mobility of labor. In the standard neo-classical trade model (the Heckscher-Ohlin model), free trade leads to relative and absolute factor price equalization that, by itself, reduces economic incentives for international migration. Therefore, trade and international migration are substitutes. Mundell (1957) and Gliberman (1999) argue that, according to this model, free trade between Canada and the US should lower the outflow of highly-qualified professionals from Canada. Of course, the neoclassical trade model is an extreme case because of the stringent assumptions underlying this model. These include: perfect competition, homogeneous product, full employment and complete markets, identical production technologies, the use of same factors of production, constant returns to scale technologies, and instantaneous adjustment to policy changes.

Harris and Schmitt (2003) in their review of recent developments in the trade theory note that when these assumptions are relaxed, on theoretical grounds, pressures to migrate can easily increase with freer trade. Introducing factor specificity, imperfect competition and increasing returns to scale can yield results opposite to the standard H-O model, implying that trade and international labor mobility are complements.²⁸ Consider, for example, the case of increasing returns to scale at the sector level. Let us assume that the technology used in the labor-intensive sector exhibits increasing returns to scale. The expansion of production in the US through trade

²⁷ Mann (2003) notes that productivity growth might have been 2.5% instead of 2.8% for the 1995-2002 period and that annual real GDP growth might have been 0.3 percentage points lower if global integration of IT production had not occurred

²⁸ Models with technological differences across countries can also reverse the standard result. Other relaxations of the Heckscher-Ohlin setting that can reverse the standard result include adjustment lags, migration costs, risk, and migration networks. For a discussion of these issues, see, for example, Harris and Schmitt (2003), Mercenier and Schmitt (2002), Wildasin (2003), Faini, et al. (1999), and Venables (1999).

liberalization could encourage inflow of migrants to meet the demand in a growing and more productive industry. A general conclusion of this literature is that when trade is based on economies of scale, migration and trade are complements (Markusen, 1983; Markusen and Melvin, 1981).

The empirical evidence on the relationship between trade and the migration of workers in a North American context is only beginning to emerge. Harris and Schmitt (2003) note that the current levels of migration between Canada and the US are quite low in relation to other periods in history. There are some limited forms of labor mobility within the NAFTA countries covering certain types of professionals under the TN visa program.²⁹ The apparent one-way flow of highly-qualified professionals such as physicians, nurses, natural scientists and engineers from Canada to the US raised considerable alarm as to the possibility of a serious brain drain.³⁰ There is some empirical evidence to suggest a positive relationship between trade and migration of workers. Gould (1994) found a positive and significant relationship between trade and immigration in the US and similarly Head and Reis (1998) and Head, Reis and Wagner (1998) find it for Canada. Wildasin (2003) argues that large gross internal flows of labor in the US and Canada, despite free trade, is evidence that trade and migration are not substitutes. He suggests that this could also be true in the international context.

The trade and the migration flows data for Canada and the US suggest that they move in the same direction, at least in the short-term. For example, the trade data for the year 2002 shows that the US contributed little over 60 percent of Canada's import of goods and services, and Canada contributed about 18 percent of US import of goods, and 8 percent of US import of services. In a similar fashion, Canada contributed a considerable share of HQPs moving into the US (Table 2.2), in particular the temporarily migrating skilled workers (11 percent). In contrast, 40 percent of all the temporarily migrating skilled workers into Canada came from the US. However, in terms of permanent workers, neither country is a significant source of migrants to the other. One possible explanation is that both Canada and the US receive most of their highly-qualified permanent workers from the emerging industrialized countries, such as China and India.

Table 2.2 Share of Labour Flows between Canada and the US, 2002

	US contribution of inflows to Canada	Canada contribution of inflows to the US
All workers		
Temporary	24%	9%
Permanent	est. 2-3%	2%
Skilled workers		
Temporary	40%	11%
Permanent	1%	4%

Calculation by authors

Sources of data: CIC, US-CIS, 2002

The available evidence from the EU suggests that since its creation, significant progress has been made towards intra-EU trade in goods: around 60 percent of Member States' trade in goods with the rest of the EU. However, the movement of workers between Member States has been limited. Although there is some evidence to suggest that there has been an overall increase in mobility of workers within organizations, and the relative importance of virtual and short-term assignments has increased most significantly (PWC, 2002).

²⁹ Globerman (1999) concludes that trade liberalization has had little impact on permanent immigration. However, temporary migration of Canadian professionals to the US has increased somewhat since the FTA. He also suggests that the number of US professional workers emigrating temporarily to Canada has also increased consistently since 1989, although at a substantially slower rate than comparable migration of Canadian TC/TN visa holders.

³⁰ For a discussion of this issue at length, see Finnie (2001) and the references therein.

Foreign Direct Investment (FDI) and International Mobility of HQPs

In theory, FDI may either substitute or complement international mobility. FDI and HQP mobility may be substitutes if MNEs relocate facilities abroad to access low-cost labor instead of creating jobs locally that might be filled by foreign workers. Evidence from Israel and India illustrates that FDI may also be driven by access to HQPs, including R&D staff (Guellec and Cervantes, 2002). Thus, HQPs and FDI appear to be complementary international flows, with FDI attracted to locations where high skilled labor is plentiful.

FDI and international mobility of HQPs may be complements as MNEs stress the potential need for factor movements, especially the relocation of managers and technical experts, to expedite production rationalization and increased trade following trade liberalization. This perspective suggests that freer trade between Canada and the US, to the extent that it encourages increased intra-industry trade and investment, may increase economic incentives for bilateral migration. Trade liberalization may therefore induce more migration of specialized workers, insofar as FDI requires them (Globerman, 1999).

The data shows that intra-company transferees have increased in the OECD countries over the late 1990s (Table 1.2 in the previous section). This may represent both the increased importance of takeovers, mergers and FDI in the economy, and the shift toward short-term assignments of highly-qualified professionals such as managers and executives (see Chart 1.4). Clearly, we need more empirical research to show a relationship between the location of FDI and MNEs, and the international mobility of HQPs.

The new global economy is witnessing two additional trends: First, the trade and investment in services is rising steadily, and, Second, growth in international outsourcing. In the discussion to follow, we turn our attention to these two issues and examine their implications for the increased mobility of HQPs.

International Trade and FDI in Services

In the new global economy, there is a trend increase in trade, employment and investment in services.³¹ However, barriers to trade and investment in services continue to be an important obstacle to further globalization of the service sector. One concern is with the issue of how trade liberalization in services would affect the international mobility of highly-qualified professionals?³² Technological change is dramatically changing the landscape of the global financial system. The growth in services trade raises the prospect of a global e-labor markets for some types of professional services. Examples include software engineering, data entry, translation services and distance teaching. We discussed the implications of this issue for the international mobility of HQPs in section 2.1 above. The issue is particularly important in the context of North America and other advanced APEC economies (Harris and Schmitt, 2003).

The globalization of trade in educational services is increasing. This is occurring in two different ways: First, OECD countries are increasingly seeking to attract foreign students at the master's, PhD and the post-doctoral levels, particularly in the field of science and technology (S&T), and facilitating their access to the labor market. Host countries can capture much benefits of student migration. In the US, stay rates of foreign PhD students is extremely high – in excess of 50

³¹ A number of explanations have been put forward for the growth in service trade and investment. These include: technological change, changes in trade policy, changes in domestic policy (“deregulation”) and demand and supply effects, such as increases in the demand for services due to increases in real income or the average education level. It is important to identify the importance of these factors in explaining services trade and investment trends (Copeland, 2003). For a review of global integration of financial service industry, see Neave (2003), a paper prepared for Industry Canada under the Services Research project.

³² By invoking relevant sections of Modes 3 and 4 of GATS, Whalley (2003) recognizes that changes in factor mobility restrictions could be a *sine qua non* to attain significant trade liberalization in services. And with segmented factor markets, especially labor markets, larger effects could be realized if services liberalization, and becomes an indirect conduit for liberalizing domestic factor markets. This latter point is also consistent with relaxed immigration controls, a viewpoint articulated by some countries within the OECD.

percent for Europeans for example (Harris, 2003); and second, cross-border collaboration of higher education and research institutions is rapidly growing. This may act either as a substitute or as a complement to international mobility of students, much as FDI accompanies or substitutes for the migration of highly-qualified individuals (OECD, 2002b).

Outsourcing in a global economy and the international mobility of HQPs

“The rising integration of world markets has brought with it a disintegration of the production process” (Feenstra, 1998). Cheaper access to information induced by technological change has facilitated the integration and coordination of internationally diverse production processes. Firms are outsourcing either domestically or abroad, a range of manufacturing or service activities, from product design to assembly, from R&D to marketing, distribution and after-sales service (Grossman and Helpman, 2002). They argue that outsourcing of inputs and business services is one of the rapidly growing components of international trade.³³

Although outsourcing in manufacturing has been occurring for a long time, a relatively new development is the outsourcing of increased variety of services made possible by the new application of the ICTs. For example, call centers have moved to India and elsewhere. Routine back office accounting work, such as handling accounts are also shifting abroad and becoming centralized for global corporations.³⁴ Does it mean that there will be greater demand for local hires of mobile workers and use of virtual teams and lower international mobility? In a recent article, Mann (2003) argues that an international value chain should increasingly produce not only IT hardware but also software and services. This will, just like hardware, lead to a decline in the prices of software and services and make the overall IT packages affordable for more businesses and other end users. This will promote deeper integration and wider diffusion of IT to new sectors and businesses in the US economy and lead to a greater demand in the US for IT-proficient workers. This suggests that the demand for internationally mobile HQPs will increase in the US. However, evidence on this issue is rather non-existent and more research is required.

2.3 Research and Innovation

The OECD growth project and other studies have found a strong link between innovation and growth. Cameron (1998) surveys the empirical evidence on the link between innovation and economic growth in the light of new growth theory and notes two major conclusions. First, innovation makes a significant contribution to output and TFP growth. Evidence shows that typically a 1 percent increase in the stock of R&D leads to a rise in output of 0.05–0.1 percent.³⁵ Studies also find a strong and significant link between R&D and productivity growth, with the private rate of return to R&D investment being estimated as 10-20 percent, and because of knowledge spillovers social rate of return is found to be much higher, 20-50 percent. Second, there are significant knowledge and technology spillovers between firms, industries and countries. The evidence shows that for small open economies (SOEs) such as Canada, knowledge and technology spillovers from abroad have a larger impact on productivity than spillovers from domestic R&D.³⁶

³³ As an example of foreign outsourcing, Feenstra (1998), citing Tempest (1996), describes the production process of a Barbie doll. Mattel obtains the raw material for the doll (plastic and hair) in Chinese Taipei and Japan, conducts assembly in Indonesia and Malaysia, buys the molds in the US, the doll clothing in China, and the paints used in decorating the dolls in the US.

³⁴ A series of articles have recently appeared in the US newspapers debating the outflow of US jobs to the countries such as India and China. See, for example, Schumer and Roberts “Second Thoughts on Free Trade”, The New York Times, 6 January, 2004; and Reisman, “A reply to Schumer and Roberts”, The New York Times, January 9, 2004; Murphy, “Free Trade and Factor Mobility”, The New York Times, January 11, 2004.

³⁵ Griffith, et al. (1998) show that R&D may play a different role in small and large economies. In large economies, R&D mainly accelerates rate of innovation; in small economies, it facilitates technology transfer from abroad.

³⁶ Evidence for Canada also shows that the impact on productivity growth of investment in ICT and of international spillovers linked to import of IT goods is large (Gera, et al. 1999). Firm-level empirical evidence shows that skilled labor is complementary with a cluster of factors including ITC and new products and

OECD (2002b) suggests that research and innovation in advanced countries is a key factor for the international mobility of science and technology (S&T) professionals. This is especially true for S&T professionals in developing countries but also in advanced countries where the environment for excellence in scientific research and innovation exists. Human capital is a key factor in innovation and S&T personnel are increasingly required by an economy more based on research and innovation (OECD, 2000).³⁷

Although more evidence is needed on this issues, a host of research and innovation factors seem to be contributing to the mobility of S&T personnel in the 1990s (Guellec and Cervantes, 2002).

First, both the higher level and growth of R&D spending are key to creating increased employment opportunities for S&T graduates in advanced economies. The services sector in the new global economy is becoming increasingly innovative and contributing to increased demand for highly-qualified individuals such as ICT professionals. In Canada, for example, business expenditure on R&D is growing faster in services than in goods-producing industries.³⁸

Second, the number of strategic alliances in regard to R&D and technical collaboration between firms has increased, particularly in areas such as ICT and biotechnology.³⁹ Collaboration and networking are now fundamental to the corporate strategies of firms, and contribute to the mobility of science and technology (S&T) professionals.

Third, OECD (2000) argues that start-up firms play an important role in the innovation process, as they are important sources of new ideas and innovations. The availability and forms of financing, such as venture capital, are of critical importance to innovative and entrepreneurial activity. Stephan and Levin (1999) find that the foreign born account for 25 percent of the founders of start-up enterprises in the US biotechnology sector. Clearly, the climate for innovation plays an important role for the entrepreneur-minded S&T personnel to move abroad for business start-ups and self-employment.⁴⁰

Fourth, industry clusters—the phenomena of same-industry firms locating in geographical proximity—tend to generate agglomeration economies i.e. positive spillovers between firms in the same industry (Porter, 1998). In the literature, entrepreneurship, linkages to a major and growing market, and the availability of skilled labor are identified as three key ingredients in the formation of a cluster (Bresnahan, et al., 2001). Both native-born and skilled workers from abroad move to these locations in order to benefit from employment opportunities. More importantly, MNEs cluster in particular locations due to common causes (i.e., proximity to demand, low-cost inputs etc.) and perhaps to access agglomeration economies flowing across firms.⁴¹ This provides incentive for HQPs to migrate.

services (Bresnahan, Brynjolfsson and Hitt, 2002). Technological innovation has accelerated among the OECD economies since the mid-1980s as measured by the surge in patenting activity, particularly in the US. Of the overall growth in patents granted by the US Patent office over the 1992-99 period ICT accounted for 31% and biotechnology for 14%.

³⁷ Nicholson (2003), based on regression analysis of 21 OECD countries over 1971-98, finds that 0.1 percentage point change in business R&D as a percentage of GDP leads to an impact effect of greater than 1.2 percent on level of GDP per capital in steady state. Griffith, et al (1998) show that R&D may play a different role in small and large economies. In large economies, R&D mainly accelerates of rate of innovation; in small economies, it facilitates technology transfer from abroad.

³⁸ In 2002, the share of research originating in services was about 35%, compared to 18% in the 1980s. The share in the US is about 20% and the OECD average is at 15%.

³⁹ A number of studies on the biotechnology industry show that company's commercial success is closely linked to their connections with the scientific community (Darby, et al. 1999).

⁴⁰ A study by Saxenian (2000) shows that nearly a third of Silicon Valley's 1990 workforce was composed of immigrants, two-thirds of them from Asia, primarily China or India. Chinese and Indian engineers started 29% of Silicon Valley's technology companies over the 1995-98 period, up from 13% in the 1980-84 period.

⁴¹ A key benefit of agglomeration, arising through external economies of scale, is that clusters promote technological transfers and knowledge spillovers as closer geographical proximity improves communication (Globerman, 2001). Evidence suggests that technologically-intensive industries tend to be more localized than other industries and that spillovers and information flow locally more easily than at a distance (Jaff, et

OECD (2002b) argues that the presence of high technology clusters, innovative industry and centers of excellence for scientific research are important magnets for attracting HQPs. Based on the evidence from OECD surveys, Guellec and Cervantes (2002) note that much international migration of scientists and engineers is in fact highly localized around knowledge-intensive clusters (e.g. Silicon Valley), scientific research areas (e.g. biosciences) and R&D-intensive companies (e.g. Lucent Technologies). In an empirical study of biotechnology industry, Darby and Zucker (1999) find that a close relationship exists between the geographic location of the emergence of new biotechnology enterprises and the location of star scientists.

Fifth, the internationalization of R&D and innovative activities is an important component of the new global economy. The limited evidence on the allocation of R&D activities of MNEs shows that firms conduct R&D in countries where they produce. While there may be special purposes for a MNE firm to locate some of its research facilities abroad, a key explanation is to adapt their products to local conditions (Head and Reis, 2003; Fors, 1998; and Niosi, 1999). Guellec and van Pottelsberghe (2001) present three new patent-based indicators of internationalization of technology reflecting international co-operation in research and the location of research facilities of MNEs. The authors suggest that professionals generating these inventions and the ownership of these inventions have greater incentives for migrating abroad.

Sixth, temporary migration is often motivated by the quality of higher education and research, especially at the PhD level. The US experience illustrates that financial support for academic research activities is a major pull factor. OECD (2001b), based on the evidence from National Science Foundation (1998), reports that more than 75 percent of the 10,000 foreign doctoral recipients at US universities in 1996 reported their university as the primary source of support for their graduate training. According to Statistics Canada, Survey of Earned Doctorates (2003), 17 percent of Ph.D. graduates from Canadian universities indicated that they have had definite plans to work or continue their studies (e.g. postdoctoral) in the US.⁴²

We need more research on issues such as, is increased economic integration through trade and FDI a factor driving the mobility of HQPs? What are the mechanisms that would make mobility of skilled workers complementary to trade, FDI, R&D, technology and, more generally, innovation activities? Has greater service market integration lead to higher mobility of HQPs?

2.4 Increased Income and Employment Opportunities

Differences in labor market conditions, income and employment opportunities and career prospects have always been a major driver of international mobility of HQPs. And, this was very much true during the 1990s. In the US, for example, higher levels of productivity combined with the unprecedented period of economic expansion through the 1990s resulted in higher wages and salaries, notably at the higher skill levels and attracted skilled professionals from all over the world. Borjas (1994) argues that higher relative wages for skills tend to bias the composition of emigrants towards the highly skilled – a phenomenon characterized as “self-selection” bias.

In the case of Canada and the US, for example, a number of labor market factors may have contributed to the increased outflow of Canadian professionals to the US in the 1990s (OECD, 2003a). First, increased demand for highly-qualified individuals in the US resulted in higher wages and salaries, notably at the higher skill levels where the Canada-US wage gap is the greatest.⁴³

al., 1993; Audretsch and Feldman, 1996). An important implication is that personal contacts through conferences, trade fairs, seminars, or sales meetings, are a significant transmission mechanism.

⁴² A demonstration project for the Survey of Earned Doctorates was conducted by Statistics Canada from November 2002 to June 2003 with the cooperation and support of the University of Toronto and l'Université de Montréal (including HEC Montréal and École Polytechnique).

⁴³ In a study of wage structures over 1981-96 period in Canada and the US, Card (2003) concludes that the combination of declining average wages in Canada relative to the US, widening wage inequality in the US, and constant wage inequality in Canada imply that the economic incentives for emigration have increased for all Canadians, but especially for younger, highly educated Canadians. A recent study for Canada finds that

This led to the emigration of highly-qualified professionals in certain knowledge-intensive professions such as physicians, nurses, natural scientists and engineers to the US.

Second, higher returns to education in the US than in Canada may also contribute to increased flows of highly-qualified professionals from Canada to the US (Card, 2003). A study by Psacharopoulos and Patrinos (2002) also confirms that the average return to an extra year of education (in percent) is lower in Canada (8.9 percent) than in the US (10 percent). These numbers show the proportional impact on pre-tax wages of an extra year of education on average.⁴⁴ The phenomenon of higher return to education combined to that of higher productivity in the US may have contributed to the outflow of highly-qualified Canadians to the US.

Third, given the relatively larger size of the US labor market compared to the Canadian market, it offers a greater variety of outlets for job opportunities, particularly for those with specialized skills. According to the Survey of 1995 graduates who moved to the US, work-related factors that attracted them to the US include the greater availability of jobs in a particular field (44 percent), higher salaries (39 percent), chance to gain or develop skills (21 percent), better career advancement opportunities (16 percent) and lower taxes (8 percent).⁴⁵

2.5 Changing Individual Preferences

A recent survey of Europeans of working age shows that as individuals' skills and qualifications increase they are keen to seek opportunities outside their home economies. This seems to be particularly true for those in younger age groups, where mobility is sometimes considered to be an important part of their personal development (PWC, 2002). The survey results vary between different groups of the population. For example, a much higher proportion of younger people would like to move than those in older age groups; single people are more inclined to move than married or living together; senior managers/directors are more inclined than those in other occupational groups; those on low incomes are slightly less keen to move; and a slightly higher proportion of men would like to move than women.

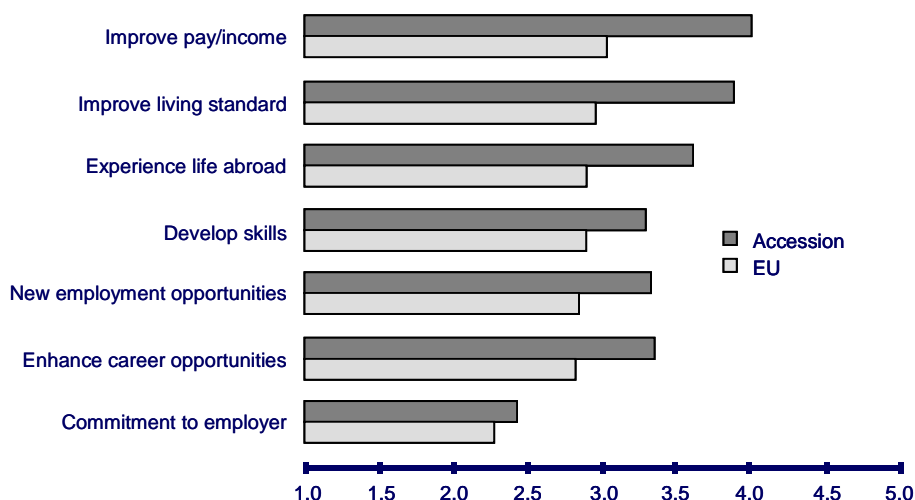
What motivates individuals to be internationally mobile? The survey results show, as Chart 2.1 illustrates, the two strongest motivators are to improve their pay and income and to enhance their standard of living. Experiencing life abroad and the development of skills are also significant motivators. Interestingly, the commitment to employer is of least importance as a motivator. It is important that more research be undertaken on issues such as to what extent changes in the incidence of mobility do reflect adjustments in firms' requirements for labor mobility in the global economy or, instead, suggest changes in the structure of incentives or motivations for skilled individuals?

the wage differential between more-educated and less-educated workers has increased substantially from 1995 and 2000 (Boudarbat, Lemieux and Riddell, 2003).

⁴⁴ In a recent paper, Collins and Davis (2003) argue that if education costs were more highly subsidized and returns to education more heavily taxed in Canada, Canadian effective tax rates (ETRs) would not differ greatly from those in the US. However, there would be strong tax incentive to emigrate. The authors argue that policy initiatives aimed at reducing human capital ETRs in Canada will only have a payoff on the emigration front if they are directed at taxing returns less, rather than subsidizing costs more.

⁴⁵ Fourth, personal income tax rates are lower in the US than in Canada, particularly for high-income earners. Canadian emigrants in the higher income brackets do not perceive the higher public spending in Canada on health care, tertiary education and other social services as fully compensating the higher tax rates in Canada. A study by Wagner (2000) documents the influence of tax rates on the migration decisions of Canadians to the United States. The findings show that lower US taxes are a significant pull factor attracting Canadians to the US. He estimated that if Canadian and US taxes were identical, migration of university educated workers to the US would have decreased by 41%.

Chart 2.1 What Motivates Individuals to be Internationally Mobile?*



* Using a scale of 1 to 5 (where 1 means 'would not motivate at all' and 5 means 'would be major motivation') respondents were asked to what extent each of the factors would motivate them to live and work in another country.

Source: MORI survey for PricewaterhouseCoopers

3. COSTS AND BENEFITS OF INTERNATIONAL MOBILITY OF HQPS

The mobility of HQPs, at internal and international levels, has been a matter of concern to policy makers. While there is less debate on the benefits and costs of internal mobility of HQPs at the national level, the international movement tends to create substantial concern to public and policy makers alike. This is largely due to the “brain drain” – a dominating public view. Concerns remain in the sending countries that a large scale and permanent loss of human capital will increase the gap in growth performance between rich countries and limit the ability to “catch up” in developing countries. (OECD, 2002a) The factor migration literature generally suggests small efficiency gains and strong distributional effects – the migrating factor and host country gain and immobile factors in the source country lose.⁴⁶ Harris (2004b) argues that in the “brain drain” model, the welfare impacts are small because the net transfer of highly-qualified individuals in aggregate terms is minute as measured against existing stocks of human capital.

Subsequent research on the mobility of HQPs has moved beyond the traditional brain drain perspective and argued that cross-border movement will not lead to a zero-sum outcome, although the distribution of costs and benefits may remain uneven.⁴⁷ Some countries may incur cost in the short run and possibly in the long run. The new view - Brain Circulation perspective – argues that there is a pattern of brain circulation whereby returning migrants may bring along accumulated knowledge, skills, contacts, and access to international best practices. In this model, a cross-border movement of HQPs can generate benefits on a global basis by improving international flow of goods, services, and, more importantly, knowledge. Additional global benefits are possible through the formation of international research/technology networks and better jobs-skills matches (Solimano and Pollack, 2004; Harris, 2004b).

⁴⁶ Harris (2004a) argues that results may be biased due to relatively small factor movements in recent history expressed relative to total labor force.

⁴⁷ While redistribution of gains between provinces/states is feasible within a country, the equalization issue is more difficult to deal with in the international context.

Harris (2004b) reviews the welfare economics of cross-border labor mobility under two perspectives – the strategic competition approach and the labor market integration perspective. He concludes that an increased labor mobility raises a number of policy dilemmas. The zero-sum non-cooperative game between countries means that small countries may be potential losers in competing for scarce human capital resources. Alternatively, labor market integration initiatives within free trade areas may carry large benefits to small countries. Initiatives to improve labor mobility for HQPs between small and large economies, such as Canada and the US, or Australia and New Zealand, could prove to be quite important for long run growth of a smaller country.

The literature on labor market integration suggests mutual gains from trade through increased division of labor and other possible beneficial effects such as faster rates of income and productivity convergence between nations or regions (see, for example, Harris, 2004b). Using a CGE model, Iregui (2003) estimates substantial worldwide efficiency gains – 13–59 percent of world GDP – from the elimination of global restrictions on labor mobility of both unskilled and skilled workers. However, when only skilled workers move freely the worldwide gains are smaller, ranging from 3 percent to 11 percent of world GDP, since skilled labor represents a small fraction of the labor force in developing regions. Mercenier and Schmitt (2003), using an illustrative three country model, estimate much smaller net welfare effects from allowing free mobility of entrepreneurs.

In this section, a key objective is to enhance our understanding of the economic costs and benefits associated with international mobility of HQPs beyond the brain drain literature.⁴⁸

3.1 Aggregate Welfare Gains of Increased HQP Mobility: Beyond Brain Drain

The literature on mobility of HQPs suggests many channels through which potential welfare gains can be realized. The gains are made possible through increased specialization, human capital acquisition, and knowledge spillovers.⁴⁹ More importantly, an increased mobility of workers could lead to a convergence of income levels and productivity across participating countries.

Increased Specialization

Wildasin (2003) suggests that international mobility of HQPs will improve the aggregate welfare of integrated economies in the same way as internal mobility of workers contributes to a welfare gain in the domestic economy. To the extent that skill specialization is complementary to specialization in goods and services markets, a free mobility of labor gives way to overall efficiency gains. He argues that benefits of free mobility are derived via more efficient allocation of existing stock of specialized human capital as it flows from low productive regions to high productive regions in search of higher returns or improved job match.⁵⁰ Wildasin concludes that gross migration in general is efficiency enhancing⁵¹, although the distribution of efficiency gains across regions remains uncertain. For example, a one-way flow between two regions can lead to an aggregate net gain, however, the gain to one region may incur at the expense of the other region. Conversely, it is possible that both regions can mutually gain from free mobility of workers if there is an exchange of specialized workers encompassing different skill sets. A brain circulation, thus, leads to higher growth rates through increased specialization and productivity.

⁴⁸ For a comprehensive treatment of the issues, see Harris (2004b).

⁴⁹ Another possible channel is via redistribution of risk across factors of production (Wildasin 2003). Greater mobility of skilled labor can shift the distribution of income-loss risk across factors of production, in particular from mobile workers to owners of immobile resources. Theoretically, aggregate gains from optimal risk sharing are generated by allowing income-loss risk to spread from risk-averse workers to relatively less risk-averse (immobile) resource owners. Nevertheless, empirical evidence regarding this argument remains to be investigated.

⁵⁰ Empirical evidence showing the efficiency-enhancing effect of labor mobility can be found in Hamilton and Whalley (1984), and Topel (1986).

⁵¹ Return migration is another factor contributing to gross flows. OECD (2002a,c) argues that skilled migration between advanced OECD countries is often temporary and the source country will benefit upon their return with their new technological competencies, valuable management experience, entrepreneurial skills and access to global networks.

The mobility of HQPs enhances efficiency in knowledge production as it reduces R&D duplication and facilitates innovation. Furthermore, participation in global knowledge industries enables global knowledge workers to acquire access to international science and technology networks through which knowledge is shared and transferred. This bodes well both for the source and host countries.

The impact of an increased mobility of HQPs on product specialization and trade could result in a sending country being left with less skill-intensive production, as reflected in an illustrative static general equilibrium model by Mercernier and Schmitt (2003). However, the outcome may be different if dynamic considerations of product specialization over time are introduced in the model. While not focusing on movement of workers per se, Mann (2003) illustrates that the mobility of the 'work' of skilled labor is playing an important role in changing specialization of production. She uses the example of the globalization of IT services, to show the shift of production from industrialized countries to developing countries⁵² and argues that such industrial restructuring is the source of productivity growth across all countries.

Human Capital Acquisition

The economic impact of the increased mobility of HQPs on human capital accumulation is contrary to the traditional brain drain view. In the new perspective, the out-migration of knowledge workers, in both temporary and permanent forms can increase human capital accumulation in the source country. Mobility of HQPs increases international competition for scarce human capital, resulting in an increased incentive to invest in human capital. In the sending country, returns to human capital rise. This generates incentives for higher rate of human capital acquisition (Wildasin, 2003; Harris and Schmitt, 2003; and Commander, Kangasniemi and Winters, 2003).⁵³ Findings from Beine, Docquier and Rapoport (2001) provide empirical support for "beneficial brain drain" growth effect for developing countries.⁵⁴

Wildasin (2003) describes another mechanism where mobility tends to increase human capital investment. By enlarging the market size, where labor services can be sold, the risk of income-loss is minimized and the expected return of personal education investments increases. When workers are freely mobile, the risk of income-loss over their life cycle decreases allowing greater option value of employment opportunity. This positively influences individuals to acquire more human capital.⁵⁵ In this model, the impact of free mobility of HQPs on human capital accumulation is positive for all countries.

Knowledge Spillovers

Increased mobility of skilled workers facilitates knowledge creation and enhances cross-border knowledge spillovers. Such spillovers benefit both sending and receiving countries in the form of higher innovation, productivity and growth across industries. Brain circulation suggests small country benefits from two-way flow of knowledge workers. A number of recent studies show that spillovers associated with R&D expenditures are substantial. Coe and Helpman (1995) find that international R&D spillovers are of great importance, especially in small open economies (SOEs).⁵⁶ The study shows that Canada is a recipient of large spillover effects from US, and more

⁵² As developing countries increase their share of production of standardized IT products (for instance, semiconductor chips), the advanced economies move on to higher-value products (e.g. microprocessors) and find ways to use their technologies in more productive ways. The idea is in line with Vernon's product-cycle model in international trade literature.

⁵³ More benefit is added up when taken into account the positive external effect of human capital accumulation.

⁵⁴ Similar argument on beneficial brain drain due to human capital accumulation is also found in several studies, which assume that there is some uncertainty about the ability to move abroad. See a survey by Commander, et al. (2003).

⁵⁵ Even if an individual has no incentive to acquire more human capital, risk reduction is still beneficial due to expansion of opportunity set, thus larger option value.

⁵⁶ Eaton and Kortum (1999) show that even for large countries international diffusion of technology is a key factor in productivity growth.

interestingly, global R&D plays an increasingly significant role than domestic R&D for productivity growth in Canada.⁵⁷ A recent study by Keller (2002), as mentioned by Harris (2004b), found that the average value of a dollar of US R&D on Canadian productivity growth is 78 percent of the value of a domestic dollar of Canadian R&D. Similarly, Gera, Gu and Lee (1999) demonstrate that R&D spillovers in Canada are primarily international in scope. They also find that international R&D spillovers, particularly from the IT sector, contribute significantly to labour productivity growth across Canadian industries.

Despite the common consent on the economic benefits of knowledge spillovers, the mechanisms transmitting knowledge spillovers remain relatively unknown. Audretsch and Feldman (2003), argue that university research laboratories are a key channel that transmits innovation-generating knowledge to private enterprises. They also note that more recently, a body of research has identified entrepreneurship as another important transmission mechanism.

Convergence of Income Levels, Productivity, and Regional Development

In a recent study, Harris and Schmitt (2003) address the question: what is the potential impact of increased labor mobility on the pattern of regional economic activity in a more integrated North American market? The authors suggest that there is no definitive answer. The new theories of trade and geography predict that in some circumstances, increased mobility will lead to regional divergence in economic activity and income levels (Krugman, 1991). Although, the recent work on growth theory suggests the contrary – increased mobility can lead to convergence in income levels and productivity (see, for example, Razin and Yuen, 1997a,b; Harris 2004a).

Supporting the divergence view, the new economic models of firm localization state that firms are attracted by factors derived from operating in close geographical proximity to each other; these are specialized suppliers of inputs, large pools of specialized workers, and knowledge spillovers. This happens largely because of the increasing returns to scale and circular causation effects. The theory predicts that, given low transportation costs, the size advantage of agglomeration leads to higher income growth and productivity as the 'core' region attracting more industries, leaving the rest on the 'periphery'. Factor mobility, thus, reinforces the core-periphery type outcome and provides further incentives for highly-qualified individuals to move to the industrialized core.

In contrast, the convergence of income levels is feasible within a human capital driven model of growth. Razin and Yuen (1997a,b) argue that capital mobility alone can induce convergence in growth rate but *not* in income level. To achieve income level convergence, the mobility of human capital is the key. As skilled workers move from low (real) wage to high wage countries, a rise in wages in the source country leads to a higher rate of human capital accumulation. Higher levels of human capital and knowledge spillovers drive economic growth rates. The process persists until a steady state is reached where real wage per worker and level of human capital are equalized across regions and income and productivity level convergence is achieved. Using data from the US states and EU countries, they find some evidence supporting the income level convergence effects.

Empirical evidence showing the contribution of mobility of HQPs to income convergence within economic unions is mixed. Harris and Schmitt (2003) note that early evidence from the US and EU suggests that actual outcomes are different to those predicted by the new economic geographic models. The experience from the US demonstrates that, where labor mobility is high, and shows that income levels have converged but the pattern of industrial development is relatively uneven. In contrast, the evidence from the EU, where labor mobility is considered low, suggests that income levels across countries vary but industrial patterns are more balanced.

⁵⁷ A number of studies by Bernstein find similar evidence for Canada (see, for example, Bernstein, 1994). A recent study by Keller (2001) also shows that spillover effects account for 97 percent of the total effect of technology on productivity growth.

3.2 Potential Costs Incurred by the Sending Economy

In the traditional brain drain perspective, the economic costs and benefits of mobility are in terms of changes in population size (scale effects). As such, the migration of HQPs is largely viewed as a zero-sum game among countries. When dynamic consideration and heterogeneity of labor are introduced, the costs may change due to the externalities generated over time. Harris (2003) argues that the costs for the country losing human capital arise from two distinct effects: (i) loss in human capital spillovers; and (ii) loss in human capital recipient capacity (which, to some extent, is necessary in absorbing international knowledge diffusion). In addition, there may be associated costs to the sending country in terms of innovation gaps and divergence of income levels and productivity.

Loss in Human Capital Spillovers

The idea is based on the notion of increasing returns to scale embodied in the form of “external effect of human capital” (Lucas, 1988). An implication of the Lucas model is that a one-time transfer of human capital between countries could have a long-term effect of raising the income gap. The out migration of highly-qualified people can reduce the growth potential if the observed amounts of human capital transfer are significant enough to impact the average level of human capital in the sending economy. This effect may also generate an increased cost of human capital on those who do not migrate. Large outflows of HQPs could lead to lower returns to public investment in education, including fiscal externality in education (EEAG, 2003).

This argument, however, may not hold in the case of Canada - US. The loss of human capital spillovers due to mobility, as Harris (2004a) argues, is not large in Canada. The reasons are twofold: First, the outflows of highly-qualified Canadians to the US are of limited order of magnitude. Moreover, the evidence indicates that most of the change in the human capital levels in Canada versus the US over time is largely due to changes in the output of education sectors and educational attainment as opposed to migration.⁵⁸ Second, there is no consensus on the size of the human capital spillovers. Harris argues that they are extremely small.⁵⁹

Reduced Knowledge Absorptive Capacity

The effect refers to the loss in an economy’s capacity to absorb international knowledge diffusion.⁶⁰ Skilled human capital is a key determinant of the capacity to successfully transfer technological knowledge from abroad. While skilled migration enhances global knowledge creation and spillovers, it may also lower the capacity to capture spillovers in the sending country.

According to Harris (2003), interaction between experts plays an integral role in the transfer of international knowledge in specialized scientific and commercial fields. To the extent, the best and the brightest – the so-called “superstars” are migrating, there may be a larger cost to the sending country.⁶¹

The EEAG report (2003) highlights that an outflow of skilled professionals may encourage specialization of economic activity away from high-skill intensive sectors. A sending country could

⁵⁸ Harris (2003) cites Murphy, Riddle and Romer (1996) who point out that Canada had a higher rate of growth of skilled workers during much of the last two decades, which led to a convergence in the human capital intensity of the two economies rather than a divergence.

⁵⁹ See, for example, Harris (2003). However, a survey of empirical works by Davies (2003) suggests the sizable effect of education externalities (including non-market externalities) that is large enough to justify the use of education subsidy to some extent. However, even based on Davies’ study, the current education subsidy could be large enough to compensate for the gap between social and private returns (in other words, these externalities are already taken into account).

⁶⁰ The literature concerning “absorptive capacity” or the firm’s ability to utilize knowledge spillovers is small, but growing (Agrawal, 2002). Other factors identified as determinants of firm’s absorptive capacity include connectedness (to other knowledge diffusing institutions and people), and investment in R&D.

⁶¹ The superstars constitute exceptional individuals in specific areas. These include sportsmen, executive individuals, team leaders, innovators, and high-technology entrepreneurs. For more discussion on this issue, see Rosen (1982), and Shapiro and Varian (1999).

be left to specialize in medium-technology goods and suffer from an “innovation gap”. The outflow of knowledge workers leads to lower rents from innovation in the sending country and negatively impacts entrepreneurship, business formation and the long-term growth potential of an economy. The adverse impacts could be much larger if the movers are from the “superstar” pool. The report argues that business formation in scientific and high-tech areas may be increasingly harmed by the outflow of top scientists. In support of its argument, the report cites a study by Zucker, et al. (1994) that examines the geographical impact of “star scientists” on the birth rates of biotechnology enterprises. The findings show that controlling for measures of overall intellectual capital, the number of star scientists has a strong positive impact on business formation in the local economy.

Mercernier and Schmitt (2003) argue that that free mobility of skilled workers affects production specialization of trading partners and their pattern of trade. Through an illustrative static general equilibrium model, they show that an altered specialization could translate in a transfer of high-tech production between regions⁶² that may adversely affect overall innovation rate in the country losing skilled workers. Clearly, more empirical work is needed in this area to validate their findings.

4. INTERNATIONAL MOBILITY OF HQPS IN APEC: POLICY IMPLICATIONS

Three major conclusions emerge from the discussion in the previous sections. First, the “brain drain” perspective suggests small efficiency gains and strong distributional effects – the migrating factor and receiving country gain and immobile factors in the sending country lose. This suggests a brain drain from low-income developing countries to high-income developed countries, which is exacerbated when it is the “best and brightest” that leave (Eden, 2004). Harris (2004b) argues that from a policy angle, this perspective implies countries strategically compete to attract HQPs.

Second, the “brain circulation” perspective suggests that international mobility of HQPs creates a two-way flow of knowledge that can benefit both the sending and receiving countries. Additionally, global benefits are possible through an improvement of international flow of goods and services, and through the formation of international research/technology networks. A key policy implication is to focus on policies that increase the cross-border mobility of HQPs.

Third, the economic integration perspective suggests that deeper integration between economies (regional or bilateral) through trade and FDI may encourage productivity and income convergence across countries over time, so it is possible that mobility of HQPs might also have this effect. Harris (2004b) argues that labor market integration initiatives within free trade areas may carry large benefit to small economies. According to this perspective, then that the economic policy discussion surrounding the cross-border movement of HQPs must take into account the wide variety of ways the migration of labor affects the economy. In particular, attention must now turn towards the links between these movements, and the institutions regulating them, and the performance in the trade of goods and services; foreign direct investment; human capital formation and MNE location; and income convergence between countries.

In this section, we examine two sets of policies (i) labor market integration policies within free trade areas such as Canada and the US, EU, and Australia and New Zealand; and (ii) policies either increasing the international mobility of HQPs and/or increasing a economy’s ability to attract globally mobile knowledge workers. Harris (2004b) argues that the former set of policies can be thought of as ‘free trade in labor services’, and the latter as unilateral policies to increase the economy’s competitive advantage in skill-intensive knowledge industries. In our discussion, we consider the former set of policies as those relating to trade, harmonization, and deeper economic integration between economies (regional or bilateral) whereas the latter set policies include immigration, domestic labor market, and science and technology, education, and tax and fiscal policies.

⁶² Their simulation result also shows that the wage inequality between skilled and unskilled workers increases due to trade and globalization. This, in turns, creates incentives for skilled workers to migrate to take advantage of earning differentials.

4.1 International Mobility of the HQPs: Policies in the Integrated Labor Market Economies

In recent years, a number of regional and bilateral free trade and investment agreements have come into effect to reduce barriers on trade in goods and services and capital movement. The integration agenda is now moving towards more coordination or integration of the labor markets. Harris (2004b) argues that slowing down of the income and productivity level convergence process between Canada and the US, for example, may partly be due to cross-border barriers in HQPs mobility.

In the discussion to follow, we focus on the experience of four regional agreements governing the international movement of labor. These include the North-American Free Trade Agreement (NAFTA), in particular its provisions on temporary movement of skilled workers; the Schengen Agreement for the European Union; the Australia-New Zealand Trans-Tasman Relations, and some recent implementation of schemes facilitating temporary transfers of business people in APEC.

Policies towards Canada-US HQP Mobility: the NAFTA

The agreement mainly applies to free trade in goods and services between Canada, the US and Mexico. It is not an exaggeration to view NAFTA as two *de facto* arrangements; one governing economic relationships between Canada and the US (as a descendant of Canada-US Free Trade Agreement - CUSFTA) and the other between the US and Mexico. This is partly due to the fact that the economic relationship between Canada and Mexico has not yet fully developed. In the following review, we focus on the labor mobility provisions under NAFTA, which affect a segment of Canada and the US labor market, i.e. the mobility of high-skilled professionals.

The genuine single labor market between Canada and the US is yet to emerge. To date, citizens of one country are required to have residency permits from the residing country in order to work and stay permanently (i.e. a landed immigrant status in Canada or a green card in the US). An exception is made for cross-border movement (temporary entry) of business persons under NAFTA which covers only certain specialty occupations.

Cross-border movement of business persons is administrated under NAFTA Chapter 16. For the US and Canada, this chapter is carried over from Chapter 15 of the previous Canada-US Free Trade Agreement (CUSFTA). The provisions facilitate the cross-border movement of four classes of business persons: Business visitors, Professionals, Intra-company transferees, and Traders and Investors (see detail in Box 4.1).

BOX 4.1

Chapter 16 of the NAFTA facilitates the cross-border movement of four categories of business persons:

1. "**Business Visitors**" are business persons who plan to carry on any business activity related to: research and design, growth, manufacturing and production, marketing, sales and distribution, after-sales service and general service.
2. "**Professionals**" are business persons who plan to carry out professional activities of the types indicated in NAFTA Appendix 1603.D.1 for an employer or on contract to an enterprise located in a member country other than one's own.
3. "**Intra-Company Transferees**" are business persons who are employed by an enterprise to perform management or executive functions or who bring specialized knowledge to this enterprise or its subsidiaries or branches established in one of the member countries. The business person must have been employed abroad in a similar capacity by the foreign company for at least one year out of the preceding three.
4. "**Traders and Investors**" are business persons who plan to carry out trade in goods and services

principally between member countries, or to establish, develop, administer or provide consulting or technical services for the administration of an investment to which foreign capital has been committed or is in the process of being committed.

Accompanying Spouses and Dependents must meet existing immigration requirements for temporary entry. In addition, unless a spouse or dependent qualifies on his/her own merit for an employment authorization under the NAFTA, he/she must go through the regular job validation process applicable to all temporary foreign workers.

The NAFTA Temporary Entry Working Group (TEWG) is mandated to consider the waiver of labour certification tests or procedures of similar effect for spouses of business persons who have been granted temporary entry for more than one year. Canada supports the extension of reciprocal employment benefits under the NAFTA to spouses of business persons (professionals, intra-company transferees and traders/investors) and continues to pursue this issue in the context of the TEWG.

Source: Department of Foreign Affairs and International Trade, The North American Free Trade Agreement, <http://www.dfait-maeci.gc.ca/nafta-alena/cross-en.asp>

Both the CUSFTA and NAFTA have brought major benefits to Canada. The performance of merchandise trade has been very good, while overall growth in service trade has improved a little, though particular service industries did benefit. FDI between the US and Mexico got a clear boost from NAFTA, a gain of 288 percent in two-way FDI stock between 1993 and 2001. In contrast, two-way FDI stock between Canada and the US increased by 135 percent between 1989 and 2001. Financial integration has also improved between Canada-US and US-Mexico through cross-border mergers and new corporate subsidiaries (Hufbauer and Schott, 2004).

However, when one compares the relative shares of exports and imports in goods and services between Canada and the US or shares of inward and outward FDI, it is clear that the migration shares are far smaller than other economic linkages. Thus, the border matters more for labor flows than it does for trade and FDI. A better understanding of the barriers to labor mobility between Canada and the US, relative to the barriers of trade and investment, is needed⁶³ To achieve the full benefits of economic integration, some further work remains to be done in a number of areas, including elimination of all non-tariff barriers (such as countervailing and anti-dumping duties); broadening NAFTA coverage to include agricultural products; reducing the cost to industry of complying with a number of special rules, such as rules of origin; and closer integration of regulatory regimes in North America. The key issue for Canada, Dodge (2003) argues, is to reduce "border risk", that is, guarantee Canadian producers and service providers access to US markets without hassle and expense at the border as *borders still do matter*. He recommends a number of steps that could help in this respect: a common tariff – that is, a customs union and common border practices for imports from, and exports to, overseas markets; harmonization of trade and commercial policies and regulation; an end to the application of trade remedies within North America; and a uniform policy with respect to federal and state/provincial subsidies.

More importantly, from the US point of view, border security is an important element of deeper economic integration; security integration and economic integration are clearly linked.

Dodge (2003) argues that to realize real welfare gains from the NAFTA, further integration of labor markets must take place. Greater harmonization of policies and adoption of common licensing standards in North America are key to reducing barriers to cross-border mobility. However, this is a complex issue as it has serious implications for existing policies in areas such as the provision of health care and the regulation of public health and drugs, and immigration policy. Hart (2004) suggests that there is still scope for improvement by the two governments to arrive at cooperative solutions in order to lessen the impact of border and non-border related barriers to HQP mobility. The future initiative, as Hart (2004) concludes, is in pursuing a more active, bilateral program of regulatory cooperation aiming either at an approach towards mutual recognition to certification,

⁶³ See, for example, Eden (2004) for the remarks she made at the International Mobility of Skilled Labour Roundtable, Ottawa, Canada, February 27, 2004.

accreditation, and other deterrents to the cross-border movement of the HQPs, or an agreeable way to reducing the impact of differences in labor market and similar regulations.

On the international trade front, policies affecting trade in services will certainly influence the movement of HQPs internationally. An approach towards liberalization of the service supply modes under GATS⁶⁴ will reduce barriers to labor mobility. Cattaneo and Neilson (2003) indicate that there exists economic gain from liberalization to all trading partners but the economic impact may vary between nations. They also suggest that studies on the economic impact remain inconclusive and more empirical works are in dire need.

Policies towards HQP Mobility: European Union

The principle of the free cross-country movement of people between EU countries had been one of the major goals of the original Treaty of Rome since 1957. However, the implementation had been slow until 1995 when the Schengen Agreement came into full effect. The accord has had a major impact of reducing the border controls on the free movement of people between the 13 EU members plus Iceland and Norway (although, the UK, Ireland, and the 10 new members are not parties of the Schengen Treaty).⁶⁵

The Schengen accord has brought about the freedom of movement of people regardless of their nationality between the member states (see Box 4.2 on key points of the Schengen Agreement). This applies not only to travelers but also workers. Work permits are not required from nationals of member states who seek employment in another member country.

BOX 4.2

Key Points of the Convention Implementing the Schengen Agreement

- Citizens of countries implementing the Schengen Agreement can cross the internal borders of the implementing countries at any point without checks.
- A visa with no territorial restrictions (visitor's or business visa allowing the holder to stay up to 90 days per six-month period, transit or airport visa) granted to a third-country national by one implementing country entitles the holder, for the same purpose and for the duration of the visa's validity, to enter without border checks other implementing countries as well.
- Any third-country national with a residence permit valid in one implementing country may travel on a valid passport, without requiring a visa, for up to 90 days per six-month period to other implementing countries.
- Harmonized visa policies of Schengen countries (common list of third countries whose nationals require visas).
- External border checks according to a common Schengen standard.
- Access by all Schengen countries to the Schengen Information System (SIS) providing personal identity and other data throughout the Schengen area.
- Close police and judicial cooperation.
- Joint efforts to combat drug-related crime.
- Rules determining competence for asylum procedures (now largely replaced by similar provisions in the Dublin Convention of 15 June 1990).

*Source: Federal Foreign Office, Government of Germany,
http://www.auswaertiges-amt.de/www/en/willkommen/einreisebestimmungen/schengen_html*

⁶⁴ In particular for service providers or Mode 4, which is still under negotiation between WTO members.

⁶⁵ Current members as of 2004 are Austria, Belgium, Denmark, France, Finland, Germany, Greece, Iceland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain and Sweden.

The intra-EU mobility of highly skilled EU citizens has been on the rise, albeit in small magnitudes, while the observed movement of the less skilled people has declined. Mobile HQPs are those with specific skills, in particular in the information communication technology field (Hart, 2004). Furthermore, there is an increasing trend of non-EU skilled workers arriving from less developed regions, such as Turkey, former Yugoslavia, Algeria, and Morocco. For the moment, it is still too early to see the effect on labor mobility of the EU enlargement (with ten new members), which took effect in May 2004.

Despite the fact that the labor market for these EU countries is practically borderless, the intra-EU labor mobility remains nominal. An estimate of 0.1 and 0.2 percent of total population per year moved between member states, according to the EU Commission's Social Situation Report 2002. Several factors were identified as causes of low mobility, for example, the reduction in the economic well-being gap between the member countries, the transition to knowledge-based economy, which, arguably, requires less geographical movement of skills, the language and cultural barriers, and the increasing participation of women in the labor market (Hart, 2004).

It is crucial to recognize that the borderless labor market does not imply that countries opt for the same laws and regulations governing professions, taxation, and other social incentives. The issue of harmonization remains sensitive and controversial. In 1997, attempts were made towards the creation of a true single market between EU members. Discussion was made on the plan to promote and encourage longer term labor mobility by removing embedded social dis-incentives (Hart, 2004). It remains an interesting investigation to understand how the EU countries manage to reconcile their different practices on professional accreditation, licensing, and other labor market regulations such as union membership and employment standards.

Up until now, the EU has been quite successful in eliminating the border-related barriers to the free mobility of its people. As Hart (2004) points out the small magnitude of movement does not reflect the strength or weakness of the intra-EU migration scheme. What is important is the institutional change that abolishes barriers, not the extent of its impact on the individual's behavior. The cooperation on free movement of workers necessitates the future cooperation between member states in many other related areas, such as employment benefits, freedom of movement for spouses and dependents, licensing, accreditation, and other labor market practices. The full benefits of bona fide single labor market will only be realized when countries find ways to cooperate in these many aspects. This is to say that a complete harmonization is not a necessary condition to reap full benefits of integrated labor market. This type of cooperation is exemplified by the following case of Australia-New Zealand labor market relations.

Policies towards HQP mobility: Australia-New Zealand (Trans-Tasman Relations)

Australia and New Zealand Closer Economic Relations (CER) started with the free trade agreement in 1983. All tariffs and quantitative restrictions on goods trade between the two countries had long been eliminated. The protocol signed later in 1988 brought services trade into CER. Today, almost all Trans-Tasman trade in services is open.

Beyond the principle CER agreement on trade, Australia and New Zealand have entered into deeper economic integration by signing many other agreements and arrangements. We focus on the following agreements, which are mainly related to labor market integration – the Trans-Tasman Travel Arrangement, and the Trans-Tasman Mutual Recognition Arrangement.⁶⁶

Since the 1920s, there has been a free flow of people between Australia and New Zealand under various arrangements. The Trans-Tasman Travel Arrangement (TTTA) introduced in 1973 allows

⁶⁶ The two economies are deeply integrated in many aspects. Among others, a notable Social Security Agreement is a cost sharing arrangement covering social benefit programs such as aged pensions, disability supports. The Reciprocal Health Care Agreement 1998 deals with access to health care by Australians and New Zealanders. Other agreements on closer economic relations are, for example, the Double Taxation Agreement, the Customs Cooperation Arrangement, the Joint Australia New Zealand Food Standards Code, the MOU on Business Law Coordination, the Joint Accreditation System Australia and New Zealand (JAS-ANZ), and the Open Skies Agreement.

Australian and New Zealand citizens to visit, live, work and remain indefinitely in either country without the need to apply for authority to enter. The TTTA is not a binding bilateral treaty between the two countries, but rather is a series of immigration procedures applied by each country and underpinned by joint expressions of political support. The most recent reaffirmation of the TTTA was the new Trans-Tasman social security arrangements in 2001.⁶⁷ In practice, the TTTA has effectively created a borderless labor market between the two nations.

The Trans-Tasman Mutual Recognition Arrangement (TTMRA) represents a significant step in reducing non-border impediments to labor mobility and enhancing freedom of skilled practitioners to work in both countries. Signed in 1998, the objective of TTMRA is to provide that a person who is registered to practice an occupation in either country is entitled to practice an equivalent occupation in the other, and goods that may legally be sold in either country may be sold in the other. Regarding the registration of occupations, the agreement covers all occupations for which some form of legislation-based registration, certification, licensing, approval, admission or other form of authorization is required by individuals.⁶⁸

APEC Policies on Business Mobility

The APEC member economies are committed to enhancing business mobility. Several initiatives were established in order to achieve this goal, for example, works in developing standards to improve the quality and consistency of the immigration services, the Advanced Passenger Information (API) and Advanced Passenger Processing (APP) systems providing convenient border clearance for airline passengers, the APEC Business Travel Card scheme and intra-company transfers (see Box 4.3 on key initiatives of APEC Business Mobility Group). The last two initiatives tend to contribute most to facilitating movement of skilled workers between the member economies.

BOX 4.3

Key Initiatives of the APEC Business Mobility Group

- The APEC Business Travel Card: express border processing through special airport lanes for cardholders, and multiple entry to participating APEC economies.
- Intra-Company Transfers: A 30-day processing standard for applications for and extensions of temporary residence permits for APEC Intra Company transfers.
- The APEC Business Travel Handbook: up to date information on visa and entry arrangements across the APEC region.
- Advance Passenger Information (API)/Advance Passenger Processing (APP): streamlined border processing for all passengers and increased border security for participating economies through the use of communications technology which enables the border clearance of passengers before they board aircraft.
- Standards, a Key to Building Capacity: Economies have agreed to develop and implement standards in all major immigration areas, as a foundation for improving immigration programs and services.

Source: APEC Business Mobility Group (or the Informal Experts' Group on Business Mobility, <http://www.businessmobility.org/key/index.html>)

⁶⁷ Under the 2001 bilateral social security arrangements, New Zealand citizens are required to apply to become formal permanent residents of Australia if they wish to access certain Australian social security payments, obtain Australian citizenship or sponsor people for permanent residence. These changes do not affect the Trans-Tasman Travel Arrangement, which remains the primary means by which New Zealand citizens travel to and stay in Australia. (Population Flows: Immigration Aspects, DIMIA, March 2004).

⁶⁸ A separate mutual-recognition arrangement between the two countries applies for the case of medical practitioners.

The APEC Business Travel Card scheme provides frequent business travelers with visa-free travel and fast-track airport processing when visiting participating economies. Australia, Korea and the Philippines had successfully implemented the scheme since 1998. Today there are 16 participating economies, including Canada; China; Hong Kong, China; and Japan but not the US. The scheme cuts through the red tape of business travel and directly facilitates the cross-border movement of business people.

The initiative on intra-company transfers provides a 30-day processing standard for applications for, and extensions of, temporary residence permits for APEC intra-company transfers of executives and senior managers. In 2001, participating economies agreed to extend the scope of the initiative to “specialists”, however there is no common definition for such group. Nevertheless, members agreed that what constituted a specialist would be defined by individual economies.

4.2 Policies to Attract HQPs: Unilateral Initiatives in Selected APEC Economies

Immigration policy

Manufacturing and services activities in the new global economy increasingly rely on the acquisition and deployment of human expertise. As Head and Ries (2003) point out, knowledge workers are one of the most important internationally mobile resources and the international competition for the mobile factor has increased their cross-border mobility. With the emergence of an international skills market, a national ability to train, retain and attract global knowledge workers is a key to sustaining or stimulating a country’s economic growth. Competition for these mobile resources has a strong zero-sum aspect to it, at least as perceived by policy makers and the enterprises engaging in the strategic competition game (Harris, 2004b). National governments are competing via various policies for these workers. In this section, we focus on the immigration policies aimed to attract foreign skilled labor.⁶⁹

Traditional immigration APEC economies like the US, Australia, and Canada have comprehensive immigration schemes specifically aimed at attracting highly-qualified migrants on a permanent basis. A program for permanent migration of skilled foreigners is usually based on a points system. Notable pioneers and users of the skill-based points system are Canada and Australia. Table 4.1 reproduced from McHale (2002) provides a broad overview of skill-based permanent immigration policies in Canada, Australia, Germany, the UK, and the US.

Many countries show significant improvement in shortening the length of time taken for application and approval of permanent immigration in addition to reducing speed-retarding red tape. These are important elements in competition for skilled foreigners. Germany and the UK are two notable countries that have showed significant improvement (McHale, 2002). The German government recently passed an immigration reform bill with a points-based system. In the UK, the Highly Skilled Migrants Programme (HSMP) was introduced in early 2002. In Australia, self-assessment of skills before permanent migration application has helped simplify the procedure, while, in Canada, the processing time can take more than 18 months especially for high-volume countries such as China and India.

Greater permissibility of applying for permanent status while working under a temporary working visa is a strong element in attracting HQPs who intend to stay indefinitely. In Canada, Australia, and the US, status change from temporary visa to permanent resident is allowed. In 2002, there were more than 15,000 intra-company transferees, 87,000 temporary workers, and 18,700 students who were converted to permanent resident status in the US (US-CIS, 2002).

⁶⁹ Other attraction policies include tax incentives for foreign skilled workers, lenient regulations on business creation and entrepreneurship, R&D incentives, continuing education incentives such as scholarships and financial assistance for graduate students. The comparative study on these policies deserves a thorough investigation and will not be in the scope of our review here.

Table 4.1 Skilled-focused Permanent Migration Programs in Selected Countries

	Canada	Australia	Germany	UK	US
Program	Independent skilled workers program	Skill migration (multiple programs ^a)	New immigration law (effective 2003)	Highly skilled migrant program ^b (introduced on pilot basis in Jan.02)	Employment-based preferences (permanent residency)
Number (percent of total) 1995 2000	81,000 (38%) 118,000 (52%)	24,100 (29%) 44,730 (56%)	85,300 107,000
Cap	No	No	No	No	Yes (140,000)
Points system	Yes	Yes ^c	Yes	Yes	No
Labor market test	No	No	No	No	Yes (with exception)
Selection criteria	Age, language, education, experience, job offer, adaptability	Age, language, education, occupation ^d , experience	(i) Highly skilled professionals with job offers: qualifications and earnings; (ii) workers without job offers: points system	Past earnings ^e , education, experience, professional achievement	Job offer (certification from the Department of Labor or no adverse impact on domestic workers required in most cases ^f)
Leading source countries in 2000	China (23%) India (10%) Pakistan (8%) Korea (4%)	UK (15%) S. Africa (14%) India (10%) Indonesia (9%)	Not applicable	Not applicable	India (15%) China (13%) Philippines (10%) Canada (7%)

- (a) Included programs (number in 2000/01): employer nominations (7,510); business skills (7,360); distinguished talents (230); skilled independent (22,380); skilled Australian sponsored (7,200); and 1 November onshore (60).
- (b) This program is not strictly designed for permanent migration. Initial acceptance is for a period of 1 year. The applicant can then apply to have the visa extended for a further 3 years. At the end of the four years, a migrant wishing to remain in the UK permanently can apply for permanent residence or "settlement". This route to permanent residency is also available to work permit holders, so the difference between the two programs as a means to permanent residency should not be exaggerated. A key difference, however, is that those entering under the HSMP are not tied to a particular employer.
- (c) A new points system was introduced in July 1999. A new category for skilled independent overseas students was added in July 2001. Applicants with Australian qualifications that apply within six months of completing their studies are exempt from the work experience requirement. No points test applies to the employer nomination stream, though candidates must meet basic requirements.
- (d) Occupation must be on the Skilled Occupations List (SOL).
- (e) Points based on past earnings are country specific, with poorer countries tending to receive more points for a given level of pound sterling earnings. For example, someone from Canada would need to have earned £250,000 to receive the maximum 50 points in this category, whereas someone from India would need to have earned £90,000.
- (f) There are five preference categories (E1) priority workers (28.6 percent), certification not required; (E2) professionals holding advanced degrees (28.6 percent), certification required; (E3) professional holding bachelors degrees and other workers (28.6 percent), certification required; (E4) special immigrants (7.1 percent); and (E5) employment creation investors (7.1 percent), must invest between \$0.5 million and \$1 million depending on geographic area and create at least 10 full-time jobs.

Source: *McHale (2002), Table 2*

Attracting highly-qualified foreigners on a temporary basis is becoming increasingly important for countries as a strategy to cope with labor shortages, especially in sectors such as IT and health. In Europe, temporary migration has been the norm, and schemes have been designed to deal with specific labor shortages (McLaughlan and Salt, 2002). While fewer countries (such as, the UK and Australia) have a specific scheme aiming at health professionals and nurses, most governments, including those of Canada, the US, Australia, France, and Germany⁷⁰, have modified the existing work permit systems to facilitate entries of IT specialists. In some dynamic Asian economies, such as Singapore, Chinese Taipei, and China, measures have recently been implemented to ease skill shortages in the information and communication sector (OECD, 2002b).

Generally, a job-offer is needed when a highly-qualified foreigner applies for a temporary working visa. While inquiring for a job offer or an employment letter from an employer may not be deemed as impediment to HQP attraction strategy, an official requirement on a “labor market test” or “validation” could be considered a hindrance. For example, in Canada, an employer must give details of the job offer to the government officials including a description of the duties, duration of employment, wages and working conditions, a statement of essential qualifications, and registrations or licenses that the applicant needs. An officer must confirm that the wages and working conditions associated with the job offer are standard for that type of employment, the job cannot easily be filled by a qualified and available Canadian or land immigrant, and that allowing a foreign national to fill the position is unlikely to have a negative effect on the Canadian economy and labor force. Employers of NAFTA-TN workers and software developers are exempted from this process. In the US and Australia, there is no such requirement, although employers must attest that employment of foreigners will bring benefits or create no harm to the host economy. Table 4.2 presents the defining features of national policies to support and encourage temporary migration of HQPs in Canada, Germany, France, the UK, and the US (reproduced from McHale, 2002).

Many countries have managed to reduce the length of time taken for work permit approval although the UK provides a faster response rate (McLaughlan and Salt, 2002). In Canada, changes in the 2002 legislation were made to speed up the authorization process and, more importantly, to facilitate entry of temporary workers. Fast-track procedures for issuing work permits for certain occupations exist in several countries including Australia, France, and Germany.

⁷⁰ In Germany, the government introduced a “green card” program under which 20,000 computer and technology specialists can work in Germany for up to five years. By 2001, about 10,000 of them had found employment in Germany. OECD – STI Outlook 2002 Ch. 8.

Table 4.2 Skilled-focused Temporary Migration Programs in Selected Countries

	Canada	Australia	Germany	UK	US
Program	Employment authorization – temporary residents	Temporary (long stay) business entry	IT specialists temporary relief program (“Green Card”) ^a	Work permits	H-1B specialty professional workers
Number (2000/01)	86,225 ^b	40,493 ^c	8,000 ^d	82,437 ^e	201,079 ^f
Job offer required	Yes	Yes	Yes	Yes	Yes
Cap	No	No	Yes (20,000 total)	No	Yes (195,000 per year)
Labor market test	Yes (validation required by HRSDC; exception for software developers)	No (but employers must show that the temporary entrant will provide a “benefit to Australia” ^h)	Yes (employment agency checks EU worker availability and qualifications / remuneration)	Yes (waived for “shortage occupations”)	No (but employers must “attest” to no adverse effect on US workers)
Tied to employer	Yes	Yes	No ⁱ	Yes ^j	Yes
Length of visa (max.)	3 years	4 years	3 years	5 years	3 years
Renewable	Yes	Yes	Yes (5 yr max.)	Yes (10 yr max.)	Yes (6 yr max.)
Spouse employment	No ^k	Yes	Yes (after 1 year)	Yes	No
Possibility of permanent settlement	Yes (under new law)	Yes	No (but possible under new law)	Yes (after four years)	Yes ^l

- (a) Program was introduced in August 2000 to relieve perceived shortages in the IT sector. Germany also operates a much larger work permit system (333,381 in 2000). The aim of the “Green Card” system was to make the recruitment of IT professionals easier through un-bureaucratic, rapid and transparent procedures (McLaughlan and Salt, 2002).
- (b) Number is for 2000. The stock of temporary workers with employment authorizations on December 31, 2000 was 88,962 (CIC, 2001).
- (c) Number is for 2000/01 and includes 3,411 independent executives establishing businesses in Australia. In addition, 3,438 visas were issued to medical practitioners and their dependents and 1,738 visas were issued to people joining educational and research institutions. The estimated stock of long stay business entrants as of 30 June 2001 was 56,000. The median duration of stay of visa holders as of that data was just under six months.
- (d) Number is for the period from August 2000 to June 2001.
- (e) Includes only out-of-country work permit approvals (McLaughlan and Salt, 2002).
- (f) Number is for the Fiscal Year 2001 (which begins in October 2000). A further 130,127 petitions were approved for continuing employment (INS 2002).
- (g) Renewals do not count towards the cap.
- (h) The benefit can come in various ways: create or maintain employment; expand trade; develop links with international markets; or improve competitiveness. Emphasis is on positive effects rather than the absence of harm.
- (i) Switching employers is possible without further labor market test. Five-year limit applies to combined employments.
- (j) Employees switching employers must have new employer apply for a new permit.
- (k) Spouses can apply for employment authorization on their own merit. Under the Spousal Employment Authorization Program, spouses of workers in engineering, management, technical and skilled grades can receive an authorization without a labor market test (McLaughlan and Salt, 2002).
- (l) Visa holders can apply for permanent residency while they are in H-1B status. Extensions to H-1B status are possible in one-year increments for those whose visa expires when an application for permanent residency has been pending for more than one year (McLaughlan and Salt, 2002).

Source: *McHale (2002), Table 3*

Another effective measure many countries have adopted, is retaining foreign graduates by allowing foreign students to change their visa status at the end of their education and permitting their entry into the labor market. In the US, almost half of new recipients of H-1B visas are students who graduated from US schools. In several APEC/OECD economies such as Australia, Canada, Germany, France (for IT graduates only) and Switzerland, amendments were made to allow students to stay temporarily after the completion of their studies in order to search for jobs in the host country. Measuring the efficacy and success of these attraction policies remains a challenge to most countries. According to McLaughlan and Salt (2002), only a few cases, notably Australia, the US, and Germany, have showed systematic attempts either to collect the necessary data or carry out a full evaluation and follow-up research in this respect. Frameworks for evaluation are only beginning to work out. Criteria for determining success include qualitative assessment of policy objectives, quantitative measurement of outcome against target, public opinion, level of complains from employers, applicants, as well as other stakeholders like trade unions.

In summary, advanced APEC/OECD economies have adopted policies to attract internationally mobile HQPs by (1) encouraging immigration of the highly-qualified through specialized skill-related visa programs; and (2) encouraging immigration of potential HQPs by attracting specialized students.

Domestic Labor Market Policy

Harris (2004b) argues that greater flexibility of labor markets is consistent with, and generally encourages a more mobile workforce. OECD research shows that the mobility of S&T professionals, for example, between sectors and regions remains low in many countries due to administrative and regulatory barriers. (OECD, 2003b)

Canadian labor markets, for example, are fairly flexible by OECD standards. However, certain institutional problems such as (1) inadequate recognition of foreign credentials, and (2) multiplicity of jurisdictions regarding labor laws create barriers to mobility and affect the successful integration of immigrants into the labor force.

According to OECD (2003a), there is some anecdotal evidence showing that the barriers in credential recognition are greater in Canada than in the U.S. This is partly due to relatively more strict regulations on professions and trades, and also more conservative attitude of Canadian employers towards foreign work experience. The problem of inadequate recognition of foreign credentials in Canada is partly reflected by the fact that the returns to education are lower for foreign-educated immigrants than for the Canadian-born (OCED, 2003a). Similarly, foreign work experience, especially from developing countries, yields little returns in Canadian labor market. Organizations which regulate or license trades and professions may not recognize or be able to properly evaluate their credentials; there are similar issues to consider in non-regulated occupations. The result is that foreign skilled workers tend to be unemployed or underemployed in the Canadian labor market, this impacts subsequent flows of skilled migrants, whether temporary or permanent.

Recognizing that barriers to mobility of skilled workers could generate welfare loss to the economy, the federal and provincial governments have responded to the credential recognition problem. To reduce imperfect portability and information uncertainty of foreign credentials, the Canadian Information Centre for International Credentials (CICIC) was established in 1990. The CICIC works as a national clearing-house and provides referral services to support recognition and transferability of educational and occupational qualifications between Canada and other countries. It also serves as a link for Canadian academic and professional bodies to international organizations and to information centers around the world.⁷¹ At provincial level, programs are set up to support credential evaluation services for certain professions.⁷² In addition, some self-regulated professional organizations, such as the Medical Council of Canada and the Canadian

⁷¹ See <http://www.cicic.ca>

⁷² Ontario, Quebec, Alberta, Manitoba, and British Columbia

Council of Professional Engineers, offer the evaluation of foreign credentials related to their specialties.

The second key institutional barrier to skilled-labor mobility – the problem of multiplicity of jurisdictions regarding labor laws – affects both Canadian-born as much as foreign workers but can be more obstructive for the latter due to their lack of familiarity with the system (OCED, 2003a). In Canada, diversity of provincial standards exists in such key areas as labor markets, financial markets, and the markets for some services. In 1995 an intergovernmental agreement – the Agreement on Internal Trade (AIT) was established. It focuses on reducing trade barriers between provinces and territories and harmonizing inter-provincial standards. Under the labor mobility chapter, restrictions on internal labor mobility have been officially removed since July 2001. For example, all local residency requirements have been eliminated and the mutual recognition agreement on professional certification now covers 97 percent of regulated professional workers (OECD, 2003a). Clearly, there is recognition that the harmonization of regulatory standards in the labor market is the key step in moving towards freer movement of workers both domestically and beyond.

In his speech delivered to the Couchiching Institute on Public Affairs on the economic integration of North America, the Governor of the Bank of Canada stressed that resolving the domestic multiplicity of jurisdiction is the first step towards capturing the full benefit of deeper economic integration within NAFTA. Canada has a non-trivial problem in this regard. In Canada, for example, there are different criteria for professional certification of trades people, different provincial securities regulations and different rules related to transportation. It is very important that we harmonize regulatory standards between provinces in Canada.⁷³

Coordination and further implementation of these measures remain a challenge to governments, self-regulated bodies, as well as employers and employees. More research is needed on assessment and evaluation of these policy changes, such as the new immigration act, and how it impacts international mobility of skilled workers.⁷⁴

Science and Technology (S&T) policy

Science and technology policies are critical to attracting globally mobile S&T personnel. To a large extent, the policies towards science and technologies in most APEC/OECD economies have embraced the notion that the creation, diffusion and use of knowledge has been and will continue to be one of the main factors underpinning their long-term productivity performance.

Canada, for example, has a significant ‘innovation gap’ (Government of Canada, *Achieving Excellence*, 2002). Canada’s overall level of innovation capacity is near the bottom in the G-7. Over the past few years, Canada has been reinvesting in S&T and focusing on a number of new initiatives including reforming the organization and governance of universities and public research, support for private-sector R&D and innovation, promoting collaboration and networking among private and public sector organizations, promoting industry-science relations, and sponsoring programs to foster international collaboration in science. Some new infrastructures for research and innovation measures include the creation of the Canadian Foundation for Innovation, Canada’s Networks of Centres of Excellence, Research Chairs and enhanced funding for the Granting Councils. Consistent with these efforts, the government has recently embarked on its

⁷³ Remarks by David Dodge, Governor of the Bank of Canada, to the Couchiching Institute on Public Affairs, 7 August 2003 (www.bankofcanada.ca/en/speeches/2003/sp03-11.htm)

⁷⁴ In a comparative perspective, the EU countries also face similar barriers to labor mobility. A recent report on the European survey of businesses has identified the key policy-related factors that businesses see as hindering the free movement of workers in Europe. These include the lack of integrated EU-wide employment legislation, differences in tax and benefit systems, pensions, foreign credential recognition, and immigration procedures (PWC, 2002).

Innovation Strategy. In 2002, the Government of Canada released *Achieving Excellence and Knowledge Matters* – the foundation pieces for its innovation strategy.⁷⁵

Science and Innovation policies matter for the international mobility of skilled workers. The new infrastructure measures for research and innovation have fostered return migration of top Canadian talents. Some examples of anecdotal evidence are: (1) more than 150 scientists have come back to Canada from universities and institutes in the US, Europe and Australia in the last three years; (2) Canadian Research Chairs have attracted about 840 scientists and social scientists, including about 160 recruited from other countries.⁷⁶ Chinese Taipei and Ireland have also succeeded in attracting return migrants and fostering “brain circulation” in S&T professions.⁷⁷ At the same time, China and India are developing their own scientific research base and actively recruiting back highly-qualified expatriates.

Obviously, a country’s innovation performance is highly endogenous. It depends on a myriad of factors only a subset of which are subject to direct policy influence – e.g. support for R&D or higher education, flexible labor market policies, appropriate intellectual property regimes, etc. Clearly, these policies encourage international mobility of S&T personnel. OECD (2003b) argues that research employment is increasingly becoming more dynamic and involves greater collaboration between universities and private sector firms in the new global economy. Consequently, mobility of S&T personnel is becoming more important to matching supply and demand and diffusing knowledge. To foster mobility of researchers both at the national and international level, it is critical to reduce regulatory barriers and create incentives. Many OECD countries are taking a number of initiatives for fostering the mobility of researchers. Examples include, regulations on dual employment or restrictions on participation in entrepreneurial activities are being removed; creating incentives for mobility between public research and business; competition for research funds; human resource management policies in business and public research institutions that reward mobility in career advancement.⁷⁸

More importantly, there is clear need to coordinate science and innovation policies with migration policies to enhance the attractiveness of APEC economies as a destination for attracting S&T professionals.

Tax and Fiscal Policy

Tax incentives play an important role in facilitating recruitment of internationally mobile HQPs or developing repatriation schemes for national experts who live or study abroad (OECD, 2003c). Some OECD governments use special tax incentives to attract highly mobile professional and technical workers. For example, in Belgium, highly-qualified professionals including executives and researchers are eligible for a special non-resident tax status which grants a tax exemption for days spent outside the country. A key condition is that employment must be with a qualifying entity such as a scientific research center or laboratory, or business under foreign control and it must be of a temporary nature. Sweden passed a similar law in 2001 to reduce the tax burden on foreign experts that remain in the country for less than five years. The Netherlands uses comparable tax incentives for HQPs. OECD (2003c) notes that these tax incentives have proven to be cost-effective means of recruiting and retaining HQPs.

⁷⁵ The government’s strategy (www.innovationstrategy.gc.ca) is focused on four inter-related priorities: (1) Create and use knowledge strategically to benefit Canadians: promote the creation, adoption and commercialization of knowledge; (2) Increase the supply of highly qualified people: ensure the supply of people who create and use knowledge; (3) Work toward a better innovation environment of trust and confidence, where public interest is protected and marketplace policies provide incentives to innovate; (4) Strengthen communities: support innovation at the local level so our communities continue to be magnets for investment and opportunity.

⁷⁶ See, for example, Globe article by Anne McIlroy, Science Reporter, March 26, 2003.

⁷⁷ OECD/STP/(2002)34

⁷⁸ See, for example, OECD--DSTI/STP(2003)30, 14 October 2003.

In a Canadian study, Harris (2004b) argues that selective tax incentives be used to encourage Canadians to take up temporary jobs outside the country in knowledge-intensive professions. The study also recommends offering reduced income tax rates to attract HQPs returning from abroad,

Education Policy

Education structures, organization and functioning in the APEC regions are far from uniform. Each education system has its strengths and weaknesses. Economies with high graduation rates at the tertiary level, which is an indicator of advanced knowledge by the education system, are more likely to be developing or maintaining a mobile skilled labor force. Harris (2004b) argues that a highly skilled labor force is more likely to be mobile than a less skilled labor force. He suggests that global mobility of HQPs could be encouraged in a number of ways. For example, more emphasis could be placed on the year of 'study abroad' option. In Canada, such a scheme is mildly popular with respect to European destinations there are very few undergraduate programs which target either the US or Mexico. The study recommends that federal government could explicitly provide scholarships for such kinds of educational activities. Moreover, support of graduate students studying abroad would also increase the number of Canadians with 'foreign experience'.

5. SUMMARY AND CONCLUSION

In the knowledge-based economies of today, HQPs are indispensable to an innovative economy. Reaching the goal of a more innovative economy requires that the highly-qualified workforce is of sufficient quantity and quality to support the expansion of innovative activities by firms. Satisfying this key condition for the labor force poses challenges as HQPs have become increasingly mobile and the market for some segments of highly-qualified workers has become more global. Many industrialized countries compete strategically in attracting these workers. Therefore, in adjusting to new skill requirements, APEC economies must consider their performance in attracting HQPs from the rest of the world and in retaining domestic talents.

Consequently, it has become increasingly important to understand key issues surrounding the international mobility of HQPs in order to adopt the right policy approaches towards it. Attention must now turn towards improving our understanding of the issues such as what are the implications of this new trend for the APEC economies? Would facilitating international mobility for HQPs bring economic benefits to the participating economies?

This paper focuses on four key issues and identifies policy initiatives and potential directions for future research. First, it examines the global trends in the international migratory flows of HQPs. Second, it discusses the fundamental (non-policy) drivers of the increased HQP flows in the new global economy. Third, it reviews the literature on the economic costs and benefits associated with cross-country movement of HQPs and the main factors conditioning these costs and benefits. Finally, we address the question: how policy has adjusted or should adjust to increased international HQP mobility in the new global economy?

Our findings show that international mobility of HQPs has increased significantly in the last decade, especially from Asia to major APEC/OECD economies. Three observations are particularly notable: First, the mobility of HQPs has increased among industrialized APEC economies in the 1990s; Second, the increase in HQP migration is characterized mainly by temporary inflows as opposed to permanent inflows; and Third, there is some evidence on return migration from APEC/OECD economies. Interestingly, the experiences of the integrated labor market economies have mixed experiences. For example, in the North American context, the temporary outflow of highly-qualified Canadians to the US under TN visa increased significantly in the 1990s, particularly during the 1997–2002 period. In contrast, labor market integration in the EU countries does not seem to have led to an increase in flows of workers between regions. Although, there is some evidence of an overall increase in mobility of workers within

organizations, the relative importance of virtual and short-term assignments has increased significantly among the EU countries.

Measuring the scale of the international movement of highly skilled individuals remains a challenge. We need to have a better understanding of the pattern and direction of flows, and the characteristics of movers. We need answers to questions such as are HQPs, much like capital and FDI, becoming more mobile globally than in the past? Are global movements of HQPs becoming more multi-dimensional (brain circulation) than in the past or do they tend to be one-way flows (brain drain)? Are the patterns of HQP migration across countries much different than those within a national labor market such as the US or Canada? What is the history of HQP migration in an integrated labor market such as the European Union?

A recent European report points out that international mobility of HQPs is becoming increasingly important to business as they are expanding their production and marketing activities globally (PWC, 2002). Our findings seem to be broadly consistent with this view. Our analysis suggests that mobility of HQPs has increased in parallel to an increasing importance of technological change, globalization of production and integration of markets through international trade and FDI, location of MNEs, strategic alliances and networks with high-technology global firms and clusters of research and innovation, opportunities for high-technology entrepreneurship and the internationalization of R&D activities of national firms. Our findings also seem to suggest that increased income and employment opportunities, and career prospects and attractiveness of the education and research system coupled with the changing preferences of highly qualified personnel towards working abroad are also key drivers of international mobility of skilled workers in the new global economy.

Overall, there still remain significant knowledge gaps and more research on the fundamental drivers of international mobility of skilled labor is clearly warranted. For example, we need to better understand the underlying fundamental factors driving the international mobility of HQPs. How have these factors changed over time? How do they vary across different groups of HQPs or by sector of activity?

A review of the literature on welfare economics of labor mobility suggests that there are many channels through which potential benefits of international mobility of HQPs can be realized by the participating economies. These are increased specialization of production, increased human capital acquisition, and enhanced knowledge creation and cross-border spillovers. However, the distribution of benefits is likely uneven. Consequently, some sending countries may incur costs in the short run and possibly in the long run. The potential costs may include loss in human capital spillovers, reduced knowledge absorptive capacity, and an increased innovation gap.

There is not much literature on the impact of labor mobility on economic convergence/divergence among integrated labor markets. Evidence from the EU countries and US provides some support to the income levels and productivity convergence effects. In Canada, for example, where inter-provincial mobility is large, the evidence does not provide credence to the view that internal migration leads to the actual convergence of regional per capita income. More empirical evidence is clearly needed on the costs and benefits associated with cross-country movement of HQPs. Further investigation on mechanisms or channels through which increased HQP mobility may contribute to convergence is also warranted.

Finally, the policy discussion focuses on two sets of policies (i) labor market integration policies within free trade areas such as Canada and the US, EU, and Australia and New Zealand; and (ii) policies either increasing the international mobility of HQPs and/or increasing country's ability to attract globally mobile knowledge workers. We consider the former set of policies as those relating to trade, harmonization, and deeper economic integration between economies (regional or bilateral) whereas the latter set policies include immigration, domestic labor market, and science and technology, education, and tax and fiscal policies.

A review of the policies in the integrated labor market economies suggests that greater harmonization of policies and adoption of common licensing standards, are key to reducing barriers to cross-border mobility. In the case of Canada-US, for example, Dodge (2003) argues,

that to realize real welfare gains from the NAFTA, further integration of labor markets must take place. Harris (2004b) argues that the slowing down of the income convergence process between Canada and the US, despite the free movement of labor and capital, may partly be due to cross-border barriers in HQP mobility. Clearly we need to know more about the significant regulatory and other barriers to some partial/complete integration of Canadian and US labor markets. On the international trade front, policies affecting trade in services, particularly business services will certainly influence the movement of HQPs internationally. Further liberalization of the service supply modes under GATS will reduce barriers to international mobility of HQPs.

The discussion also examines a selective set of policies such as immigration, domestic labor market practices, trade and science and technology policies as they relate to the international mobility of HQPs. A brief review of the selected APEC economies indicates that advanced APEC/OECD economies have adopted policies to attract internationally mobile HQPs by (a) encouraging immigration of the highly-qualified through specialized skill-related visa programs; and (b) encouraging immigration of potential HQPs by attracting specialized students. In the area of domestic labor market policies, in Canada for example, there is a recognition that the harmonization of regulatory standards in the domestic labor market is the key step in improving the mobility of HQPs both domestically and beyond.

In the areas of S&T policies, many APEC/OECD economies are taking a number of initiatives for fostering the mobility of researchers. There is a clear need to coordinate science and innovation policies with immigrating policies to enhance the attractiveness of APEC economies as a destination for attracting S&T professionals. Recently, many APEC/OECD economies have initiated tax incentives to recruit and retain internationally mobile HQPs. Harris (2004b) recommends offering reduced income tax rates to attract HQPs returning from abroad. He also suggests a number of educational measures to improve global mobility of HQPs. One such measure, for example, could be to place more emphasis on the year of 'study abroad' option.

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**THE DEVELOPMENT
OF INDUSTRIAL
CLUSTERS TOWARDS
A KNOWLEDGE-BASED
ECONOMY**

THE DEVELOPMENT OF INDUSTRIAL CLUSTERS TOWARDS A KNOWLEDGE-BASED ECONOMY

1. INTRODUCTION

1.1 Background

A cluster is a congregation of interrelated industries and institutions that create complementary linkages for the exploration and application of knowledge. Industrial clusters can be as small as a city, or as large as a cross-country network. Industrial clusters have several policy implications, including (1) that regional development policy is an essential part of the industrial policy, (2) that inter-governmental cooperation is key to the effectiveness of such a policy, and (3) that cross-country policy coordination is beneficial to the flows of capital and human resources towards the formation of an industrial cluster. It is now well understood that industrial clusters contribute to the enhancement of national competitiveness because a cluster provides complementary inputs to production, intensifies competition to enhance productivity, and shortens the response time to technological innovations and market changes.

“Clusters encompass an array of linked industries and other entities important to competition including governmental and other institutions such as universities, standard-setting agencies, think tanks, vocational training providers and trade associations” (Porter, 1998). The basic reason for clustering is that co-location of firms generates positive externality on productivity. Positive externality is most prominent when firms are “interconnected”. What does “interconnected” mean? Does it refer to vertically integrated or horizontally integrated firms, or something else? The literature seems to suggest that both vertically and horizontally integrations are essential elements of a cluster. In the initial writing of Marshall (1890), who first postulated the external benefits of a cluster, the existence of specialized suppliers is considered an important contributor to increasing returns. Most theoretical models on agglomeration build on the foundation of intermediate goods (Venables, 1996 & 1999). This implies that vertical integration is an essential element of clustering, but empirical evidence on this is scanty.

On the other hand, the benefits of clustering must also be associated with the reduction of transaction costs when firms co-locate, including search and information costs, bargaining and decision costs, as well as policing and enforcement costs (Dahlman, 1979). The co-location of firms imposes certain constraints on their behavior, making it easier to conduct businesses with one another. Co-localized firms realize the unattractive consequence of breaking the rules and will refrain from doing so. In a cluster it will be immediately noticed if some firms attempt to over-utilize asymmetric information, or pass substandard goods as premium grade, or create hold-ups in order to exploit market shortages. Behavior of this kind puts firms on “black lists,” which deprives them from information and trading opportunities. Through this sanction mechanism, co-localized firms therefore create a mutual understanding and trust that reduces malfeasance and facilitates trade. Clusters prevail because trust cuts the costs of identifying, accessing, or exchange products between members in the area (Maskell, 2001).

It remains to be explained, however, why a single firm does not arise to replace the cluster of firms if transaction cost is the key benefit of co-location. Marshall (1890) again, offers an explanation based on the advantage of “variety”. When parallel but dissimilar firms co-locate in a region, they develop a variety of solutions to the same problem, based on the same information but different perceptions and different spheres of competence. This idiosyncratic and partly tacit way of dealing with things allows firms along the horizontal dimension of a cluster to engage in the process of mutual learning and competing improvement, on which their survival depends (Maskell, 2001).

A cluster, therefore, encompasses two dimensions: a vertical dimension along which firms collaborate and perform complementary activities, and a horizontal dimension along which firms compete and perform parallel activities. It is the combination of collaboration and competition that drives the dynamics of clusters. The importance of “competition” in clusters is often neglected as

researchers tend to overemphasize the benefits of collaboration and complementarity. In a study of New York City's garment industry, Rantisi (2002) highlights the importance of competition in the innovation activities of the fashion industry. Local rivalry is highly motivating to change and peer pressure, and the desire to stand out from the group inspires innovation.

In addition to specialized suppliers, Marshall (1890) also pointed out two other causes of agglomeration effects: labor pooling and technology spillover. Labor pooling refers to the presence of a labor force suitable for the particular industry in the cluster. Labor pooling reduces the entry barriers to new firms, the exit costs of incompetent firms, and the costs of adjusting the scale of production. Labor pooling also acts as a selection mechanism that stores or even cultivates a work force to support the growth of the industry. Using data on the US manufacturing industry, Rosenthal and Strange (2001) found labor market pooling to be the most robust influence on agglomeration. Dumais et al (1997) also found that industries with a similar labor mix enjoy the greatest benefit from co-location.

Technology spillover is also found empirically to be an important contributing factor to geographic concentration of firms. First, innovative activity itself is substantially more concentrated geographically than overall production, and second, industries that emphasize research and development tend to be more spatially concentrated than those that do not (Audretsch and Feldman, 1996). Technology spillover does contribute to agglomeration, but its effect diminishes rapidly over distance (Rosenthal and Strange, 2001). In other words, you have to be close enough to the knowledge center to benefit from knowledge spillover.

Knowing the benefits of clusters is insufficient to understand how clusters come about. It is noticeable that clusters, whether they are of high-tech or low-tech industries, only exist in certain regions of certain countries. This inevitably leads to the conclusion that some regional advantages give rise to successful clusters. This may be true in the low-tech industries but not in the high-tech ones. After studying high-technology clusters in the US, Ireland, India, Israel, and Chinese Taipei, Bresnahan, Gambardella and Saxenian (2001) conclude that the economic factors that give rise to the start of a cluster can be very different from those that keep it going. Agglomeration economies arise almost naturally after a cluster has taken off, but the most difficult part is to get a new cluster started. The authors cited above identify entrepreneurship, linkage to a major and growing market, and availability of skilled labor as three key ingredients to the formation of a cluster. Among the three factors, market access is the most recognized in the literature. Empirical studies have shown market access to be an important determinant of cross-country income distribution (Hummels, 1995; Leamer, 1997).

Recent studies by Hanson (1996 & 1997) on the Mexican apparel industry, found that prior to trade liberalization in 1986 when Mexico joined the WTO, production of apparel was concentrated around Mexico City and was largely oriented towards the domestic market. With trade liberalization, there was a substantial relocation of manufacturing activity towards the US border. There is evidence of a negative relationship between relative wages and distance from Mexico City prior to 1988, and of a significant decline of this relationship between 1985 and 1988. Distance matters even though transport costs have been declining due to improvements in technology. Davis and Weinstein (1998), for example, using data for 13 OECD economies and constructing a measure of "idiosyncratic demand" for each four-digit industry based on demand in each economy and its trading partners, distance weighted, found that the elasticity of production with respect to demand to be as high as 1.6. Feenstra, Markusen and Rose (2001) also found a fairly strong home market effect in industries with differentiated products.

While the three ingredients of entrepreneurship—market access, and skilled labor—are indispensable, there seem to be various ways of formulating a recipe. This is why various clusters co-exist instead of one cluster monopolizing the entire industry. The variety of recipe is often culture related and this is why culture is an important factor in defining the development path of a cluster (Saxenian, 1994). This finding is tantamount to saying that entrepreneurship, market, and technology are three key ingredients to the formation of a cluster, but that there are multiple combinations to produce an output. The key is to find a formula that sets out a process of "cumulative causation". Some clusters appeared to arise naturally, out of natural geographic advantages.

For example, at the beginning of the Industrial Revolution, most textile industries clustered in areas rich in water resources, as water was the crucial input to textile production. However, in the high-technology age, nature-endowed inputs become less important, and created assets such as skills become more relevant. Examining the experiences of Ireland, India, Israel and Chinese Taipei, which have succeeded in developing IT clusters in recent years, market access seems to be the most critical among the three ingredients for success. The US was apparently the major and growing market for IT products, and it seems that building a linkage to this market center is a precondition for developing a cluster. In all four cases, an alliance approach was taken. They built a collaborative relationship with multinational firms based in the US to enable market access, and to benefit from technology spillovers from such an alliance. Even the “specialized suppliers” and “labor pooling” were supplanted by multinational firms.

Contrary to the general belief, putting a university at the center of the cluster can help, but it is neither necessary nor sufficient to starting a cluster. There is also no evidence showing that government policy, whether based on a protectionist infant industry, national champion, arguments or direct industrial targeting, is useful in jump-starting a cluster (Bresnahan et al, 2001). The success of a cluster can be measured by the growth of the number of firms and by the growth of existing firms. The growing number of firms is important because it is critical to the creation of knowledge simultaneously by variation and by the division of labor (Wallsten, 2001). But the growth of firms is equally important because the growing companies are often the sources of increasing returns for the continuous growth of the cluster, in form of training for potential spinouts, development of managerial and technical competencies, and the typical forward and backward linkages.

Although the ingredients to the start of a cluster have been identified, the mechanism that puts these ingredients together in order to work toward building a successful industry is not so clear. The experience of Silicon Valley has highlighted the important role played by venture capital (Rowen and Toyoda, 2002), but the experience in other countries is not as clear-cut. Venture capital also played an apparently important role in Chinese Taipei’s high-tech clusters, but the role of venture capital in other APEC member countries is not as significant. It is also clear that venture capital is important only in the start-up stage of a firm, and the traditional capital market has to take over the subsequent role in supporting the growth of the firm, which as previously mentioned, will eventually determine whether a cluster succeeds.

It is also noted in the literature that structures and institutions matter in the development of clusters. Different institutions may be needed for clusters specializing in different economic activities. Inappropriate institutions may thwart the opportunities of a resource-rich economy to develop an industry based on such a resource. Eskelinen and Kautonen (1997), for example, demonstrate how Finland, with its rich supply of high-quality timber resources, high education standards, and a long track record of world-class designers, has seen the decline of its wooden furniture industry. The explanation has been that Finnish institutions cater to the mass production of pulp and paper, which are unfit for the wooden furniture industry characterized by flexible and small-batch production. Inappropriate Finnish policies drove the furniture industry to neighboring Denmark, where the industry has blossomed. Idiosyncrasies in economic activities require variations in institutions and give rise to distinctive industry clusters.

The institutions that are discussed most often in the literature are the institutions for innovation. Regional or national innovation systems have therefore been the focus of recent studies on cluster-based industrial policy (Lawson, 1997; Lundvall, 1998). The key elements of regional innovation systems are a group of networked institutions for the creation, combination, distribution, and application of knowledge. Again, innovation institutions are part of the group of institutions that underscore a cluster. The variety of clusters gives rise to a variety of national (regional) innovation systems. For example, Silicon Valley operates within the American system of innovation, which include laws, regulations and conventions for securities, taxes, accounting, corporate governance, bankruptcy, immigration, research and development, university—business links, intellectual property protection, etc. This system is most favorable to new business ventures (Rowen and Toyoda, 2002).

In the case of the Hsinchu Science-based Park (HSBP) in Chinese Taipei, the regional system of innovation includes two premier universities, a government-sponsored research laboratory, a tax scheme that favors R&D, and an employee bonus scheme that attracts highly skilled labor to growing companies. The system also spawns a community of seasoned engineers with strong connections with Silicon Valley. The system is especially effective in spurring follow-up innovations that take advantage of the research originated in the Silicon Valley.

It is also important to note the role of universities or other research institutions (Santoro and Chakrabarti, 2002). Although Bresnahan et al (2001) have found universities to be non-essential to the start-up of a cluster, universities may just be a critical factor for the growth of the cluster. It is clear that a cluster will not grow without innovations, and innovations have to come from research. Although some knowledge can be acquired from outside, R&D does not come free – if you do not invest, you cannot absorb knowledge (Cohen and Levinthal, 1989). It takes some high-caliber universities and research institutions to build a capacity to acquire and use the knowledge that has been produced. It has also been shown in the literature that firms that locate close to research centers benefit disproportionately from the knowledge produced in such centers, which is especially true for advanced research in fields such as biotechnology (Cooke, 2002 & 2003). Likewise, firms located close to other innovative firms are more productive in R&D output than those located far away (Wallsten, 2001; Orlando, 2000). Universities are also critical in providing high-skilled labor to support the growth of a cluster. It is also increasingly recognized that close linkage between universities and industries are conducive to innovations and to commercialization of new ideas. The extent to which universities matter in the development of clusters needs to be answered by more research.

1.2 Research Issues

We may also look into the problems that inhibit the establishment of a cluster. Inability to create a knowledge base may be the most obvious barrier to the development of an industrial cluster. The inability is caused by weak economic institutions that obstruct learning efficiency and by high vulnerability to volatile global currency and financial markets that constrain patient capital necessary for the development of a broad knowledge base (Ernst, 2003). The lack of a knowledge base often deprives developing countries from upgrading themselves from an offshore assembly platform for multinational firms to self-sustained industrial clusters. With mobile international capital, developing countries attract multinational firms by low wages and lose them when the wages rise. Even if foreign investments cluster in a particular location, they usually failed to generate agglomeration benefits. In Chapter 2, we will review several industrial clusters in an attempt to uncover the underlying forces that form a cluster.

The traditional role of factor endowment in the formation of an industrial cluster has changed. Traditional literature along the line of Marshall (1890) has assumed factors to be immobile across counties. But globalization has allowed many factors to be mobile across national boundaries, particularly capital and skilled labor. It is nowadays common for anyone to be born in one economy, educated in another economy, and to work in yet another economy. Human skills also tend to cluster. Most financial experts work in London and New York, most IC-related engineers work in Silicon Valley. These experts and engineers may be born anywhere in the world. A right environment and institutions can attract the flow of skills. In the past, advanced countries attracted the skills from the developing countries, constituting a brain drain. Today, there is a reversal of that brain drain whereby skills flow from advanced to developing countries. If skills can indeed be obtained from outside, then the three ingredients for the formation of a cluster would be reduced to only two: entrepreneurship and market access. We will discuss the issue of “human circulation” in Chapter 3.

It has been argued in the literature that the success of Chinese Taipei’s computer industry can be attributed to the swiftness and flexibility of SMEs and their comprehensive subcontracting practices. Related studies in this area include Levy (1988) and Levy and Kuo (1991) on the comparison of keyboard and computer manufacturing between Chinese Taipei and Korea; Kreamer et al (1996) on the study of Chinese Taipei’s software industry; and Kawakami (1996) on the development of Chinese Taipei’s computer industry and the structure of SMEs in Chinese

Taipei. These studies have argued that the industrial specialization of Chinese Taipei's firms in the information technology (IT) industries has played a pivotal role in catapulting these firms into the international marketplace. There has, however, been little discussion in the literature as to what the main motives are for high-tech firms in the IT industries to engage in such subcontracting practices, and it may also be worth exploring what effect the prevalence of such subcontracting practices has had on the overall industrial structure. In Chapter 4, we explore the effects that subcontracting practices have had on the overall industrial structure and on industrial clusters, and we discuss the key elements involved in the undertaking of subcontracting practices by high-tech firms within the HSIP.

Issues relevant to industrial clusters and firms that have been raised in recent years include the effects of industrial clustering on firms' market entry, innovation activities, and growth. Generally speaking, most research provides evidence highlighting how industrial clusters generate positive effects on regional firms. (1) Baptista and Swann (1999) show how the formation of an industrial cluster can effectively reduce entry barriers and facilitate market entry; (2) Gemser and Wijberg (1995) and Baptista and Swann (1998) indicate that industrial clusters enable firms to be more innovative; (3) Storey (1994), Barkham, et al. (1996), Lechner and Dowling (2000), Lechner and Dowling (2003), and Hoogstra and Dijk (2004) provide evidence that regional environments matter in driving firms' growth. The rapid growth of Chinese Taipei's ICT industry since the middle 1980s has generated increasing amounts of research into firms' productivity differences within this sector. However, less attention has been paid to research issues concerning the effect of industrial clusters on firms' productivity growth. In Chapter 5, we use the micro data on Chinese Taipei's ICT industry for 1999 to highlight the influence of business environments and industrial clusters upon the productivities at a plant level.

Finally, what is the role of government in the formation and development of clusters? Although Bresnahan et al (2001) disapprove of proactive government policies based on protectionist or infant industry arguments, or pick-the-winner target setting strategies, they nevertheless confirm the useful role of the government in providing "accommodative" policies. In fact, we question the distinction between proactive and accommodative policies. Is skill training proactive or accommodative? There is a plethora of failing attempts to jump-start an industrial cluster. We can easily point out the missing ingredient in the formula. But does it not mean that the government has not been "proactive" enough in identifying the missing part of the formula and finding a solution before a cluster-based policy is launched. Given that it takes many ingredients to bind together a winning formula and there is no guarantee that a region will be naturally endowed with such resources, the action that brings together these resources constitutes that core policy requirement for a government interested in cluster development. This is not to mention various institutions that facilitate the cluster development that may have to be created and nurtured through government investments or regulations. Policy discussions will be made in Chapter 6.

2. CASE STUDIES OF APEC MEMBERS' INDUSTRIAL CLUSTERS

2.1 Introduction

As noted in the opening section, there are a number of distinct advantages for firms involved in the formation of an industrial cluster. To reiterate, these include firstly, that a cluster provides complementary resources such as technology and information exchange, management assistance, and so on, to improve the performance of all firms within the cluster. Secondly, the cluster strengthens competition and thus promotes technical efficiency because, as firms are located nearby, the inherently fierce competition for clients or suppliers becomes unavoidable; nevertheless, competition inevitably pushes up the level of efficiency. Thirdly, firms can quickly respond to the demands of the market, or to changes in technology, since firms within the cluster can reorganize subcontracting work more quickly than those outside of the cluster. This particular ability to leverage resources to adapt to fluctuations in the market and changes in technology has been the major benefit for firms located within the cluster.

There are, however, a number of questions surrounding the existence of such clusters, such as:

what is the historical background and what have been the major incentives behind the formation of clusters by firms?; how do clusters interact with other clusters?; have they been able to adapt to the more open, internationalized environment that has emerged in recent years?; and, as time goes by, how will these clusters continue to evolve? All of these questions, and perhaps countless others, are worthy of further exploration. Therefore, the aim of this chapter is to introduce four case studies – Chinese Taipei's Hsinchu Science-based Industrial Park (HSIP), the Silicon Valley in the US, Malaysia's Penang and Kelang Valley clusters, and the Hamamatsu cluster in Japan – in an effort to gain an understanding of, and to draw some lessons from, their developmental experiences.

2.2 Hsinchu Science-based Industrial Park (HSIP)

Following the first oil crisis in 1973, the government realized that Chinese Taipei's industrial development was built on a weak, labor-intensive structure, which was liable to disintegrate during any protracted period of recession. It was clear that Chinese Taipei needed to pursue a policy of development of hi-tech, high value-added industries, and in order to attract investment and technology transfers from foreign hi-tech industries, the government had to provide a suitably attractive environment. It therefore decided to create a science-based industrial park similar to the well-established example of Silicon Valley in California.

When deciding on the location for the new park, the availability of highly skilled manpower and technical support were vital preconditions, and Hsinchu was seen as a prime target, with its two universities – the National Tsing Hua University and the National Chiao Tung University – being particularly strong in sciences, and thus ensuring that there would be no shortage of skilled workers. One additional factor, the fact that the Industrial Technology Research Institute (ITRI), an organization created to provide much needed technological support, had already been established in Hsinchu, made Hsinchu the obvious choice.

With the effective provision of manpower supply, and other incentive measures for land purchase and building construction having been created, the government formally established the HSIP in 1980. In the previous year, the Statute for the Science-based Industrial Park Establishment and Administration (1979) had been promulgated, providing, in Article 15, five-year tax holidays for companies establishing themselves within the park, along with exemptions from import duties, commodity taxes and business taxes for imported equipment, raw materials, parts and semi-finished products imported from abroad (Article 17), and a variety of other tax incentive measures.

The whole concept behind the establishment of the HSIP represented the creation by the government of a space where industry could group together, enabling manufacturers to reduce the costs of personnel training, buildings, land and other basic infrastructure, whilst also allowing them to enjoy the benefits of concentration in technology transmission (Mai, 1996; Mai and Peng, 1999). In addition, the tax incentives also clearly had the effect of encouraging manufacturers to invest within the park.

In their observations of the development of the HSIP, Wang et al (2002) divided the process of development into several stages, which included the joint venture stage (1980–1987), the dynamic growth stage (1988–1992), the stable development stage (1993–2000), and the innovative transformation stage (2001–present).

The HSIP was founded in 1980 to start its joint venture stage, as guided by government policy. Following its establishment, only 14 companies gained approval for their relocation into the industrial park between 1980 and 1987, with the total amount of investment at that time being NT\$1.24 billion. The mainstream development of the park at that time fell into the category of computers and peripherals, with only 4,090 of the employees within the park being technical personnel. During this stage, the main dynamic of the park's emerging technical development came from the government statute and the introduction of foreign technologies by the ITRI.

In the dynamic growth stage, which commenced in 1988, the Chinese Taipei Mask Corporation

started manufacturing optical masks, whilst in the same year, some companies also started engaging in IC testing. These companies laid the foundation for the semiconductor industry by establishing a prototype for the integration of all of the elements of Chinese Taipei's IC industry. In addition, the companies established strategic alliances with other countries, which led to IC becoming the leading industry in the park. As a result of the stable development stage, which has been taking place since 1993, the IC industry has become the number one industry in the park in terms of the number of companies, people employed, capital investment and sales revenue. At that time, the market began to pull money in, and the model of vertical disintegration was completed as this unique clustering effect helped Chinese Taipei's science-based technical industry to enter the global market. The vertical disintegration of the IC industry also became the norm in the development of Chinese Taipei's high-tech industry.

The development of the industrial park is closely related to the return of Chinese engineers from overseas. The increase in the number of overseas Chinese engineers returning to Chinese Taipei led not only to the technological development of the industrial park, but also to the rapid development of the economy as a whole.

Obtaining technologies from foreign economies has long been Chinese Taipei's major industrial development strategy. Many researchers have pointed out that technology licensing, venture capital and foreign investment have contributed to the development of local industry. In addition, many studies have asserted that returning engineers from the US (where they had received their higher education) had made significant contributions to the development of Hsinchu (Castells and Hall, 1994; Hobday, 1995; Mathews, 1997); however, these studies have largely assumed the US (Silicon Valley) to be the major export source of core technologies, whilst Hsinchu was seen as merely a peripheral area of industrialization since it was receiving the importation of foreign technologies in a passive way.

Although these studies have explained why Chinese Taipei was no longer a low-wage manufacturing base, they have not articulated the ways in which the new dynamics emerging from the interaction between Hsinchu and Silicon Valley have affected technological development in Chinese Taipei. Indeed, such interaction is moving towards a complementary and mutually beneficial relationship rather than a hierarchical and zero-sum relationship. These studies have therefore ignored the phenomenon of interactions with multinational corporations (MNCs) in the construction of various global economic systems. For this reason, we will explain international interaction from a perspective of technology connection, and from an alternative perspective of the introduction of skilled manpower.

Technology Connections

The most successful example of R&D clustering is indeed the technology cluster in Silicon Valley. The subsequent connections developed between Silicon Valley and the HSIP were built up by overseas engineers and specialists returning from Silicon Valley to Chinese Taipei, as these connections were based on personal networks via international strategic alliances wherein joint R&D is conducted between MNCs and Chinese Taipei's subcontractors. For example, Chinese Taipei Windows CE Alliance was an alliance that was targeted at expanding the share of the software market. Such cooperation not only accelerated the development of products with high value-added, but also reduced the obstacles to R&D through close ties with the major international firms. Such a scenario indicates that Chinese Taipei's high-tech firms were fairly aggressive in both their R&D and their competition for technology licenses, and it also indicates that Chinese Taipei's firms have developed a technological capacity that the international community has clearly recognized.

Introduction of Skilled Manpower

HSIP is supported by a strong research center in close proximity to the park. Two major universities, Tsing Hua and Chiao Tung, are located just outside the park, with both of these universities having traditionally placed significant emphasis on science and engineering disciplines. By 2003, the two universities had a combined student population of 20,268, along with 1,066 professors. Collaborative research projects are often conducted between universities and companies in the park; furthermore, the government-sponsored research institute, ITRI, is located only five kilometers away from the park. Employment within the park is naturally biased toward

skilled workers; by 2003, the park was employing a total of 98,685 workers, of which 46 percent were junior college graduates or above.

Before Chinese Taipei's own capacity for R&D was fully developed, aggressive recruitment of overseas engineers and specialists helped to bring in the advanced technologies and know-how. The introduction of these talented employees contributed to the development of Chinese Taipei's semiconductor and information industries for a number of reasons. Firstly, overseas Chinese workers have an impressive track record of service. As Tu (1995) noted, Chinese Taipei and the US established a special and close relationship way back in the 1950s, with this relationship incorporating material supply during the early stage, and thereafter, increasing numbers of returning overseas students. This relationship therefore provided Chinese Taipei with easy access to Western culture and language.

Secondly, Chinese Taipei developed itself into a depot for MNCs in the Asia-Pacific region by improving its relationships with Japan and Europe. Yang (1998) affirmed that there was a considerable correlation between the development of Chinese Taipei's electronic and information industry, and talented individuals educated in the US. The Chinese Taipei government has offered strong incentives to encourage overseas specialists to return to work in Chinese Taipei. On 31 December 2001, there were 4,292 overseas engineers and specialists working in the companies in HSIP, and 123 companies established by Chinese entrepreneurs returning from abroad.

Access to a Major and Growing Market

Since the 1980s, because of solid manufacturing ability, timely delivery, efficient management and reasonable cost, US firms such as IBM, Compaq, and HP subcontract their production to Chinese Taipei's computer manufacturing companies. As a result of such partnerships, Chinese Taipei's information technology started to take off, which certainly gave a great boost for the further development in HSIP. In the IC industry, Chinese Taipei's foundry firms serve as the manufacturing base for the US fabless IC design houses; the growing 'original equipment manufacturer' (OEM) demand for US IC design houses help build Chinese Taipei's world class foundry company-Chinese Taipei's Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Company (UMC). In the HSIP, the production value for the IC industry has accounted for 57 percent of Chinese Taipei's overall IC industry.

Entrepreneurship Encouragement

Owing to international technology transfer and the nurturing of manufacturing ability, HSIP's favorable environment created a swarm for entrepreneurship in the mid-1990s. In this period, technology personnel from IC, computer and its peripheral industry began to set up their own businesses. As of the end of year 2001, the start up companies owned by overseas Chinese has reached 723. The key to this entrepreneurship has been threefold. First, the Industrial Technology Research Institute (ITRI) transfers its research results, which results in the rising of the spin-off companies. As of year 2000, ITRI officially has spun off 31 companies (Wang and Hsu et al, 2002). Second, the demonstration effect instigates entrepreneurship. Since the mid-1990s, Chinese Taipei's IC manufacturing companies (TSMC, UMC), IC design houses (VIA, SIS) have performed beyond expectation; consequently, it encourages more people to start up their own venture, and entrepreneurship spreads. Third, the booming of venture capital also contributes greatly to start up business to raise funds in the early stage.

Overall Performance

As it can be seen from the level of employee productivity, measured by sales divided by the number of employees, per capita sales generated by employees within the park in 1992 were lower than in some other industrial areas, such as Taipei and Taoyuan Counties. However, the average per capita sales within the park grew from NT\$2.5 million in 1992, to NT\$ 5 million in 1995. The calculations shown in Table 1 provide a comparison between productivity in the HSIP and other major industrial areas based upon a national productivity perspective. From this comparison, per capita sales in the park's information and electronic industries in 1999 were 30 per cent above the national average. The result suggests that the information and electronic industries achieved more agglomeration benefits than the industries in Taipei and Taoyuan Counties.

Table 1 Sales Generated by Employees (employee productivity)

Unit: NT\$ millions

	Employee Productivity		
	1992	1995	1999
National average	2.43	3.82	5.07
HSIP	2.55	5.06	6.60

Source: Wang, et. al. (2002).

HSIP's Contribution to Economic Development

There is no doubt as to the important contribution made by HSIP to Chinese Taipei's economic development; indeed, the park has had a major impact, both in terms of stimulating development of the hi-tech industry and in earning foreign exchange from the growth of exports. In the period of 20 years after the establishment of the HSIP, the government had invested NT\$18 billion in 'software' and 'hardware' infrastructure at the park, turning it into the main center for Chinese Taipei's industrial development. Companies located within the HSIP spent, on average, 5.94 percent of their sales revenue on R&D in 2000, whilst the number of people employed at the park had increased from 8,275 in 1986, to 102,775 in 2000. Furthermore, total sales of companies located within the park increased from US\$450 million in 1986, to US\$29.80 billion in 2000 (see Table 2). Either investing in the establishment of a new company themselves, or engaging in production or R&D work on behalf of others, the large number of ethnic Chinese technical experts who have returned to Chinese Taipei to work within the HSIP have made a significant contribution towards raising the level of technology in the related industries.

Table 2 The Development of the Hsinchu Science-Based Industrial Park

Indicators	1986	2000
No. of companies established within the park	59	289
No. of persons employed within the park	8,275	102,775
Total paid-in capital of all companies located within the park	US\$151 million	US\$226 billion
Expenditure on R&D as percentage of business volume	5.4 per cent ^a	5.94 per cent ^b
Total business volume of all companies located within the park	US\$450 million	US\$29.80 billion
Total export value of all companies located within the park	US\$4.51 billion ^c	US\$15.98 billion ^d

Notes:

^a The data provided here are from 1990, when the park began reporting this data.^b The data provided here are 1999 data.^c The data provided here are from 1993, when the park began reporting this data.^d Accounting for approximately 9.1% of Chinese Taipei's total export value.

Source: Science-based Industrial Park Quarterly Statistical Report (consecutive issues).

Thus, one of the major contributions that the HSIP has made to Chinese Taipei's industrial development is the role that it has played in transferring overseas technology and encouraging technical specialists living overseas to return home (San and Wang, 1996). According to estimates by San (1999), over the period from 1980 to 1989, a total of 14,880 people who had been studying overseas returned to work in Chinese Taipei; this figure more than doubled, to around 30,238, over the period from 1990 to 1995, and these figures were equivalent to 44.4 percent and 56.5 percent of the respective number of all people obtaining Masters or Ph.D. degrees in Chinese Taipei during the same periods.

In a questionnaire survey of companies located within the HSIP, San (1999) discovered that amongst the main sources of technology for companies in the park, 'technology brought back by people who had studied abroad' was second in importance only to 'own research and development (R&D) work.' Clearly, the HSIP has been very effective in encouraging technical specialists working overseas to return home, and a considerable amount of technology has been

acquired as a result. So important has the park been to the development of Chinese Taipei's hi-tech industries, as it has become known as 'Chinese Taipei's Silicon Valley'.

The Future Development of the HSIP

The statute covering the development of the high-tech industry has been in place for many years, and given the rapid pace of development of the high-tech industry, this statute may well now be out of date. Consequently, the statute may now represent a hindrance to the continuing development of the new high-tech industries. At the same time, the ignorance of market principles allows businesses of lower performance (or those with no real competitive advantage) to remain within the HSIP, thus wasting these scarce land resources. Hence, both legislative and administrative obstructions need to be removed so that those truly qualified high-tech businesses can continue to develop in the park. In addition, the HSIP has begun to compete with similar parks in other developing countries, including the Multimedia Super Corridor in Malaysia, and the manufacturing-based technical cluster in Shanghai.

Chinese Taipei is currently facing a crossroads in its R&D and manufacturing. The decision on which role to stand by, between R&D and manufacturing, depends on how entrepreneurs in Chinese Taipei perceive their future. Since Chinese Taipei's high-tech clusters are under pressure to transform themselves, there will be a risk of them being substituted by the competing clusters in Shanghai if the wrong decisions are made. Thus the leading enterprises in the industry must take this problem seriously and consider how to turn this challenge into an opportunity to achieve another period of growth in technology in Chinese Taipei. These enterprises should also follow the role model set by Silicon Valley and aim to improve their own level of competitiveness in technological development.

As regards the outlook for the industry's comparative advantage, rather than expanding its manufacturing capacity, Chinese Taipei should work harder to develop R&D centers. It will also be necessary for Chinese Taipei to maintain its R&D in high value-added areas in order to create a complementary relationship with Shanghai for the sustainable development of the high-tech industry in Chinese Taipei. Secondly, Chinese Taipei should cooperate with Silicon Valley to make up for the lack of necessary technology required for use in the innovative R&D centers. This cooperation should also cover technology transfer and the establishment of cross-border R&D centers so as to make use of foreign technological resources in order to improve local technologies.

Chinese Taipei's high-tech companies have already transformed themselves from 'original equipment manufacturer' (OEM) subcontractors to 'original design manufacturers' (ODMs), and are now moving towards becoming 'original brand manufacturers' (OBMs). The high-tech businesses on the island should endeavor to enhance the vertical disintegration of R&D and manufacturing, whilst also seeking to develop core industrial competitiveness through complementary and cooperative disintegration between Silicon Valley and Shanghai.

2.3 Silicon Valley, the U.S.

Geographically, Silicon Valley is contained within a 30-mile by 10-mile strip of land between the cities of San Francisco and San Jose in Santa Clara County in Northern California. This economic region begins in the Northwest of the Valley in Palo Alto, where the bulk of theoretical and practical technological research in this field is carried out at Stanford University and the Stanford University Research Park.

A combination of regional advantages and historical accidents conspired to produce the greatest 'science park' in the world, and observers have identified a number of regional advantages for the valley, including world-class academic institutions (Stanford University and the University of California at Berkeley), brilliant scientists, military procurement of semiconductors, and the pleasant climate of Northern California (Rogers and Larson, 1994).

Several factors have been attributed to the success of the valley, the first of which is the influence of nearby higher education institutions, particularly Stanford University. In the 1920s, Stanford

recruited highly respected faculty members from the East Coast of the US, including such important recruits as Fred Terman, David Hewlett and William Packard, who became the pioneers for innovation and commercialization of innovative products. In 1950, Hewlett-Packard (HP) sold 70 different products, achieving sales in excess of US\$2 million and rapidly expanded to a 200-employee company, and the formation of HP's distinctive Silicon Valley management style soon encouraged numerous enterprises to follow. In 1954, HP rented part of Stanford Research Park for its operations, which then led to the formation of the cluster of industries in Palo Alto.

Secondly, the government also played a major role in the prosperity of Silicon Valley. The relocation to California of the military contractor, Lockheed, in the mid-1950s brought federal defense dollars to the area, whilst public procurement from defense agencies also hastened the growth of the semiconductor industry.

Thirdly, the flexible environment, informal means of information exchange and the high level of labor mobility also promoted collective learning and flexible adjustment between companies that subsequently encouraged further entrepreneurship and experimentation (Saxenian, 1994).

The Contribution of Silicon Valley to the US Economy

The driving force behind the economy in the valley is technology, and more specifically, specialized clusters of technology firms and talented individuals. Almost 40 percent of Silicon Valley's workforce is employed in technology-related industries, and many more jobs are tied to the support of these industries. These clusters are dynamic, constantly innovating and changing. They draw strength from the valley's business environment, its tangible assets, such as world-class universities, extensive supplier networks and specialized professional services, as well as from intangible qualities such as competitive spirit and the willingness to take risks.

In the 1990s, Silicon Valley's economy has been shifting from a high-tech manufacturing economy to a knowledge-based economy. This economy is now moving towards higher value and greater service-oriented activities. The valley's competitive advantage comes from the productive and creative use of human inputs, from value rather than from volume.

After more than 50 years of continuing progress, Silicon Valley has made a significant contribution to the long-term economic development of the US, with a number of indices demonstrating its importance. First of all, the value added per employee in the valley (a measure of productivity), increased by 4.6 percent in 2001 to US\$170,000, as compared to the national figure of US\$56,000. Secondly, although the valley is home to less than 1 percent of the US population, its latest annual patent awards came to more than 6,800, 8 percent of all the patents awarded to US residents.

2.4 Penang and the Kelang Valley, Malaysia

Background

The industrial clusters in Penang and the Kelang Valley in Malaysia have enjoyed strong MNC operations in electronics manufacturing since the early 1970s, indeed, foreign-owned corporations accounted for 83 percent of all fixed assets in the electronics industry in Malaysia in 1998. Comparing these two Malaysian electronics clusters, and drawing on Rasiah (2002), this paper underlines the human capital and network cohesion that exists between the domestic and foreign firms within these clusters, and the coordination between government and businesses as the critical conditions for such industrial clustering.

Both regions enjoy advanced levels of basic infrastructure and educational institutions. Over the period from 1970 to 1990, the high unemployment rates of around 6.0 percent to 8.1 percent ensured that MNCs engaged in labor-intensive assembly began relocating to this economy. Political stability, financial incentives and controls on unionization ensured that Malaysia was one of the more attractive sites. However the exhaustion of labor reserves in the 1990s resulted in a significant shift in the demand structure for human capital in Malaysia's manufacturing sector. The resultant labor shortages, rising wages and the emergence of other low production cost sites, such as mainland China, Thailand and the Philippines, along with their improvements in basic

infrastructure and political stability, began to challenge the ability of Penang and the Kelang Valley to sustain their operations.

The labor shortage problems of the 1990s led to a shift in the government's industrial strategies from a focus on employment generation to industrial deepening, clustering and the upgrading of industry to higher value-added activities. These new policies included the 'Action Plan for Industrial Technology Development' in 1990, and the 'Second Industrial Master Plan,' which set out the guidelines for the proposed transformation in 1995.

Alongside the Federal Ministry of Education, which governs formal education institutions, including general, vocational and technical education, the Human Resource Development Council Fund, which was established in 1993, required manufacturing firms with 20 or more employees to contribute 1 percent of their payroll to the council, which the firm could then reclaim by submitting bills from approved training establishments. In order to complement the domestic human resource capabilities, the government initiated exemptions for IT firms in the Multimedia Super Corridor (MSC) starting from 1997, to support the importation of technical and professional human capital from abroad.

Despite the intense emphasis on the development of infrastructure, the supply of high-tech human capital has consistently lagged behind the growing demand, and as a result, there has been a severe widening of the gap between the supply and demand of human capital, and a constant structural mismatch caused by coordination problems within the two clusters. Both Penang and the Kelang Valley have therefore failed to establish a sufficient supply of high-tech human capital, largely as a result of the problems of poor coordination of supply and demand. Although allowing immigration of professionals possessing high-tech human capital may be the only answer to overcoming this growing deficit, the main barriers to accessing such high-tech talent are the existing conservative immigration policies.

Penang

Penang's manufacturing sector accounted for 13 percent of the economy's GDP in 1971, a figure that subsequently rose to 46 percent by 2000. The electronics industry in Penang employed over 90,000 workers in 1995, with the outstanding economic performance of this particular cluster being attributed to the important contribution of the MNCs. The essential intermediary role of the Penang Development Corporation (PDC) was established in 1969 with the aim of placing considerable effort into attracting export-oriented MNCs into the manufacturing sector. Integrated business networks, with the PDC fuelling their cohesion, have helped in the dissemination of knowledge embodied in human capital for the creation of new firms, differentiation, and the division of labor. The development of the MNCs has driven strong supplier networks, whilst institutional coordination aimed at supporting their growth has increased the localization of inputs by MNCs.

From a perspective of a global production network, Penang has successfully drawn industry 'species' from other locations. Specific capabilities, in terms of specialization, have helped the region to sustain its level of growth, and have provided the mechanisms for accelerating inter-firm links. Industry 'sub-species' have also evolved domestically in Penang to stimulate further differentiation and diversity. The development of several tiers of firms has enabled workforces to further expand their development of knowledge and its dissemination within the Penang cluster. Within such clusters, there are often a number of MNCs that tend to play the vital role of a training ground for the hiring and nurturing of entrepreneurs; this has thus stepped up the creation of new firms, and has led to a more flexible industrial system within the region. In contrast to the Kelang Valley, Penang was able to develop sufficient network cohesion and institutional coordination to support the need for flexibility and interface between its domestic firms and the MNCs. Strong inter-firm relations and systemic coordination effects have thereby generated and expanded this industrial clustering whilst also appropriating considerable economic synergies.

Kelang Valley

Barely trailing the accomplishments in Penang, the electronics industry in the Kelang Valley was employing almost 85,000 people in 1995, and in fact, the Kelang Valley was better endowed than Penang when the first major influx of electronics MNCs relocated to Malaysia in the early 1970s.

As a result, it was quickly able to set up its high-volume production capacities in consumer electronics, semiconductors and picture tubes. However, the lack of an intermediate agency, such as the PDC in Penang, weakened the network and inter-firm cohesion in this cluster, despite the fact that it already enjoyed a concentration of manufacturing firms. This resulted in the development of comparatively less knowledge spillover, and the lack of real stimulation of inter-firm links and new firm creation.

Generally speaking, many of the parts and components produced by industries within this cluster, particularly those for the electronics industry, have been produced as elements within global production networks coordinated by the parent MNCs. A number of high value-added components, such as TFT LCD display screens, are imported from their subsidiaries or suppliers located in their home bases. Parts of the foreign MNCs act as anchors, offering markets and technological support for both foreign and local firms; however, most local suppliers are still limited to low value-added non-core activities, hence the key technologies and high value-added components are mainly imported from MNCs' other expatriate subsidiaries, or from their home countries, such as the US, Japan and Chinese Taipei.

As a result of their poor network cohesion with domestic firms, MNCs in the Kelang Valley not only source from abroad, but also internalize the production of upstream activities, demonstrating that the more popular form of division of labor is intra-firm rather than inter-firm. The competitiveness of local firms is largely undermined by their costly and poor quality supplies, which results in MNCs building up very few industrial linkages within the domestic economy; indeed, foreign firms will generally tend to source most of their supplies from their home bases. We can therefore expect that the weakness of the vertical division of labor between MNCs and local suppliers in the Kelang Valley has also led to limited knowledge spillover.

In addition to infrastructure and national policies, human capital, in particular, abundant skilled labor and entrepreneurship, which are the international linkages that are embodied in MNCs, become even more important in driving the formation of industrial clusters, especially in this era of the globalization of production. Some successful industrial clusters have managed to overcome the problem of local supply capabilities falling behind the existing demand by absorbing those foreigners who have working permits.

In the past, when the immigration of foreign professional workers were restricted, Penang relied on the network cohesion derived by the PDC, the intermediate agency, to improve systemic coordination, and that the relative ease of firm entry and exit encouraged entrepreneurship. The presence of such systematic coordination also helped to develop the inter-firm dissemination of tacit and experiential knowledge in Penang, much more so than in the Kelang Valley. As noted by Rasiah (2001), the quality of government vis-à-vis business coordination in Penang means that even small machine tool firms in Penang perform much better than those in the Kelang Valley. Today, the restrictions on the movement of professionals have been largely relaxed, and both Penang and Kelang Valley have seen new vitality in the high-tech industries.

2.5 Hamamatsu, Japan

Hamamatsu, which comprises of a cluster of machinery and musical instrument industries, is located to the South of Tokyo, with famous companies within the cluster including Honda, Suzuki, Yamaha and Kawai. The most notable feature of Hamamatsu has been the smooth transition of its traditional industries to modern practices. Once a centre for the production of textile machinery (prior to the Second World War) Hamamatsu successfully transformed itself into the post-war manufacturing centre for motorcycles and musical instruments, and today, it is still one of the most important manufacturing centers in Japan for machine tools and musical instruments.

As a home base for Suzuki Motor, which has evolved from a producer of motorcycles into an automobile manufacturer, Hamamatsu provides virtually all the parts needed for auto manufacturing. Suzuki's major parts suppliers are located within a 15km radius of its Hamamatsu plant, thus allowing face-to-face communications at all times. Such proximity and close contact with suppliers reduces transaction costs and facilitates the effective coordination of production.

Supporting these parts, suppliers are a network of companies specializing in metal molding, precision instruments, computer-aided design, computer software, and so on; this supporting industry underscores the strength of the Hamamatsu cluster.

Hamamatsu also boasts a large number of angel and venture capitalists (VCs); indeed, there is no shortage of investors for those who can manage to come up with a novel product. Many experienced entrepreneurs turned themselves into VC managers, providing advice to young entrepreneurs seeking to start up their own companies. It is estimated that Hamamatsu is the most concentrated area of VC companies in Japan (Takeuchi, 2002:37) and these VCs are well connected to local financial institutions which provide them with the necessary refinancing, whilst local financial institutions are also accustomed to collaborating with such VC operations.

The development of Hamamatsu into an industrial cluster has a long history. Hamamatsu has been an important manufacturing centre since Japan first started out on its path towards industrialization in the 19th century, and since its inception as a manufacturing centre, the area has been characterized by stiff competition within the same industry. Product variety is the key feature of this competition, with the less efficient companies being eliminated and thus allowing the small number of surviving firms to dominate the regional market, the Japanese market, and even the global market. In the heyday of the motorcycle industry, for example, which only emerged after the Second World War, there were at least 30 brands competing with one another. In the end, only Suzuki, Honda and Yamaha survived, and even today, these are still the three major motorcycle producers in Japan, which also dominates the motorcycle market on a global scale. The only major Japanese motorcycle producer outside of Hamamatsu city is Kawasaki, which is located to the north of Hamamatsu.

In the case of musical instruments, the rivalry between Yamaha and Kawai is also notable, with both aspiring to become the world's leading brand. Competition drives innovation and forces competitors to mobilize their upstream suppliers and downstream service providers to engage in closer collaboration. Collaboration takes place not only in the area of production, but also in the area of R&D, with the co-design of products allowing collaborators to exchange information and to share knowledge.

Rivalry exists not only within the market, but it is in fact also noticeable within the community. The employees of the large companies stride along the middle of the street, whilst those of small companies tend to walk along the side of the road. Rivalry between schoolmates and neighbors also extends to the competition between companies, with such rivalry having inspired new innovations and the start up of new enterprises.

Hamamatsu is renowned for its ability to continuously produce new industries to replace older ones; as already noted, motorcycle manufacturers such as Honda and Suzuki have successfully transformed themselves into auto manufacturers, whilst musical instrument makers, Yamaha and Kawai, have evolved from the production of organs and pianos to manufacturers of electronic musical devices. Furthermore, the more traditional machinery industry has been on the decline in recent years, but the photo electronic industry has emerged as a new industrial force to replace it.

2.6 Summary

Within this chapter, the sustainability of a cluster has been the most important policy issue to be explored. Such sustainability implies that naturally endowed factors are not the key element for a successful cluster because the region's comparative advantage will shift over time and the price of naturally endowed factors will usually be bid up by the growth of the industry. Indeed, if naturally endowed factors were to be the key to competitiveness, the success of the cluster would become its own enemy. Therefore, comparative advantage must be created through assets such as skilled labor or institutions that are capable of keeping the cluster going. Companies in Hamamatsu are noted for their ability to jump industries; for example, between 1991 and 1994, 1.1 percent of enterprises in the region switched from one industry to another, the highest proportion amongst all major industrial cities in Japan (Takeuchi, 2002:34). Many manufacturers of musical instruments

diversified into electronic machinery, with such industrial switching being considered a second time start-up of a new business by existing companies.

The core strength underpinning the evolution of industry in Hamamatsu is its embedded manufacturing capability, a capability that is particularly evident in the vehicle manufacturing industry. From motorcycles to automobiles, Japan's major manufacturers were all born in Hamamatsu, with the subcontracting system comprising of parts suppliers, assemblers of semi-finished goods and machine tool providers, forming a strong network jointly responsible for complete vehicle production; indeed, the vehicle industry is underpinned by a strong and comprehensive machinery industry which was, in turn, initially cultivated by the textiles industry. The machinery industry is itself also underpinned by a strong casting and precision measurement industry.

The experience of Hamamatsu points conclusively to the key roles played by specialized suppliers, whilst the presence of an effective venture capital community, which was conducive to business start-ups, also helped with the transformation of industry. It is also very noticeable that the companies in the Hamamatsu cluster are globally connected, with their products being strongly oriented towards the international market.

Finally, we summarized the features of the above four industrial clusters to compare their similarity and differences. Their features may provide some policy intuition for government as well as firms. As noted in Chapter 1, there are several advantages for firms in the formation of an industrial cluster. First of all, it can provide complementary resources such as technology and information exchange, management assistance, and so on, to enhance the performance of firms within the cluster. Secondly, it strengthens competition and thus promotes the technical efficiency of firms; since these firms are located in very close proximity, fierce competition for both clients and suppliers is unavoidable. However, competition also pushes up efficiency. Thirdly, firms can quickly respond to the demands of the market or to changes in technology; firms within the cluster can reorganize their OEM contractors much more quickly than those outside of the cluster, thus, the ability to leverage resources to adapt to the market and to fluctuations in technology has been a major benefit for firms located within the cluster.

Rapid cross-border dispersion is also a feature of industrial clusters, with the cluster-based economy and the future path of cluster development continuing to be of significant importance. Such dispersion will also be applicable in the traditional industries such as the textiles industry, but only if dispersion is not restricted to lower-end products.

The need for systems integration also emerges, particularly the ability to combine local connections with geographical differences. A significant example of this kind of evolution is the global production network (GPN), an important inspiration for the future development of industrial clusters. International connections are thus essential with regard to the sustained growth of industrial clusters. Furthermore, not only can these connections revitalize the local connections, but they can also provide the local clusters with opportunities to obtain international knowledge. Silicon Valley is a classic example of this kind of development of infinite upgrading capacity and power.

In terms of the dispersion of international knowledge, the GPN also represents a virtuous circle, for a number of reasons. Firstly, it extends the value chain of a company and fosters greater business opportunities for professional suppliers of small and medium size. Secondly, as suppliers continue to upgrade their capacity, this places additional pressure upon the clusters, in terms of the need for the continuous introduction of knowledge intensive and high value-added supporting activities. Thirdly, the participation of small and medium enterprises (SMEs) in the GPN helps them to obtain knowledge and to overcome the obstacles traditionally involved in this process. A well-known example is Chinese Taipei's computer manufacturers.

The advantages of the GPN cannot rely solely upon market power because there is still a need for government support and policies. The Scandinavian countries, the Netherlands, Chinese Taipei, Singapore and South Korea all provide notable examples of governments providing strong support to their domestic industries as a means of achieving rapid economic development.

From an examination of the experiences of cluster development in Malaysia, there was clearly an imbalance in the demand and supply of research students, scientific researchers and engineers; however, it was also unlikely that industry would be able to increase the inflow of scientific talent from overseas, largely because of the economy's very restrictive immigration policies. The inadequate scientific manpower makes it impossible for Malaysia to attract large numbers of high-tech companies to move into Penang and the Kelang Valley; however, the tacit and experiential knowledge attached to human resources in Penang still differs from that in the Kelang Valley.

The Penang Development Corporation (PDC) created the Penang Skills Development Centre (PSDC) as a means of helping vendors to solve their personnel and training problems. The open networks between the companies also reinforced the available interface for adjusting demand and supply in the production lines. These networks then turned some companies' technological limits into other companies' business opportunities, which in turn, strengthened the differentiation and professional labor disintegration in the production system, bringing in human resources with experience and knowledge. This also succeeded in improving the dynamics and diversification of industries in Penang.

In contrast to the industrial development in Penang, there was a lack of connections and networks between the cross-national electronic companies in the Kelang Valley, although these companies were characterized by world-class production and operation methods. The other disadvantage was that the supporting authorities in the local government did not fulfill the role of communicator between the companies. Clearly the industrial operation in the Kelang Valley lacks differentiation and well-defined labor distribution.

3. CLUSTER AND LABOR FORCE DYNAMICS: THE CASE OF HSINCHU SCIENCE-BASED INDUSTRIAL PARK (HSIP)

3.1 Introduction

Literature related to analysis of labor market of industrial clustering is relatively sparse, although the effect of labor pooling on agglomeration has been highlighted since Marshall's earlier study (Marshall, 1890). A recent study by Rosenthal and Strange (2001), using data on the US manufacturing industry, also found that labor market pooling has the most robust effect on influencing agglomeration at all levels of geography in the United States. However, it specifically refers to the pooling effects of skilled labor on agglomeration. As our introduction indicated as well, skilled labor is one of the most critical ingredients to start an industrial cluster and even maintain its competitive advantage, sources of skilled labor force, incentives/channels/mechanisms or even milieus to attract skilled labor force and their contribution to innovative activities become critically important for an initiation and sustainability for a cluster. Therefore, studies on labor market or labor force of industrial cluster tend to focus on these aspects.

Among this literature, empirical studies on latecomers or new clusters in the world economy tend to emphasize the contribution of exogenous sources of the highly skilled on cluster formation, and effects of this labor force on technology spillover in that particular cluster. For example, the reverse brain drain and overseas Chinese connections have been identified as playing a significant contribution to Chinese Taipei's high-tech industrialization and the success of the Hsinchu Science-Based Industrial Park (HSIP) (Mathews, 1997; Hsu, 1997; San and Su, 2002; Tsai and Tai, 2001; Saxenian and Hsu, 2000; Hsu and Saxenian, 2000; Pack, 2001).

Although the upgrading of the domestic labor force quality and their ability to generate new knowledge have been recognized (Pack, 2001), the contributions of the domestic labor force remains neglected in studying the competitiveness of late coming high-tech clusters, such as the Hsinchu region in Chinese Taipei. In short, the literature that particularly bridges the human resources and industrial cluster focuses too much on the exogenous infuses of the high-skilled

labor force to the formation and even the success of an industrial cluster. It is quite surprising that the structure of labor markets and its dynamics draw little attention in the current literature.

Some literature did notice the lack of labor-market analysis and tried to call attention on this aspect to study the high-tech agglomeration (Malecki, 1989; Angel, 1989; Angel, 1991). Literature focusing on this line is interested in studying how the labor market has successfully facilitated the flexible production system for a certain industrial district of the post-Fordism regime. For example, Angel's study focused on examining the local labor-market dynamics and their relation to the organization of production systems in Silicon Valley (Angel, 1991). In addition, there are studies examining the effects of a clustered high-skilled labor force and its fluid nature on labor market, allowing the high-intensity of internal mobility within the technical community, especially job-hopping. It generates prominent effects on enhancing the quick diffusion and learning of technology and, consequently on consolidating the stickiness of a particular cluster. These studies are mostly using Silicon Valley as a prototype of industrial cluster, which cannot represent the diversities of industrial bases and differential paths of development for different industrial clusters all over the world.

The HSIP has been undergoing different stages of development since its establishment in 1980 and has maintained a dramatic growth during the 1990s. In addition to the contribution of overseas returnees, the domestic high-tech labor force has been playing a far more significant role in creating the second Chinese Taipei miracle, namely the high-tech development in the world market, at the expansion stage for the HSIP's development. It is critical to understand how the domestic technical community contributes to sustain the HSIP's global competitiveness. It will demonstrate significant policy implications for other industrial clusters in achieving their relative autonomy and self-sustainability in a highly competitive and spatially linked global market. Nevertheless, this issue has been greatly neglected by literature on industrial clustering.

The purpose of this chapter is to provide a descriptive analysis and discussion about the changes of labor force structure and quality in the HSIP along with its developmental path. We include this topic as part of the project and aim at providing a historically dynamic picture in order to understand the internal development of a high-tech cluster in this highly globally connected market based on analysis of labor force structure. Hopefully it will generate more deliberative ideas in sharing development experiences among APEC members either at different stages or on different tracts of high-tech development. This Chapter focuses mainly on analyzing the structure of the HSIP's labor force and its changes by different developmental stages based on aggregate data. It also looks at how the sources and composition of human resources has been changed through time and among different industries in the HSIP. It indirectly reflects that there are differential roles for the returnee and domestic high-tech labor force in different industries and at different stages of development.

3.2 Structure of the HSIP's Labor Force

Because HSIP in Chinese Taipei has its distinctive nature of high-technology industrialization, high-skill and young labor forces are the major compositions of its human resources (Table 3). At the end of 2002, there were 98,616 employees in total, not including foreign labor. Employees who hold a Ph.D. or a master degree account for around one fifth of the total labor force. Two thirds of the labor force hold higher than college degrees. The quality of the labor force in general is significantly higher than those in other regions in Chinese Taipei that provide labor force with high educational levels (Table 4). This high-tech cluster also attracts a concentration of relatively young labor force with average age of only 32 years. Eighty-seven percent of employees are in the age category of 20 to 40 year's old.

Table 3 Educational levels and age structure of employees in the HSIP, 2002

Education	Items	Total	Ph.D.	Master	Bachelor	Junior college	High school	Others
	Employees	98,616	1,210	17,967	21,690	24,433	27,202	6,114
	Percentage	100.00	1.23	18.22	21.99	24.78	27.58	6.20
Average age: 32.01								
Age	Items	Total	14-19	20-29	30-39	40-49	50-59	Others
	Males	48,750	361	16,103	25,436	5,749	970	131
	Females	49,866	994	27,177	17,076	4,115	480	24
	Total	98,616	1,355	43,280	42,512	9,864	1,450	155
	Percentage	100.00	1.37	43.88	43.10	10.00	1.47	0.18
Industry	Items	Total	Integrated circuits	Computers & peripherals	Telecommunications	Opto-electronics	Precision machinery	Bio-technology
	Total	98,616	60390	12,813	6,869	16,939	893	712
	Percentage	100.00	61.2	13.0	7.0	17.2	0.9	0.7

Source: *The Hsinchu Science-based Industrial Park Quarterly Statistical report, 2002/12* (The Hsinchu Science-based Industrial Park Administration).

Table 4 Educational levels in percentage for total labor forces in selective regions of Chinese Taipei, 2002

Regions	Ph.D. & Master	Bachelor	Junior college	High school	Others
The HSIP	19.45	21.99	24.78	27.58	6.20
Taipei City	4.08	20.11	15.31	28.86	31.64
Hsinchu City	4.80	15.42	13.42	29.62	36.74
Hsinchu County	1.77	9.33	12.56	32.95	43.39
Taichung City	2.55	15.17	16.44	34.11	31.73
Kaoshiung City	2.21	13.28	14.86	34.07	35.58
Chinese Taipei	1.48	9.76	12.05	31.97	44.74

Source: *Urban and Regional Development Statistics, 2002* (Urban and Housing Development Department, Council for economic Planning Development.)

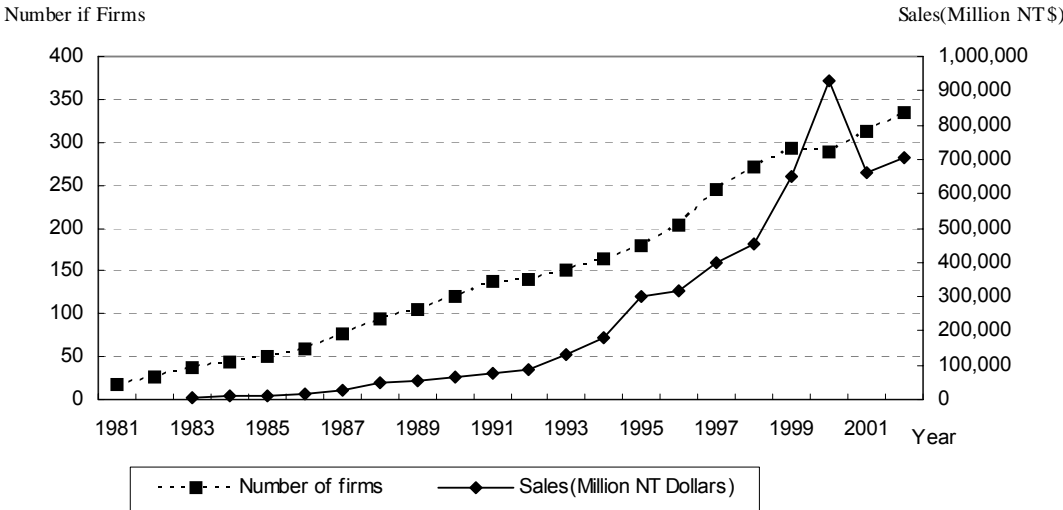
Looking at the distribution of the labor force by industry, we find that more than a half of all employees are hired by the sector of integrated circuits. In addition to this, leading industry opto-electronics, and computers & peripherals are the other two industries using a higher percentage of the labor force, followed by the telecommunication industry. Employees in the precision machinery and biotechnology industry represent less than 1000 persons. Although the distribution of labor force by industry provides a means to examine the industrial structure of the HSIP, it does not necessarily show their relative contribution to the competitiveness and sustainability of the cluster. We will come back to this point in the later part of this chapter.

3.3 Dynamics of the HSIP's Development

Although the HSIP has been admired as the "Eastern Silicon Valley" and contributed to a great extent for the "Second Chinese Taipei's Industrial Miracle" in terms of overall sales, it is now facing another stage of development. For the past few years, we have seen a significant number of high-tech firms based in the HSIP accelerating their investment in China. Along with the rapid growth of the Chinese economy, a new map for the global linkages of high-tech clusters is emerging. This new trend of high-tech division of labor definitely has great influence on the future development of HSIP. If we look at the past development of the HSIP, we also find that its growth rate has been moderated since the year 2000, which is not surprising for most industrial clusters after the expansion stage. The competitiveness of a high-tech cluster is rooted in its capabilities of innovation.

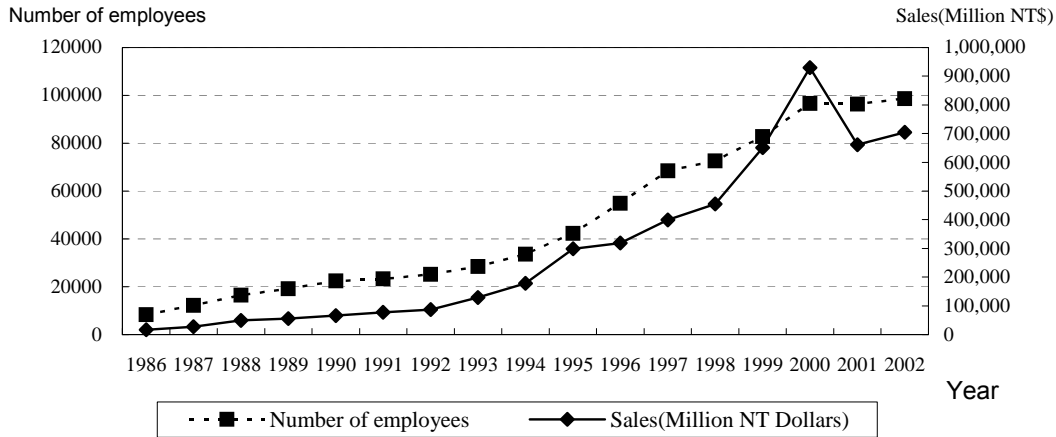
In any rate, the HSIP provides an important lifeline for Chinese Taipei's industrial base. Its overall sales in 2002 were 705,453 million NT dollars, which accounted for 35.28% of Chinese Taipei's total manufacturing output. For the past 20 years, it has been undergoing different stages of development. If we ignore the abnormal ascent of overall sales for years 1999 and 2001 to smooth the curve (Figure 1 and Figure 2), we can divide the development of the HSIP into three stages differentiated at 1987/88 and 1993/94 with references to Lou and Wang (2002) and Chen (2003). Lou and Wang (2002) divided the development of the HSIP into three periods based on the growth curve of sale value, which are starting period (1981-87), growing period (1987-1993) and transferring period (after 1993). It is coincident with developmental stages based on trajectories of technology learning/development for integrated circuit industry in Chen's study (2003), namely preparation (before 1974), technology import (1975-79), technology absorption and diffusion I (1979-82), technology absorption and diffusion II (1983-1988), technology deepening (1989-94), technology widening (1995-2000) and after 2000. This accordance is owing to the fact that the industry of integrated circuit has contributed the largest share of the overall sales in the HSIP since the mid 1980s. Comparing Figure 3 and Figure 4, the trend in growth of employees is more synchronized with the growth of the overall sales than the firms to overall sales.

Figure 1 Growth of firms and annual sales for the HSIP, 1981-2002



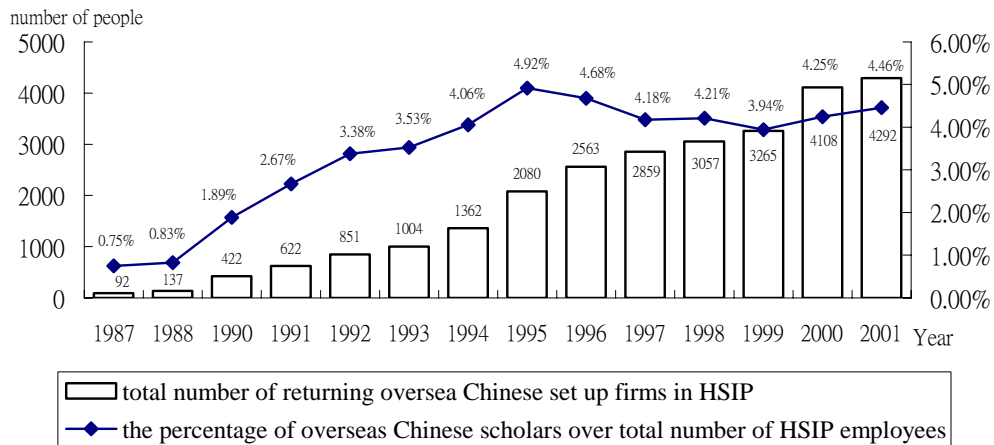
Source: *The Hsinchu Science-based Industrial Park Annual Statistical Report (The Hsinchu Science-based Industrial Park Administration)*.

Figure 2 Growth of employees and annual sales for the HSIP, 1981-2002



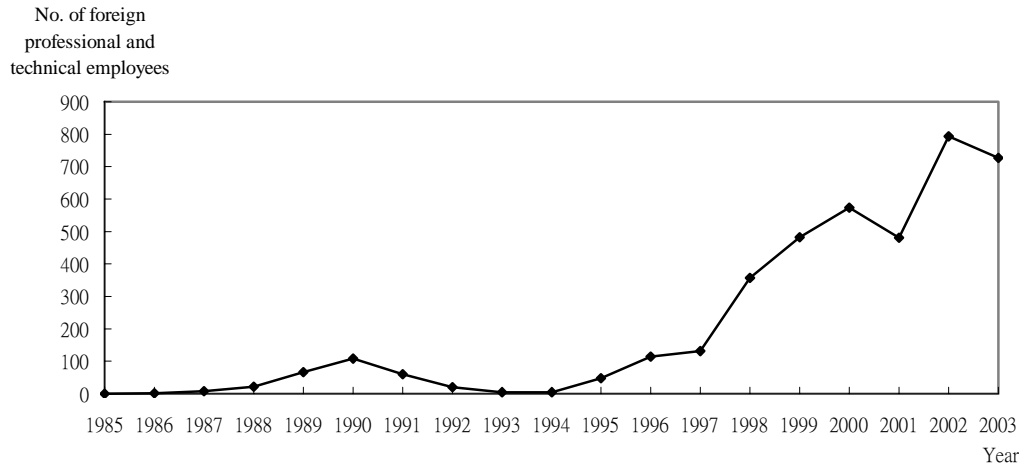
Source: *The Hsinchu Science-based Industrial Park Annual Statistical Report (The Hsinchu Science-based Industrial Park Administration).*

Figure 3 The trend of overseas Chinese returnees to work in HSIP



Source: *Wang, et. al. (2002), pp.2-16.*

Figure 4 Foreign professional and technical employees in the HSIP, 1985-2003



Source: *The Hsinchu Science-based Industrial Parks Administration*

3.4 Effects of Overseas Returnees on Human Resources of the HSIP

If a high-skilled labor force is one of the most critical factors for the formation of a high-tech cluster, then successfully attracting overseas Chinese back to Chinese Taipei was admired as one of the deliberative policies by the government of Chinese Taipei to achieve the successful development of high-tech industry and the HSIP (Mathews, 1997; Lin, 1997). Many studies have well documented the contribution of the overseas returnees to the success of the HSIP (Luo and Wang, 2002; San, 2002; Tsai and Tai, 2001; Hsu, 1997; Xue, 1997). Some emphasized especially their contribution to technology transfer and diffusion. Others highlighted the social capital, such as entrepreneurship and ethnic ties that enrich the entrepreneur milieu of the HSIP and intensify the spatial linkages between Hsinchu and Silicon Valley through ethnic ties.

Generally speaking, the effects of overseas returnees on the technology transfer and diffusion have been identified as the most critical factor for their contribution to the late coming high-tech cluster, such as the HSIP since the very beginning. However, their composition in overall human resources and their contribution needs to be examined and clarified in more detail for several reasons.

One is due to limited supply of Chinese high-tech human resources abroad, especially from the United States. Although the number of students going abroad to obtain degrees and then returning have both kept increasing for the past three decades, for those returning to Chinese Taipei the proportion of natural science degree holders has been dropping significantly from 56.4 percent in the 1970s, to 40.7 percent in the 1980s and 35.9 percent in the 1990's (Tsai and Tai, 2001). Besides, we find that a fair amount of Chinese engineers now in Silicon Valley are from China rather than from Chinese Taipei. Another reason is the competition of high-tech human resources among different industrial clusters. With rapid emergence and growth of the Chinese Economy, Hsinchu is facing severe competition from Shanghai for high-tech human resources with Chinese ties. In short, reliance on overseas returnees for technology transfer and diffusion may have its limitation due to competition in supply.

From Figure 3, we find that the total number of returnees who went back to set up firms in the HSIP have kept increasing for the past two decades, from 92 in 1987 to 4,292 persons in 2001. In 1995, the number had significantly jumped from 1,362 in 1994 to 2,080 in 1995. Nevertheless, the proportion of overseas returnees to total employees started to decrease since then and has remained in the range between 4.92 percent and 3.94 percent. If reliance on the external influx of technology via human capital, i.e. focused on discussing the human embodied technology, is

inevitably the nature for late coming high-tech clusters, then we find that foreign professional and technical employees have kept increasing steadily and significantly since 1995 as well. The high skilled human resources are not only from technology-advanced countries, but also from neighboring developing countries. Both indicate that there have been some significant changes in the HSIP in terms of human resources after the year 1995, at the stage of expansion or technology widening.

In fact, San's recent study (2001) demonstrates that contributions of overseas Chinese varied in different job types and industries, which will provide us with a clearer picture. Generally speaking, overseas returnees have the greatest contribution to make on product development and modification, and have less contribution in product sales and different types of management. In the job type of product development and modification, their importance has been highly recognized by industries of integrated circuits and biotechnology industry, followed by precision machinery, telecommunication, and computer and peripherals. Besides, San's study demonstrates that firm characteristics, such as technology intensity, R&D input and situation in market competition, all will influence a firm's tendency of hiring overseas returnees. A firm with higher technology intensity tends to hire more overseas returnees. On the contrary, a firm that has more R&D input tends to hire less overseas returnees. Finally, a firm in a more competitive market and a more mature industry hires a smaller number of overseas returnees.

Table 5 Nationality of foreign professional and technical employees in the HSIP, 2003/10

Nationality	US	Japan	Malaysia	Korea	Philippine	Singapore	India	UK	Germany	Canada	France	Russia	Others
Total	199	122	87	60	39	37	30	29	16	16	15	13	64

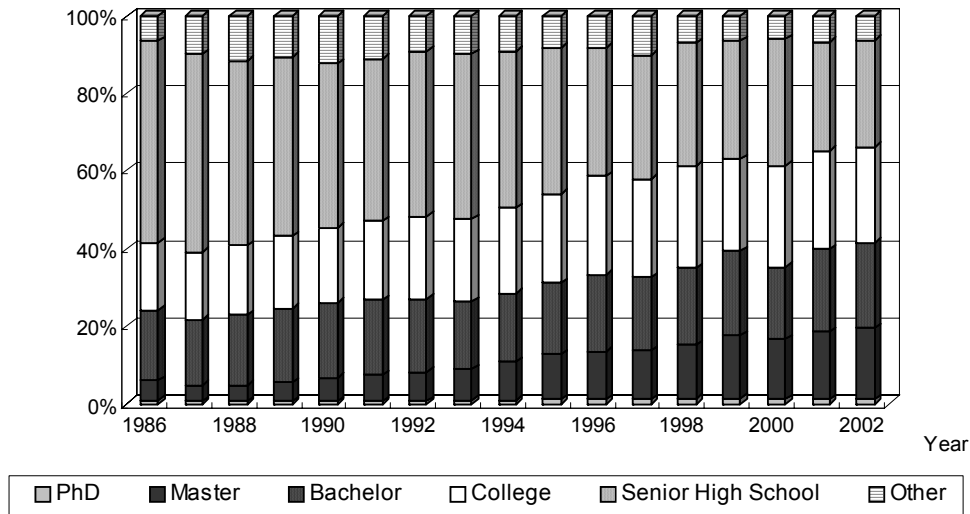
Note: nationality listed out, if more than 10 persons

Source: The Hsinchu Science-based Industrial Parks Administration

In brief, the contribution of overseas returnees to the development of the HSIP has been highly recognized since the early 1980s. The total number of returnees has kept increasing along with the growth of the HSIP. However, their proportion in terms of the total labor force has begun to stabilize, and even drop since 1995. Their contribution is mainly in technology transfers and diffusions, or more specifically in product development and modifications. Their employment and contribution varies among industries in the HSIP. As a result, the domestic labor force has been playing a far more important role in the success and future sustainability of the HSIP, which has not been fully documented by the literature. It is necessary to understand the contribution of the domestic labor force, in order to understand the differences in structure of labor force among industries.

3.5 Contribution of Domestic Labor Force

Figure 5 Structure of labor forces by education in the HSIP, 1986-2002



Source: *The Hsinchu Science-based Industrial Park Annual Statistical Report* (The Hsinchu Science-based Industrial Park Administration).

As indicated earlier, the HSIP has attracted the most intelligent manpower in Chinese Taipei (Table 4). If looking at human resources in the HSIP by educational level, we find that proportions of master degree and junior college degree holders have kept increasing since the mid 1980s and the proportions of senior high school graduates and others decreasing significantly (Figure 5). It is very clear that a labor force with lower educational levels, especially the high school degree holder, has been upgraded and replaced by junior college employees. In addition, employees with a master degree have become more significant as the backbone of the R&D labor force in the HSIP (Table 6). To examine the composition of the current labor force in the HSIP, we find that there are nearly equal proportions of employees with foreign and domestic Ph.D. degrees. Nevertheless, domestic masters are the most important high-skilled labor force in the HSIP, no matter whether in terms of number or proportion.

Table 6 Human resources by education in the HSIP, 2002

Education	Ph.D.	Master	Bachelor	Junior college	High school	Others	Total
Domestic degree	627	14,266	18,277	23,611	26,612	6,060	89,453
Foreign degree	583	3,701	3,413	822	590	54	9,163
Total	1,210	17,967	21,690	24,433	27,202	6,114	98,616
Percentage	1.23	18.22	21.99	24.78	27.58	6.20	100.00

Source: The Hsinchu Science-based Industrial Park Administration

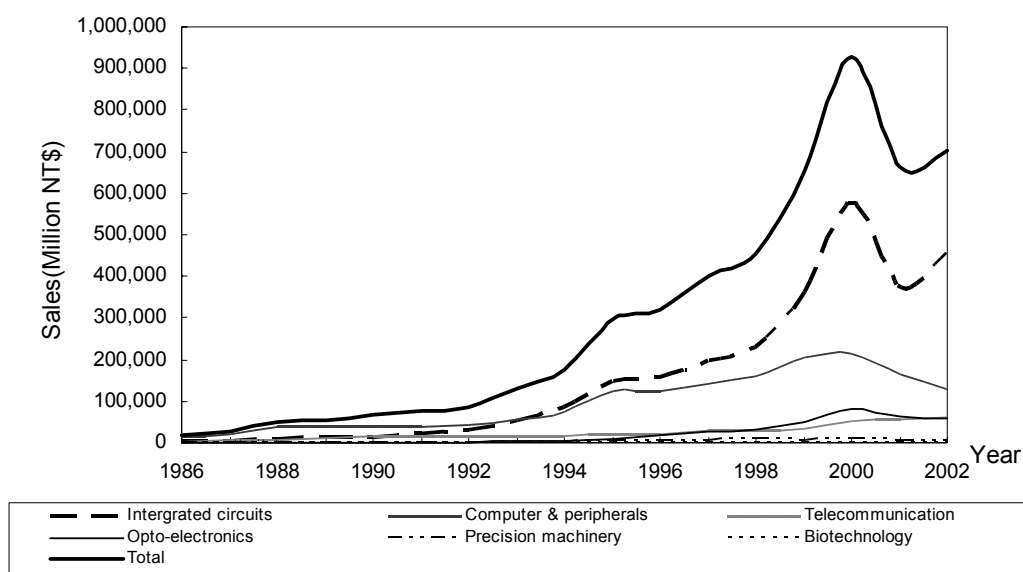
There is no basic research, nor systematic database that can be used to trace the differential contributions of domestic and foreign experts on the HSIP. A preliminary study by Chiu et al (2003) attempted to test whether employees of the HSIP with foreign or domestic Ph.D. degrees or their interactions have significant effects on increasing the numbers of patents and productivities for the

HSIP. Their study tentatively concluded that foreign Ph.D. employees seem to make a greater contribution than those with a domestic Ph.D. on patenting, but have no strong evidence on superior productivity. They also indicate that the impact of returnees on productivity is quite weak. At any rate, based on descriptive data and exploratory studies, such as Chiu et al (2003), there is no strong evidence to prove that the competition and continuous growth of the HSIP, a high-tech cluster, is highly reliant on the influx of an external labor force, although numbers of overseas returnees, as well as foreign professional and technical employees, keep growing.

3.6 Cluster Dynamics and Differences among Industries

As the nucleus of the Hsinchu high-tech cluster or Hsinchu-Taipei high-tech corridor, the HSIP has changed dramatically, not necessarily in terms of industrial composition, but in terms of industrial structure along with its development path. Although industries of integrated circuits and computer & peripherals have long been two major industries in the HSIP since the mid 1980s, in 1993 integrated circuits started to surpass computer & peripherals in terms of overall sales and became the leading industry in the HSIP. We can also see that the overall sales for computer & peripherals began decreasing significantly. In the late 1990s, two industries, telecommunication and opto-electronics, both had marked growth as well. However, the growth trend of opto-electronic follows that of computer & peripherals for a little while. This trend reflects the increasing path of outward movement of the more labor-intensive part of those two industries to China according to our field investigations in China. That is also because computer & peripherals, along with part of the opto-electronic industry, have more to do with the final products and are more subject to market competition than others (Figure 6).

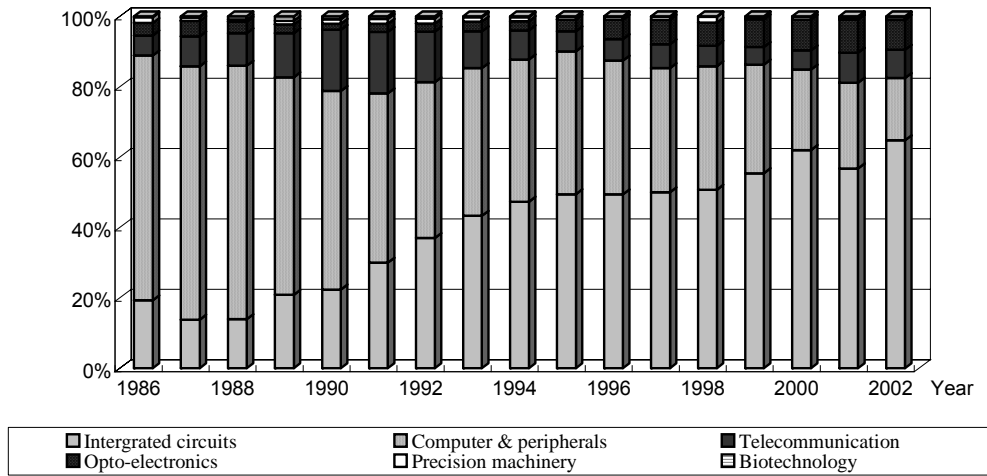
Figure 6 Changes of overall sales by industry in the HSIP, 1986-2002



Source: The Hsinchu Science-based Industrial Park Administration

This trend can be compared with trends of R&D expenditures by industry in the HSIP. We find that the integrated circuits industry is the most technology-intensive of all. R&D expenditures for computer & peripherals has not increased significantly along with the development of the HSIP, and even dropped in the late 1990s, though it has long been the second largest industry in the HSIP.

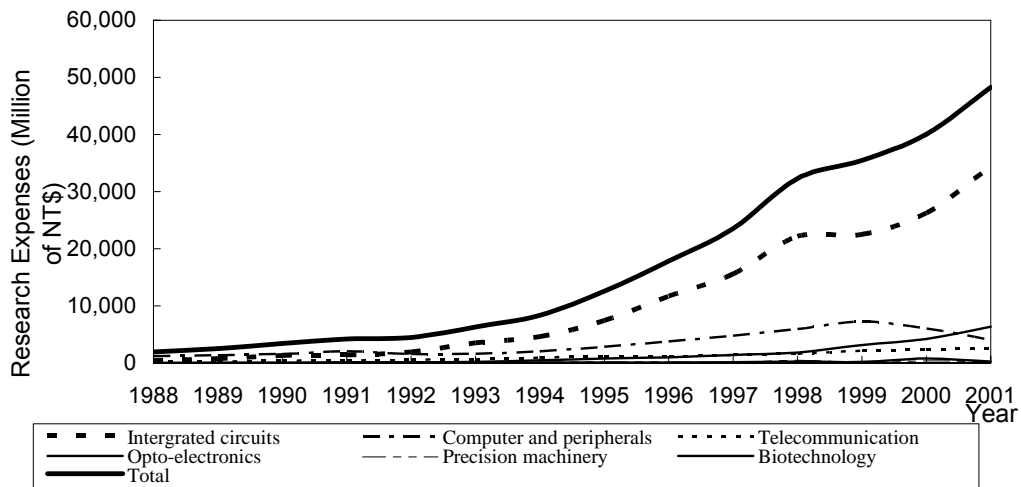
Figure 7 Changes of R & D expenditures by industry in the HSIP, 1988- 2002



Source: The Hsinchu Science-based Industrial Park Administration

The relative importance of the industries in the HSIP, or industrial structure of the HSIP, can be seen from the following two figures (Figure 7 and Figure 8). Coincident with the above discussion on stages of development for the HSIP, proportional changes of overall sales and employees both can be identified by periods differentiated by 1987/88 and 1993/94. Definitely, both trends were induced by the dynamics of the integrated circuits industry. Relatively speaking, in the first half decade of the 1990s both proportion of overall sales and proportion of employees for the integrated circuit industry increased significantly and its growth trend stabilized in the second half of the 1990s. However, the proportions for overall sales and employees shrank significantly for the computer and peripherals industry. That is, the relative importance of the computer and peripherals has been decreased during the past decade. Besides, there was an increase in the relative importance of the opto-electronic industry.

Figure 8 Changes in the proportions of overall sales for industries in the HSIP, 1986-2002



Source: The Hsinchu Science-based Industrial Park Administration

This evidence gave us a very clear picture that there is a great dynamic for the HSIP in the past one and half decades in particular. The integrated circuit industry replaced the computer & peripherals industry as the most important industry in the HSIP and contributed half of the overall sales, and hired around half of the labor force. The computer and peripherals industry, once the most important ingredient for information industry in the HSIP and in Chinese Taipei, shared only around one fifth of the overall sales and labor force in the HSIP. Industries of opto-electronic and telecommunication were getting more important in the HSIP. In fact, there is significant growth in the opto-electronics industry in Chinese Taipei, which was not shown by data for the HSIP. It is a quick booming, and even leading industry in the Tainan Science-based Industry Park and will be the major industry for the coming Taichung Science-based Industry Park.

If we go look further at the high-tech intensity, both in terms of R&D personnel and expenditures, we find that the biotechnology industry had the highest technology intensity of all industries in 2001, both in terms of expenditures and personnel (Table 7 and Table 8). Integrated circuits and opto-electronics had higher proportions of R&D expenditures to overall sales, while computer & peripherals and telecommunications had higher proportions of researchers to total employees. The former two relied more on capital than personnel, while the latter two relied more on personnel than capital for R&D activities. Table 7 also gives us a general picture for R&D inputs in the HSIP for different industries during 1992 and 2001.

Table 7 Percentages of R & D expenditures to overall sales by industry for two science-based industrial parks in Chinese Taipei, 1992-2001

Year	Total	Integrated circuits	Computers & peripherals	Telecommunications	Opto-electronics	Precision machinery	Biotechnology
1992	5.1	6.1	4.1	4.6	8.8	10.0	8.5
1993	4.9	6.3	3.0	5.2	6.5	10.4	16.7
1994	4.6	5.5	2.8	6.6	9.3	6.5	19.1
1995	4.2	5.0	2.3	7.1	7.8	8.9	42.8
1996	5.6	7.4	3.1	5.8	5.6	6.7	27.5
1997	5.9	7.8	3.4	5.3	5.1	5.1	33.2
1998	7.1	9.6	3.7	6.1	6.3	6.4	41.7
1999	5.4	6.2	3.6	6.7	6.2	2.0	34.5
2000	4.2	4.5	2.9	4.6	4.6	5.1	65.1
2001	6.5	7.6	3.6	5.2	6.7	3.5	62.4

Source: National science Council 2002, *Indicators of Science and technology*.

Table 8 R & D Manpower by Industry for two science-based industrial parks in Chinese Taipei, 2001

Type Industry	R & D Manpower	Researchers	Technicians	Supporting personnel	Numbers of employees	Researchers as percentage of employees
Total	19,476 (100%)	14,064	3,782	1,630	105,782	13.3
Integrated circuits	9,491 (48.73%)	7,054	1,542	895	62,041	11.4
Computers & peripherals	4,449 (22.84%)	3,113	2,095	241	13,363	23.3
Telecommunications	2,156 (11.07%)	1,475	503	178	7,293	20.2
Opto-electronics	2,776 (14.25%)	1,943	574	259	20,751	9.4
Precision machinery	181 (0.93%)	145	25	11	1,296	11.2
Biotechnology	423 (2.17%)	334	43	46	1,038	32.2

Source: National science Council 2002, *Indicators of Science and technology*.

Targeted at human resources of the high skilled, domestic supply definitely will be the major source of labor and a necessary condition for autonomous development, but a continuous brain gain from abroad is a necessary condition in this highly competitive and innovative global economy. In addition to the influx of overseas returnees, we find that there is a significant increase of foreign technical and professional staff as discussed above. Along with the changing industrial structure of the HSIP, nationality distribution of foreign technical and professional employees also gives us a clear picture of the structure of the high skilled human resources in the HSIP.

If we just look at the first four industries, there are some variations. For the integrated circuit industry, more than a half the foreign high skilled employees are from the United States, Japan and other advanced countries (Table 9). A great proportion is from neighboring developing countries. For computer and peripherals and telecommunications, a significant numbers are from the United States, but the proportions are far less than that for integrated circuit industry. Most of their foreign staff is from neighboring developing countries with cheaper salary levels. Opto-electronics followed the pattern of integrated circuits, although Japan and Korea, who have higher technology levels, are more important for providing foreign human resources. This, in some way, indirectly reflects various contributions of domestic human resources among industries to the high-tech cluster, because overseas returnees and foreign technical and professional employees account for less than one fourth of the researchers in the HSIP.

Table 9 Nationality of foreign professional and technical employees by industry in the HSIP, 2003/10

Nationality	US	Japan	Malaysia	Korea	Philippine	Singapore	India	UK	German	Canada	France	Russia	Others	Total
Integrated Circuit	147	97	49	51	24	27	3	24	11	5	5	1	38	482
Computer Peripherals	23	4	23	0	14	3	21	5	0	5	6	7	12	123
Telecommunication	20	1	6	0	0	1	5	0	0	2	1	4	13	53
Opto-Electronics	4	18	7	9	1	5	1	0	0	4	3	1	1	54
Precision Machinery	3	2	0	0	0	1	0	0	5	0	0	0	0	11
Bio-technology	2	0	2	0	0	0	0	0	0	0	0	0	0	4
Total	199	122	87	60	39	37	30	29	16	16	15	13	64	677

Source: The Hsinchu Science-based Industrial Parks Administration

4. SUBCONTRACTING, INDUSTRIAL SPECIALIZATION AND CLUSTER: THE CASE OF HSIP

4.1 Introduction

The liberalization of international trade has had a tremendous impact on the production models of many firms in many countries, as the production structure of many of these firms have changed accordingly. In recent years, subcontracting, outsourcing or industrial specialization have begun to replace existing production models of vertical integration, whilst the evolution of the production structure has been increasingly accelerated, largely as a result of improvements in transportation means and the development of the Internet, which have both substantially shortened the distance between national borders.

Owing to the rapid shortening of product life cycles in recent years and the demand for diversification of products, the erstwhile 'big business,' known for its economies of scale, has faced an enormous challenge with regard to its inadequate production flexibility. Conversely, small and medium enterprises (SMEs) have honed their competitive edge by means of specialization, cutting into the markets and seeking their particular niche. Scott (1993) suggested that in the past, business favored economies of scale, whereas today's focus within industrial organizations is centered on how to capitalize the external economies of scope. Therefore, firms involved in

different production stages may join hands through industrial specialization to form a production network so as to fully explore the external economies of scope.

It has been argued in the literature that the success of Chinese Taipei's computer industry can be attributed to the swiftness and flexibility of SMEs and their comprehensive subcontracting practices. Related studies in this area include Levy (1988) and Levy and Kuo (1991) on the comparison of keyboard and computer manufacturing between Chinese Taipei and Korea; Huang (1995) on the study of Chinese Taipei's computer industry; Kraemer (1996) on the study of Chinese Taipei's software industry; and Kawakami (1996) on the development of Chinese Taipei's computer industry and the structure of SMEs in Chinese Taipei. These studies have argued that the industrial specialization of Chinese Taipei's firms in the information technology (IT) industries has played a pivotal role in catapulting these firms into the international marketplace.

There has, however, been little discussion in the literature as to what the main motives are for high-tech firms in the IT industries to engage in such subcontracting practices, and it may also be worth exploring what effect the prevalence of such subcontracting practices has had on the overall industrial structure as well as on industrial clusters. In this study we will attempt to fill the gaps in the literature by examining these issues, with specific focus on the subcontracting behavior of high-tech firms in the Hsinchu Science-based Industrial Park (HSIP) in Chinese Taipei. Our overall aim is to consider the key elements involved in the undertaking of such subcontracting practices by high-tech firms within the HSIP, whether subcontracting is a common practice for these firms, whether or not the practice of subcontracting provides a competitive edge for these firms, and whether the subcontracting operations of these firms enhances or enlarges the clusters effect of other firms within or around the HSIP.

4.2 Data Survey in HSIP

From the theoretical discussion, we expect that firms may lower their production costs by subcontracting part of their production activities. In reality, however, it remains to be shown whether subcontracting really does lower costs. In addition, apart from cost reduction, there may well be other considerations that lead firms to resort to subcontracting. These issues require further clarification. In this chapter, therefore, we rely on the results of a questionnaire survey to carry out our empirical analysis. To begin with, we first examine the primary reasons why firms rely upon subcontracting rather than in-house production, followed by analysis of the relevant factors affecting the degree of subcontracting, i.e., the subcontracting ratio, and whether such subcontracting behavior is common practice in the industries examined.

For our empirical study, we examine high-tech firms in the Hsinchu Science-based Industrial Park (HSIP) in Chinese Taipei for three major reasons: (i) the HSIP is the most successful example of high-tech industrial clusters in Chinese Taipei, and has in fact become a major focus for the study of high-tech firms in Chinese Taipei; (ii) by studying the subcontracting behavior of high-tech firms, we can gain an in-depth understanding of how it affects the competitive advantage of high-tech firms and whether it has any impact on industrial clusters; (iii) since this study conducts a census of all the high-tech firms in the HSIP in Chinese Taipei, the survey results can be regarded as representative.

Survey Method and Sampling Structure

This survey began in early November 2002 and ended in mid-January 2003. The questionnaire, which contained basic information on the surveyed firms as well as information relating to market entry barriers, was mailed to all of the 334 high-tech firms in the HSIP. As discussed earlier, this study set up three variables to capture the various characteristics relating to industrial specialization, namely, the subcontracting ratio, the depth of subcontracting and the duration of subcontracting. The surveyed firms were specifically asked about their knowledge of the subcontracting behavior of their foreign counterparts and also the reasons why subcontracting was necessary. At the end of the survey, a total of 90 usable samples were collected, giving an

effective return rate of 28.30 percent.¹ Statistics on the questionnaires returned are provided in Table 10, from which we can see that the IC industry accounted for the highest number of returned samples, with 36 of the 90 copies returned. By proportion, however, with the exceptions of the communications and IC industries, the return rates for all other industries exceeded 30 percent, whilst the biotech industry showed a 50 percent return rate, the highest of all.

Table 10 Return sample statistics

Industries	Number of Samples Returned	Number of Firms listed in the HSIP	Return Ratio (%)
Precision Instrument	4	12	33.33
Biotech	9	18	50
Computer Peripherals	16	52	30.78
Opto-electronics	18	58	31.03
IC	36	134	26.87
Communications	7	60	11.67
Total	90	334	27

Note: Number of effective samples = 90.

Source: Findings of this study.

Basic Characteristics of the Surveyed Firms

The basic information collected by the survey included variables such as the age of the firm (*Age*), the stage of production (*Stage*), registered capital (*Capital*), the number of employees (*labor*), the firm's export ratio (*EX*), R&D to total sales ratio (*RD*) and size of the firm (*Size*).

Table 11 Basic characteristics of firms in the HSIP

Variable	Definition of Variable	N=90	N=80	N=10	Max. and Min. Value
		All Samples	Firms with Subcontracting	Firms without subcontracting	
<i>Age</i>	Number of years established as at the end of 2003.	8.30 (4.95)	8.15 (4.94)	9.50 (5.10)	22 1
<i>Stage</i>	The firm's current stage of production.	1.72 (0.77)	1.73 (0.76)	1.57 (0.98)	3 1
<i>Capital</i>	Registered capital (in NT\$ million).	2,443.24 (9,093.89)	2,717.60 (9,630.30)	303.20 (465.29)	67,000 12
<i>Labor</i>	Number of employees (persons).	243.54 (608.50)	262.71 (637.56)	68.63 (109.65)	3,982 10
<i>EX</i>	Ratio of exports as a percentage (%).	47.40 (35.54)	49.86 (34.66)	27.67 (38.38)	100 0
<i>RD</i>	Spending on R&D as a proportion of sales revenue (%).	54.875 (152.75)	43.32 (115.69)	146.00 (320.59)	999 0
<i>Size</i>	Scale of firm: = 1 for less than 50 persons; = 2 for 51 to 250 persons; = 3 for more than 251 persons.	1.93 (0.63)	1.99 (0.59)	1.37 (0.74)	3 1

Notes:

1 Number of effective samples = 90.

2 Figures in parenthesis are the standard deviation.

For the purpose of comparison, Table 11 categorizes the total sample, the sample of firms engaging in production subcontracting, and the sample of those not engaging in production subcontracting. The results of Table 11 are summarized as follows. The Age variable refers to the number of years that the surveyed firm has operated within the HSIP; this produces an average value of 8.3 years, suggesting that the majority of the surveyed firms were established in the

¹ The return ratio is calculated from computation of the original number of firms within each industry listed in the administration bureau of the HSIP. We found that 16 firms were not contactable for various reasons, as such, after deducting these 16 firms from our survey population, our sample return rate increased to 28.30%.

mid-1990s. As to the stage of production, we set the Stage variable as being equal to 1 if the surveyed firm reported that its primary product came under the upstream section of the industry, with 2 or 3 being assigned if the primary product came under the midstream or downstream section of the industry, respectively. The Stage variable mean was 1.72, placing most of the firms in the HSIP somewhere between the upstream and midstream stage of their respective industries.² We can also see from Table 11 that those firms operating without subcontracting were mainly upstream firms.

The information on registered capital comes directly from the Administration Bureau of the HSIP, with the average value being NT\$2,443.24 million. Table 11 shows that the registered capital for those firms engaging in subcontracting was far higher than for those without subcontracting. This suggests that it is the larger firms in the HSIP that are engaging more in subcontracting. The number of employees is variable, Labor, and also indicates that it is the larger firms, those hiring more workers, that are engaged more in subcontracting. The average export ratio (*EX*) was 47.40 percent, indicating that just over a half of the products manufactured by the firms in the HSIP are for domestic consumption. With the majority of the firms in the HSIP being in the midstream or upstream section of their industry, intra- and inter-industry trading is therefore commonplace. The *EX* variable statistics also reveal that firms with higher export ratios tend to have a higher propensity for engaging in subcontracting.

As regards spending on R&D (*RD*) as a proportion of revenue, the mean for the *RD* variable was 54.88 percent, and it is interesting to find that firms engaging in subcontracting actually have lower R&D ratios than those without subcontracting. Finally, with respect to the firm size variable (*Size*), this can be measured in terms of total assets, profit, sales amount or the number of employees. Following our examination of the quality of the data for each possible approach, it was decided that this study should utilize the number of employees as a proxy for the firm scale variable. In compiling the *Size* variable, we set it as being equal to 1 for firms with 50 employees or less, equal to 2 for firms with 51 to 250 employees, and equal to 3 for firms with 251 employees or more. Table 11 shows that the average value of the *Size* variable is 1.93, which again suggests that smaller firms have less involvement in subcontracting activities.

To summarize, the statistics in Table 11 clearly show that there are significant differences between those firms that engage in subcontracting and those firms that do not. The preliminary statistical results suggest that it is the larger firms, characterized by their higher export ratios, greater total numbers of employees, and higher amounts of registered capital, that are more involved in subcontracting.

4.3 Extent of Subcontracting and Clustering Effect

Table 12 Definition and descriptive statistics of variables

Variables	Definition of Variable	N=90		
		Mean (Std. Dev.)	Max. Value	Min. Value
<i>Ratio_i</i>	Indicates, in the manufacturing process, the ratio of the costs paid for outsourced/subcontracted raw materials, components, semi-finished products and specialization services, as a percentage of the most important products of a firm.	58.38 (25.45)	100	10
<i>Length</i>	Length of subcontracting period (years).	5.368 (4.06)	18	0
<i>Trend</i>	Subcontracting trend: = 1 indicates <i>Ratio_i</i> will progressively reduce in future; = 2 indicates <i>Ratio_i</i> will not be stable in future; = 3 indicates <i>Ratio_i</i> will remain stable in the future; = 4 indicates <i>Ratio_i</i> will progressively increase in the future.	3.026 (0.87)	4	1

² There were 39 upstream firms (47.56%), 27 midstream firms (32.93%) and 16 downstream firms (19.51%).

Variables	Definition of Variable	N=90		
		Mean (Std. Dev.)	Max. Value	Min. Value
$Plant_i$	If a firm's main reason for engaging in subcontracting was 'reduction in costs and savings on capital investment' then $Plant_i$ would be set at 1; otherwise 0.		1	0
Std_i	If a firm's main reason for engaging in subcontracting was because 'standard components already existed in the market,' then Std_i would be set to 1; otherwise 0.		1	0
$Cost_i$	If a firm's main reason for engaging in subcontracting was because 'There are already other manufacturers in this field so it does not pay, cost-wise, for us to do the same,' then $Cost_i$ would be set to 1; otherwise 0.		1	0
$otfirm$	Indicates whether subcontracting is a popular practice amongst other firms in the industry in which the firm is located. If the surveyed firm reported that it was 'very popular,' then $otfirm$ would be set at 4; if 'commonplace' was reported, then $otfirm$ would be set at 3; if 'there are only a few firms that do,' then $otfirm$ would be set at 2; if 'no' was reported then $otfirm$ would be set at 1.		4	1
$Easy$	Indicates whether the surveyed firm considered it easy for a new firm to enter the industry in which it is located. $Easy = 1$ indicates that it is not easy; = 2 indicates it is fair; = 3 indicates it is easy; = 4 indicates that it is very easy.	1.53 (0.79)	4	1
$Neighbor_i$	If a firm's main reason for locating within the Park was because it wished to be in the same neighborhood as fellow firms in the industry, then $Neighbor_i$ would be set at 1; otherwise 0.		1	0
CT	Contact intensity (by eight methods of contact, namely, telephone, fax, face-to-face contact, EDI, e-mail, Internet, EFT, and others); indicates how many of these methods the surveyed firm had adopted to get in touch with other collaborating firms. $CT = 0$ indicates none of the abovementioned, $CT = 8$ indicates that all of these methods had been adopted.	3.35 (0.96)	6	1
EC	Contact Intensity through information technology. $EC = 0$ indicates that the surveyed firm had not used any one of the four e-tools, namely, EDI, e-mail, Internet and EFT, to make contact with other collaborating firms; $EC = 4$ indicates that the surveyed firm had utilized all four of these e-tools.	1.40 (0.68)	4	0
TW_i	Local procurement as a percentage of total subcontracting value			
DT_i	The geographical distance between the surveyed firm's most important collaborating business partner, measured by shipping costs for a standard object.	9.40 (5.17)	26.7	4.2

Note: Average value and standard deviation are rounded to two digits after the decimal point.

Source: this study

It may be interesting to examine whether an industry that exhibits a greater propensity for subcontracting practices will also be an industry in which barriers to market entry are lower; an Ordered Probit model will be employed to test this relationship. Finally, in the third part of our empirical analysis we will specifically examine whether subcontracting and industrial specialization can exert even greater effects on industrial clusters. In order to undertake the abovementioned empirical analysis, we list all of the relevant descriptive statistics for both the dependent and independent variables in Table 12, where the definitions of each variable are also explained. We shall also explain each of these variables in more detail as we proceed with our discussion.

Determination of the Extent of Subcontracting

We further examine the relevant factors affecting the extent of a firm's subcontracting activities. We use subcontracting ratio ($Ratio$) as a proxy for industrial specialization. $Ratio_i$ represents the

subcontracting ratio of firm i . The statistics provided in Table 12 indicate that the average value of the subcontracting ratio for all firms surveyed was 58.38 percent, whilst the explanatory variables affect a firm's subcontracting ratio include 'savings on capital investment' ($Plant$), 'standard components already exist in the market' (Std) and 'there are already other manufacturers in this field so it does not pay, cost-wise, for us to do the same' ($Cost$). The subcontracting trend ($Trend$) and the duration of subcontracting activities by the firm ($Length$), which affect the subcontracting ratio of a firm, are also examined.

We also include in the empirical model an industrial dummy (IO), the export ratio level (EX), and the size of the firm ($Size$) to determine whether these will affect the subcontracting ratio of firms. We can now set the empirical model as follows:

$$\log Ratio_i = \alpha_0 + \alpha_1 Trend_i + \alpha_2 Length_i + \alpha_3 Plant_i + \alpha_4 Std_i + \alpha_5 Cost_i + \alpha_6 IO1_i + \alpha_7 IO2_i + \alpha_8 IO3_i + \alpha_9 IO4_i + \alpha_{10} IO5 + \alpha_{11} EX_i + \alpha_{12} Size_i + \varepsilon_i \dots\dots\dots (1)$$

$Ratio_i$: indicates that in the manufacturing process, the ratio of costs paid for outsourced/subcontracted raw materials, components, semi-finished products and specialization services, as a proportion of the primary products of a firm; α_i is the estimation coefficients for the explanatory variables; and ε_i is the error term. Since the range of $Ratio_i$ is between 0 and 100, this study takes the logarithm for its empirical estimation.

Explanatory Variables

Subcontracting trend and length: $Trend_i$ is the subcontracting trend, which indicates whether or not the firm plans to continue to subcontract part of its production processes in the future; if the firm believes that the ratio will increase, the variable is set at 4; if steady, the variable is set at 3; if unsteady, the variable is set at 2; if the ratio is to be reduced, the variable is set at 1. The $Length_i$ variable indicates how long the surveyed firm has been engaging in subcontracting, measured in years.³ This study expects that the greater the value of the subcontracting trend, and the longer the duration of a surveyed firm's subcontracting, the greater the subcontracting ratio will be. As such, this study hypothesizes that both α_1 and α_2 should be positive.

Standard components and cost variable: $Plant_i$ determines whether the surveyed firm reported that 'reduction in costs and savings on capital investment' were primary concerns in the firm's adoption of subcontracting; if yes then $Plant_i$ would be set as equal to 1, otherwise 0. Std_i indicates whether the reason for subcontracting was that 'standard components already exist in the market'; if yes then Std_i would be set as equal to 1, otherwise 0. $Cost_i$ indicates whether the reason for subcontracting was that 'there are already other manufacturers in this field so it does not pay, cost-wise, for us to do the same'. If the surveyed firm responded yes, then variable $Cost_i$ would be set as equal to 1; otherwise 0.

Our survey reveals that 66.67 percent of the surveyed firms indicated that the primary reason for them engaging in subcontracting was that 'there are already other manufacturers in this field so it does not pay, cost-wise, for us to do the same'; 62.82 percent reported that the reason for engaging in subcontracting was for 'cost reductions and savings on capital investment,' and 28.21 percent reported that it was due to the fact that 'standard components already exist in the market'. In light of the above survey results, we may infer that costs and specialization are the two primary factors considered by firms with regard to subcontracting. In addition, our theoretical model also points out that under certain conditions, subcontracting may lower the production costs of a firm. As such, we hypothesize that α_3 , α_4 and α_5 , will all have positive impacts on $Ratio_i$.

Industrial Dummy: There were six major industries in the HSIP. $IO1 = 1$ indicates that the firm is in the semiconductor industry, $IO2 = 1$ indicates that the firm is in the computer peripherals industry,

³ The figure is computed up until December 2002. In addition, it is interesting to note that the average age of the surveyed firms in the sample was 8.3 years whilst the average length of subcontracting practices for these firms was 5.37 years, which suggests that, on average, the survey firms adopted subcontracting at a point approximately three years after their establishment.

$IO3 = 1$ indicates that the firm is in the communications industry, $IO4 = 1$ indicates that the firm is in the opto-electronics industry, and $IO5 = 1$ indicates that the firm is in the precision instruments industry. The estimation coefficients for these industrial dummy variables represent their relative performance when compared to the reference group, i.e., the biotech industry. From our survey, we find that the communications industry has the highest subcontracting ratio, at 67.5 percent, followed by 65.55 percent of the computer peripherals industry, 58.80 percent of the IC industry, 57.35 percent of the opto-electronics industry, 55.75 percent of the precision instruments industry, and 45.0 percent of the biotech industry. As such, this study hypothesizes that the estimation coefficients for α_6 to α_{10} will all be positive.

Export Ratio: EX_i signifies the export ratio of the surveyed firm's primary product. Since those firms that have a larger export ratio face keener international competition, and thus, come under tremendous pressure to cut down their production costs, we hypothesize that the variable EX_i will have a positive impact on $Ratio_i$ and that the estimates of α_{11} will be positive.

Size of firms: The variable $Size_i$ indicates the size of a firm. Since the larger the size of a firm, the more it aims to bring its production activities into its organization's internal operations. As such, the ratio of subcontracting should tend to be lower, and we hypothesize that the estimates of α_{12} will be negative.

Table 13 Empirical results of subcontracting ratio (log Ratio)

Variable	(1)	(2)	Expected Sign
Intercept	2.57589 (7.63) ^{***}	2.65631 (8.22) ^{**}	
(Trend _i)	0.12452 (1.75) [*]	0.14611 (2.14) ^{**}	(+)
(Length _i)	0.00234 (0.14)	0.00406 (0.24)	(+)
(Plant _i)	0.23957 (1.79) [*]	0.22574 (1.74) [*]	(+)
(Std _i)	0.01933 (0.11)	-	(+)
(Cost _i)	0.15351 (1.17)	-	(+)
IC (IO1)	0.72581 (2.90) ^{***}	0.69376 (3.24) ^{***}	(+)
Computer Peripherals (IO2)	0.68642 (2.49) ^{**}	0.66097 (2.68) ^{**}	(+)
Communications (IO3)	0.76342 (2.34) ^{**}	0.74450 (2.30) ^{**}	(+)
Opto-electronics (IO4)	05.4445 (2.15) ^{**}	0.51235 (2.22) ^{**}	(+)
Precision Instruments (IO5)	0.46175 (1.43)	0.43091 (1.35)	(+)
(EX _i)	0.00479 (2.28) ^{**}	0.00439 (2.14) ^{**}	(+)
(Size _i)	-0.06490 (-0.58)	-0.06173 (-0.59)	(-)
N	59	59	
\bar{R}^2	28.42%	29.47%	

Notes:

1. t-statistics in parenthesis.
2. *** indicates the estimated coefficients have reached a 1 per cent significance level, ** indicates the estimated coefficients have reached a 5 per cent significance level, * indicates the estimated coefficients have reached a 10 per cent significance level.

Having discussed our prediction for each of the explanatory variables, we now present our empirical results on the determination of the subcontracting ratio ($Ratio_i$) in Table 13. As the Table shows, the subcontracting trend ($Trend_i$) has a significant positive impact upon the ratio of subcontracting, which indicates that the subcontracting ratio will increase as the surveyed firm plans to increase its subcontracting in the future. This is consistent with our hypothesis.

As to the variable on the duration of subcontracting ($Length_i$), this is not significant in the Table, which suggests that the previous duration or history of existing subcontracting activities does not affect the firm's current subcontracting ratio. Furthermore, the empirical results in Table 13 confirm that if the surveyed firm considers that subcontracting can reduce its costs and capital investment, this will induce more subcontracting because the estimation coefficient for the $Plant_i$ variable is positive and significant, which is in line with our hypothesis and our theoretical argument. However, our empirical results do not confirm that the Std_i and $Cost_i$ variables will have any significant positive impact on the subcontracting ratio. As for the industrial dummies, our empirical results confirm that, with the exception of the precision instruments industry, all other industry dummy variables are positive and highly significant, thus confirming our hypothesis. These results suggest that subcontracting activities within the IC industry, computer peripherals industry, communications industry and opto-electronics industry are all significantly higher than in the biotech industry.

To summarize, our empirical results, as presented in Table 13, show that the primary factors affecting the subcontracting ratio of firms are the firm's future subcontracting plan (the $Trend_i$ variable) and whether the firm considers that subcontracting can be an effective means of saving costs and reducing its capital investment (the $Plant_i$ variable). In addition, our empirical results confirm that firms that are more export oriented will tend to have greater subcontracting activities. Again, the above empirical results are also in line with our argument that when firms face higher cost reduction pressure, by way of international competition, they will more actively engage in subcontracting so as to effectively reduce their production costs. Last, but not least, our empirical results fail to confirm that the size of the firm can be an important factor in determining the extent of a firm's subcontracting decisions. However, the results do confirm that the extent of subcontracting can be quite different amongst different industries.

Empirical Results on Clustering Effect

In an industry where production is highly specialized, firms are increasingly subcontracting many of their non-core production activities in order to reduce costs and regain their competitive edge. However, along with such intensifying subcontracting activities, there will inevitably be a rapid surge in both transaction costs and transportation costs, imposing new challenges upon firms. To effectively overcome such problems, firm may choose to cluster together in order to minimize these rising costs and enhance their subcontracting network. It can therefore be argued that the prevalence of the subcontracting system may enhance the clustering effect of firms.

In this chapter of the paper we test this argument using the survey results obtained from this study. It is important to note that the clustering effect has already been formed amongst firms within the HSIP; therefore, the focus of our study will not be on why the firms clustered there, but rather on explaining what the relevant factors were in determining the geographical distance that the surveyed firms have between themselves and their major upstream or downstream collaborating partners. We argue that the prevalence of the subcontracting system will push, or provide more opportunities for, firms to look for upstream or downstream collaborating firms that are already nearby, or are locating nearby, and consequently the clustering effect around the HSIP will be enhanced and enlarged.

To examine such a hypothesis, this study divides the island of Chinese Taipei according to its 15 major administrative districts and then utilizes the freight fee charges between the HSIP and each

of the 15 districts as a proxy for geographical distance.⁴ Then obtain from the survey results the location of the surveyed firms' primary downstream or upstream collaborating partners. Having gained this important information from the survey, we then assign a value for the 'distance' proxy variable, *DT*, for each of the surveyed firms in accordance with the freight rate between the HSIP and the administration district in which the collaborating firm is located. We then use the following regression model to examine the relevant factors in determining *DT*.

$$DT_i = \kappa_0 + \kappa_1 CT_i + \kappa_2 EC_i + \kappa_3 Neighbor_i + \kappa_4 Ratio_i + \kappa_5 Length_i + \kappa_6 Trend_i + \kappa_7 TW_i + \tau_i \dots\dots\dots(2)$$

where (*DT*) is a proxy dependent variable for geographical distance between the surveyed firm and its most important upstream or downstream collaborating firm; with the independent variables comprising contact intensity (*CT*) between the firms, the status of electronic contact between the firms (*EC*), subcontracting ratio (*Ratio*), subcontracting duration (*Length*), subcontracting trend (*Trend*) and the ratio of local purchase (*TW*), and η_i as the error term in the estimation. We explain these variables and their possible impacts on *DT* as follows:

Variable Definitions

Geographical distance between the surveyed firm and its most important collaborating partner: *DT_i* is the proxy variable for geographical distance between the surveyed firm and its most important domestic collaborating partner. In compiling this variable we obtain the relevant information from the Administration Bureau of the HSIP on the freight rates for 1,500-kilo cargo originating from Hsinchu to various destinations in Chinese Taipei and then convert this into a freight rate per kilo.

Contact intensity and electronic status: *CT_i* refers to the contact intensity between firms. This study includes eight possible contact methods in the questionnaire, which are telephone, fax, face-to-face contact, EDI, E-mail, Internet, EFT, and others. We then count how many of these methods are adopted. If all methods are adopted then the *CT_i* variable would be set as equal to 8; if none of these methods are used the variable would be set as equal to 3, and so on.

It is argued that *CT_i* may have both positive and negative impacts on *DT_i*, because, on the one hand, if the surveyed firm and its collaborating partner utilize more methods to contact each other, suggesting that all the possible methods have been attempted in order to enhance the communication mechanism, then it can be hypothesized that there is a genuine need for closer clustering. Consequently, *CT_i* may have a negative impact on *DT_i*. On the other hand, however, the development of more and better communication mechanisms may well suggest that geographical distance may no longer impose barriers to inter-firm collaboration; therefore, it could be equally hypothesized that *CT_i* may have a positive effect on *DT_i*. Whether *DT_i* will be positively or negatively affected by *CT_i* remains to be examined empirically and thus we are unable to hypothesize here on its potential impact.

We have, nevertheless, included in this study an additional proxy variable for contact intensity, which is aimed specifically at electronic means of communication. As we have seen above, the *CT_i* variable comprises of eight possible means of communication; of these, EDI, E-mail, Internet and EFT can be regarded as IT communication methods. In our empirical model we examine whether the intensity of the utilization of these IT communication methods will have any significant impact on *DT_i*. If the surveyed firm utilizes all of these IT communication methods to facilitate its business operations, then the *EC_i* variable would be set at 4, and if none were used, then the variable would be set at 0. However, similar to the reasons discussed above, we are unable to project the possible impact of *EC_i* on *DT_i* without further empirical study.

The neighboring factor: *Neighbor_i* records whether or not, by locating itself in the HSIP, a firm

⁴ The 15 administrative districts are: Keelung, Taipei City, Taipei County, Taoyuan, Chungli, Hsinchu (and the Science-based Industrial Park), Miaoli, Taichung, Changhua, Yunlin, Chiayi, Tainan, Kaohsiung, Pingtung and the foreign countries.

could get closer to other collaborating firms. If the surveyed firm responded, yes, then the $Neighbor_i$ variable would be set at 1, otherwise 0. We hypothesize that if the surveyed firm chose to locate itself in the HSIP so as to get closer to its primary business collaborator, then the variable $Neighbor_i$ will have a significant negative impact on DT_i .

Subcontracting ratio, subcontracting length and subcontracting trend: $Ratio_i$ indicates the subcontracting ratio of a firm. The higher the subcontracting ratio, the greater the propensity for subcontracting; therefore, there is a clear need for closer clustering. As such, we hypothesize that the variable $Ratio_i$ will have a significant negative impact on DT_i , and its corresponding regression coefficient κ_4 is expected to be negative. $Length_i$ represents the surveyed firm's subcontracting duration. The longer the duration of subcontracting for a firm, the wider the range of subcontractors becomes; therefore, κ_5 is expected to be positive. $Trend_i$ represents the surveyed firm's projection of its future subcontracting activities. The higher the projected trend, the higher the subcontracting ratio will be in the future, which will consequently lead to closer clustering amongst member firms within the industry. The estimated coefficient of κ_6 is expected to be negative.

Proportion of local purchase: TW_i represents the ratio of local purchase as a proportion of overall subcontracting value. TW_i is introduced in our empirical model in order to examine whether or not an increase in domestic procurement through subcontracting will shorten the geographical distance of the collaborating firms, or whether the surveyed firms tend to engage more in local subcontracting, and therefore choose those suppliers that are more closely located. In this study we hypothesize that firms will opt for the latter, and therefore expect that the estimated coefficient of κ_7 will be negative.

Having discussed the possible impacts of all the relevant explanatory variables, we now summarize our empirical results in Table 14, which shows that variables CT and EC are not significant in models (1) and (2), whereas CT is significant in model (3). We therefore find empirical evidence to show that an increase in the methods of communication used between firms, or in other words, an increase in the needs of communication between firms, will shorten the geographical distance between them, which will enhance or enlarge the clustering effect within or around the HSIP. This result is consistent with our hypothesis.

Table 14 shows that the regression coefficient for the subcontracting ratio ($Ratio$) variable is negative and significant, which suggests that the higher the subcontracting ratio of a firm, the keener the firm will be to shorten the distance between itself and its suppliers. This empirical result also suggests that industrial specialization may well increase the transaction costs of the firms concerned and will place pressure on the firm to look for neighboring suppliers that can ultimately become collaborators. This result is also consistent with the argument of Scott (1993).

Table 14 Empirical results on collaboration distance

Name of Variables	(1)	(2)	(3)	Expected Symbol
Constant Item (<i>intercept</i>)	16.38991 (2.97) ^{***}	15.09776 (3.19) ^{***}	14.20509 (3.54) ^{***}	
Contact Intensity (<i>CT</i>)	-1.74649 (-1.09)	-1.90241 (-1.23)	-1.40278 (-1.82) [*]	(?)
Electronic Status (<i>EC</i>)	0.32002 (0.13)	0.80913 (0.37)	-	(?)
Neighboring Factor (<i>Neighbor</i>)	-2.86923 (-1.67)	-2.87090 (-1.72) [*]	-2.91768 (-1.76) [*]	(-)
Subcontracting Ratio (<i>Ratio</i>)	-0.05024 (-1.49)	-0.05480 (-1.72) [*]	-0.05087 (-1.72) [*]	(-)
Subcontracting Length (<i>Length</i>)	0.64803 (2.08) ^{**}	0.59420 (2.07) ^{**}	0.58122 (2.08) ^{**}	(+)
Subcontracting Trend (<i>Trend</i>)	-0.55419 (0.47)	-	-	(-)
Proportion of Local Purchase (<i>TW</i>)	-0.02928 (-1.24)	-0.03044 (-1.31)	-0.02903 (-1.29)	(-)
N	53	54	54	
\bar{R}^2	15.60%	18.12%	20.73%	

Notes:

1 t-statistics are in parenthesis.

2. *** indicates the estimated coefficients have reached a 1 per cent significance level, ** indicates the estimated coefficients have reached a 5 per cent significance level, * indicates the estimated coefficients have reached a 10 per cent significance level.

Our empirical results also show that the subcontracting duration of the surveyed firm, (*Length*), will significantly and positively affect the distance between collaborating firms, which suggests that the longer the subcontracting history, the more experienced the firm will have become in selecting its collaborating partners, and the geographical distance between all of these collaborating firms will therefore be wider.

Table 14 also shows that the variable, *Neighbor*, is negative and significant in models (2) and (3) of our estimation, which confirms our hypothesis. This result suggests that the clustering effect will occur in two possible ways; firstly, firms will choose their location in such a way as to be closer to their major collaborating partners, and secondly, the prevalence of subcontracting will induce these firms to choose their collaborating partners in such a way that those located nearby will be considered, which will of course ultimately enhance the clustering effect around the HSIP. However, as subcontracting firms gain more experience and a longer history of subcontracting, they may actually enlarge the scope of their collaborating partners, and thus, the geographical distance between the collaborating partners may subsequently widen.

4.4 Conclusions

Amid ever-increasing competition and product diversification in international trade, ways of effectively responding to rapid market fluctuations and lowering production costs have become key issues for firms striving to regain their competitive edge. In this study, we find that subcontracting can be an effective operational model for cost reduction, providing firms with an enhanced competitive edge. In addition, along with the rapid improvements in information and communications technology, and the promotion of e-commerce, the interactions between collaborating firms have intensified, and have also expanded the practice of subcontracting.

The above empirical evidence is meaningful for industrial policy reference since it suggests that as the subcontracting practice becomes more popular and member firms in the industry have higher subcontracting ratios, then the relevant industry's structure will be a more open one and it will be more favorable for new firms to enter the market. Finally, in the third part of our empirical study, we confirm that the prevalence of subcontracting can have a significant and positive impact in terms of enhancing industrial clustering. This evidence is consistent with the assertion of Scott

(1993) that firms may cluster together in order to lower their corresponding transaction costs.

In summary, cost reduction is a primary consideration for firms opting for subcontracting and this can subsequently have a very profound impact. Our empirical study has shown that not only can it lower the entry barriers for new firms in the high-tech industries, but it can also consolidate the clustering effect amongst these high-tech firms; as such, it can affect both the industrial structure and the choice of location. This study has focused primarily on high-tech firms in the Hsinchu Science-based Industrial park in Chinese Taipei. Whether our empirical results can effectively transfer to other non-high-tech firms in Chinese Taipei will remain to be seen; however, our theoretical model suggests that so long as there is a possibility for firms to reduce their production costs through subcontracting, the practice of subcontracting will prevail, and all the subsequent impacts associated with subcontracting, such as the lowering of entry barriers and enhancement of industrial clustering will be likely to emerge. Furthermore, such a theoretical assertion is not limited purely to high-tech firms.

5. INDUSTRIAL CLUSTER AND FIRM'S PRODUCTIVITY: A CASE STUDY OF CHINESE TAIPEI'S ICT INDUSTRY

5.1 Introduction

Over recent decades, an ever-increasing amount of attention has been paid to the role played by industrial clusters in facilitating regional economies (Kuchiki and Tsuji, 2004) or in driving high technology industries (Bresnahan and Gambardella, 2004). The bulk of the research has focused on evidence provided by aggregate or micro data, examining the critical features shared by the various economies, such as significant investment in capital equipment and the strength of their orientation towards export markets. As in the literature surrounding this issue, industrial clusters matter in terms of firms' performance. Industrial clusters may refer to firms' business environments in terms of vertical relationships for suppliers-clients, labor pooling, infrastructures, and innovative capacity. This will determine firms' performance (Hoogstra and Dijk, 2004).

The rapid growth of Chinese Taipei's ICT industry since the middle 1980s has generated increasing amounts of research into firms' productivity differences within this sector. A number of economists have attributed some proportion of successful economic performance to the effective penetration of the export markets for manufactured products, with some studies indicating the existence of a significant linkage between productivity growth and export expansion. This important linkage can be explained from at least three perspectives: scale economies, trade exposure, and the learning effect. A number of subsequent works have provided new insights to enrich this framework, with many of them reaching similar general conclusions. Some researchers set up models to estimate the total factor productivity (TFP) dynamic in Chinese Taipei's manufacturing sector, stressing the importance of export scale economies on productivity growth, and highlighted the market selection and learning effect of exports through an empirical study (Chen and Tang, 1990; Aw, 2002; Aw and Batra, 1998; Yang, 2002). However, most of them fail to notice that the industrial clusters, business environments of firms, may effectively influence their productivities.

The purpose of this chapter is to use the micro data on Chinese Taipei's electronics industry for 1999 to highlight the influence of business environments, industrial clusters, upon the productivities at a plant level. In other words, this study explores the productivity differences for individual plants by taking into account their heterogeneity, including individual plants' attributes, such as sizes, production technologies, R&D investment, and the attributes of their business environments, such as regional R&D intensities, various externalities.

Two results significantly feature in this study: Firstly, we propose a new approach to classifying industrial clusters based on the Euclid distance between any two firms within a relevant industrial sector. For pursuing the optimal populations of an industrial cluster, we follow some proposed criteria of cluster analysis, a multivariate analysis. To some extent, in classifying industrial clusters, this research overrides the traditional studies, which heavily rely upon the administrative

region. Secondly, apart from traditional research of firms' productivities, which over-stress firms' own heterogeneities, this study highlights the roles played by regional business environments. Our empirical results may also offer an insight into the reasons why successful industrial clusters can enhance firms' competitiveness; that is, in addition to the incentives provided by competition to seek out improvements to productivity levels, regional externalities can also benefit firms through important spillover effects.

5.2 Theoretical Backgrounds for Defining Industrial Clusters

An industrial cluster is defined as "geographical concentrations of industries that gain performance advantages through co-location" (Doeringer and Terkla, 1995:225). This definition of clusters is similar to that of agglomeration economies. These include the geographic or spatial clustering of economic activity, use of common technology, the presence of a central actor (i.e., a large firm, research center, etc.), and the quality of the firm network (Jacobs and DeMan, 1996).

The role of social infrastructure in defining industrial clusters is a theme prevalent in the literature. Information flow is critical in an effective industrial cluster, and, in order to facilitate information exchange, a social infrastructure is required. While the characteristics of a cluster may be present, it is not necessarily an effective cluster; an effective cluster must also include social interaction, trust, and a shared vision in order to create the dynamic nature of a cluster (Jacobs and DeMan, 1996; Saxenian, 1994).

The definition of the vertical and horizontal industrial clusters is useful to identify key dimensions of industrial clusters. Rosenfeld (1997) underlines criteria for defining a cluster, including the scale of employment as the size of the cluster, the economic or strategic importance of the cluster, the range of products produced or services used, and the use of common inputs. Most authors argue for a broader definition of clusters that encompass both horizontal and vertical relationships, and include both direct and indirect linkages. Researchers have relied on simply defining industrial clusters as a concentration of employment in a single industry. As argued in Jacobs and DeMan (1996:425), "there is no correct definition of the cluster concept... different dimensions are of interest."

Porter (1990) championed the "Diamond of Advantage," in which four factors determine a competitive advantage for firms. The four corners of the diamond include factor conditions, demand conditions, industry strategy/rivalry, and related and supporting industries. Porter used this diamond to determine which firms and industries had competitive advantages, and his emphasis on the importance of related and supporting industries encouraged interest in clusters. Porter recognized that the majority of economic activity takes place at the regional level. Thus, his ideas are commonly applied to cities and regions. The bulk of Porter's thesis mainly deals with the competitive advantages of clustering for industries. Porter provides a simple definition of two types of clusters: vertical clusters, and horizontal clusters. Vertical clusters are made up of industries that are linked through buyer-seller relationships. By contrast, horizontal clusters include industries that sharing a common market for the end products, using a common technology or labor skills, or requiring similar natural resources (Porter, 1990).

Generally speaking, even though there are several common themes in the definition of an industrial cluster, most of the definitions of industrial clusters refer to the geographic scope of the cluster and spatial proximity. In defining the geographic scope of industrial clusters, most literature indicate that there is no uniform definition of the appropriate geographic scope of a cluster (Rosenfeld, 1996; Jacobs and DeMan, 1996; Jacobs and DeJong, 1992).

Geographical Identification of ICT Industrial Clusters in Chinese Taipei

In this study, we employ the cluster analysis, one of multivariate analyses, and the coordinate of each Chinese Taipei's ICT firms in terms of the T2-degree transverse Mercator⁵ to delineate the geographical boundaries of various ICT industrial clusters. Cluster Analysis is a multivariate

⁵ Chinese Taipei's maps have only two coordinate ways: longitude/latitude and 2-degree transverse Mercator.

analysis technique that seeks to organize information about variables so that relatively homogeneous groups or clusters can be formed. In this paper, the so-called homogenous or similar groups are defined in terms of their geographical locations.

In this way, the classification of ICT industries includes computer, communication, and audio/video electronic productions. Two main supporting industries for ICT are the electronics components industry and the electronic equipment industry. Both supporting industries are of importance in the vertical relationship for ICT production. In the process of geographical clustering, firms belonging to the electricity and electronic industrial sectors are included. The average linkage method is employed in the process of clustering firms based on their geographical deployment and weighted by number of employees in order to highlight the spatial agglomeration of labor pooling.

The data are drawn from “the annual manufacturing-plant survey in 1999” conducted by the Statistical Division under Ministry of Economic Affairs (MOEA), Chinese Taipei, in 2000. There are 2,054 establishments classified as belonging to the ICT industry, 2,368 establishments to the electronics components industry, and 3,285 to the electronic equipment industry. The survey’s data provides geographical information at the village level, helping us to outline the boundaries of ICT clusters.

Milligan and Cooper (1985) proposed that the three criteria that performed best in these simulation studies with a high degree of error in the data, were a pseudo F statistic developed by Calinski and Harabasz (1974), a pseudo t2 statistic by Duda and Hart (1973), and the cubic clustering criterion by Sarle (1983). In large samples that can be divided into the appropriate number of hypercubes, the assumption, in which a uniform distribution on a hyper-rectangle will be divided into clusters shaped roughly like hypercubes, gives very accurate results. The CCC can be used for estimating the optimal number of population clusters. Accordingly, the study refers to the optimal population of ICT cluster in Chinese Taipei to CCC, as well as the pseudo-F statistic and pseudo-t2 statistic.

Figure 9 shows the geographical deployments of 8 ICT industrial clusters in Chinese Taipei. The most northern ICT industrial cluster includes Taipei city and county, Keelung City, and part of Taoyuan County in the geographical bundle. The geographical region of the other ICT industrial clusters in the northern Chinese Taipei includes parts of Taoyuan County, Hsinchu County and city, and parts of Miaoli County.

Figure 9 Deployment of ICT Industrial Clusters in Chinese Taipei



There are three ICT clusters located in central Chinese Taipei. The first ICT cluster consists of Taichung County, and parts of Miaoli and Changhua Counties. The second ICT cluster in Central Chinese Taipei includes Nantou and part of Changhua Counties. The other ICT cluster located in central Chinese Taipei geographically includes Yunlin and Chiayi Counties. Figure 9 addresses two ICT industrial clusters located in southern Chinese Taipei, which are Tainan and Kaohsiung Counties. Finally, the only ICT cluster in eastern Chinese Taipei is deployed in Yilan County.

Table 15 displays the various features and geographical boundaries of these industrial clusters for ICTs. The most northern ICT industrial cluster consists of 1,508 plants and 106,683 employees, the largest industrial cluster in scale. The total R&D intensity, which is defined as R&D expenditure per capita, is NT\$191.55, and capital labor intensity NT\$1,658.60. In this cluster, the share of small firms is 32.32 percent, and the average TFP is 0.009 percent. The other ICT industrial clusters in the northern Chinese Taipei, consists of 173 ICT plants and 51,140 employees. Its R&D intensity and capital-labor ratio are NT\$552.56 and 8,536.34. This cluster is characterized by active innovation activities, and is the location of the globally reputed Hsinchu Science Park.

The first ICT cluster in central Chinese Taipei with Taichung, and parts of Miaoli and Changhua is featured in a lower R&D intensity. The second ICT industrial cluster, located at Nantou and part of

Changhua, is mainly agglomerated by large-scale firms, and 3,226 employees were hired by just nine ICT firms in this cluster. The last ICT cluster located in central Chinese Taipei, in Yunlin and Chiayi Counties, has a lower R&D intensity.

There are two southern ICT industrial clusters, in Tainan and Kaohsiung Counties. The two ICT clusters in southern Chinese Taipei employ 3,032 and 6,814 people at 54 and 93 establishments, respectively. In eastern Chinese Taipei, there is one ICT cluster, in Yilan County. It has attracted only seven establishments and hires 243 persons. This industrial cluster is younger and has a higher productivity growth than the others.

Firm-Level TFP for ICT Industrial Sector

We further used the same data set on Chinese Taipei's ICT industry to construct an index of firm-level TFP for each firm in 1999. By using the TFP index, our aim is to measure cross-firm productivity pattern. The TFP of a firm is estimated in the following equation, which is based upon the multilateral index developed by Good et al (1996):

$$TFP_{ft} = [(\ln Y_{ft} - \overline{\ln Y_t}) + \sum_{k=2}^t (\overline{\ln Y_k} - \overline{\ln Y_{k-1}})] - \frac{1}{2} \left[\sum_{i=1}^n (w_{kft} + \overline{w_{it}}) (\ln X_{kft} - \overline{\ln X_{ft}}) - \sum_{k=2}^t \sum_{i=1}^n (\overline{w_{ik}} + \overline{w_{ik-1}}) (\overline{\ln X_{ik}} - \overline{\ln X_{ik-1}}) \right], \quad \dots\dots\dots (3)$$

where each firm f uses the set of inputs X_{kft} and the input weights S_{ift} to produce a single output Y_{ft} . In this equation, $\overline{\ln Y_t}$, $\overline{\ln X_{ft}}$ and $\overline{w_{it}}$ refer respectively to the average values of output, input and input weight for all firms in year t. This index measures the proportional difference in TFP for firm f in year t relative to the representative firm in the base year. In this paper, we use 1999 as the base time period and consider four types of inputs (n=4); these are, material, energy, labor and capital. Due to the research focusing the TFP difference for 1999, Equation (3) can be simplified as Equation (4),

$$\ln TFP_{ft} = [(\ln Y_{ft} - \overline{\ln Y_t})] - \frac{1}{2} \left[\sum_{i=1}^n (w_{kft} + \overline{w_{it}}) (\ln X_{kft} - \overline{\ln X_{ft}}) \right]. \quad \dots\dots\dots (4)$$

Table 15 presents the average productivity differences for 1999 across industrial clusters. The average TFP level of various clusters ranges from -0.013 (Kaohsing) to 0.218 (Yilan).

Table 15 Overview of Eight ICT Clusters in Chinese Taipei

Regional Deployment of clusters	Number of establishments	Number of employees	R&D intensity (per capita R&D expenditure, NT\$)	Capital labor ratio	Average TFP
Taipei, Keelung city, and part of Taoyuan,	1,508	106,683	191.55	1,658.60	0.009
Part of Taoyuan, Hsinchu, part of Miaoli	173	51,140	552.58	8,536.34	0.090
Part of Miaoli, Taichung, and part of Changhua	184	15,555	61.28	2,325.32	0.015
Yunlin and Chiayi	26	1,276	43.49	919.20	0.041
Part of Changhua and Nantou	9	3,226	304.47	1,432.61	0.054
Tainan	54	3,032	42.52	2,014.15	0.112
Kaohsiung	93	6,814	116.55	1,101.28	-0.013
Yilan	7	243	124.90	188.94	0.218

*: Share of SMEs refers to the share of firms with number of employee under 100 to total number employees for their correspondent industries.
Source: Calculated by the authors.

5.3 Model for Examining Firms' Productivity

Based on a traditional productivity framework, this chapter presents an empirical model to examine whether the productivity pattern confronted by each firm, can be attributed to their regional environments as well as the underlying conditions of firm size, capital intensity, and other firm specific characteristics. Our empirical model comprises an equation describing the productivity difference for 1999 as a function of observable firm's attributes and their regional advantages. The dependent variables are firm's TFP indicator for 1999, taken as a logarithmic value.

Drawing on the 'size-R&D-productivity' framework,⁶ this chapter presents an empirical model to examine whether the TFP pattern confronting each firm is attributable to the underlining the conditions of firm-specific attributes and regional-specific conditions. The firm's own attributes upon the productivity considered in this paper are as follows:

SIZE refers to firm size measured by the number of employees and taken as a logarithmic form. The variable is used as a proxy for economies of scale. Based on Chinese industry data set, the empirical evidence from Liu and Wang (2003) suggests a positive relationship between firm size and TFP, to support the hypothesis that the existence of scale economies leads to a higher TFP.

LKL is the capital intensity measured by the ratio of the book value of operational fixed assets to the number of employees for 1999. This is measured in terms of new Chinese Taipei dollars per thousand people. LKL is taken as a logarithmic value in this paper, and we attempt to apply the dataset on Chinese Taipei's ICT industry to an examination of whether LKL has a positive coefficient in the TFP equation. Capital goods, such as machinery or factories, are characterized by their indivisible and inflexible nature. Morrison (1997) argued that capital is actually quasi-fixity in nature; therefore, as a firm's production technology is more capital intensive, it may suffer higher adjustment costs. Following Morrison's argument, since capital itself is characterized by its inflexible and indivisible nature, we may see capital-intensive firms suffering higher adjustment costs than labor-intensive firms when undertaking such adjustment.

RD is R&D intensity measured by per capita R&D expenditure, as the ratio of R&D expenditure to number of employees. Luh and Chang (1997) and Hanel (2000) addressed the important linkage between R&D and TFP growth. Taking the dynamic and spillover attributions of R&D into account, Luh and Chang (1997) estimated the contribution of R&D to the TFP dynamic in Chinese Taipei's manufacturing sector. It pointed to the accumulation of R&D investment making an explicit contribution towards manufacturing growth. The empirical evidence from Liu, et al., (1999) demonstrated that R&D investment enables plants to accelerate their growth. Drawing on the above arguments, we hypothesize that the coefficients of RD on the TFP equation will be positive.

In addition to a firms own attributes their regional business environments should have a critical influence upon the productivity of those firms. In order to explore the effect of regional-specific attributes on productivity, we draw on the recent work on geographical agglomeration by Aw (2002) and Yang (2002) to consider three regional attributes: regional innovation activities, Porter's externalities, and the Marshall-Arrow-Romer externality. In this study, we empirically examine the effect of three types of agglomeration externality on the productivity of regional firms:

ARDR is regional R&D intensity measured by per capita R&D expenditure in terms of NT\$ thousands. This variable is to proxy the extent of regional innovation activities or the agglomeration effect of corporate R&D activities. It is well recognized that the attributes of innovation activities have a regional spillover effect. Accordingly, we suppose that firms based in the region with high knowledge spillovers are able to enjoy higher performance in TFP.

COM is Porter's externalities. Drawing on Glaeser et al (1992), we measure Porter's externalities for an industrial cluster by the ratio of number of regional firms to the total number of employees in the region.⁶ The Porter externality arises from regional specialization and the differentiation of

⁶ Glaeser et al., (1992) adjusted Porter's externalities by the ratio of firms in industry to worker in

products. This effect stems mainly from local rivalry between firms, which further fosters the rapid diffusion of knowledge and the adoption of new ideas. The development of industrial clusters may lead to simultaneous competition and collaboration in offering innovative products and services, and further establish a sustainable competitive advantage in the dimensions of technology, the workforce, production methods, delivery time, quality, and resource procurement. To some extent, we believe it is reasonable to assume that a region under pressure from high competition forces companies to boost productivity more aggressively. Accordingly, we expect the coefficient of COM in the TFP equation to be positive.

JO is Marshall-Arrow-Romer externality. Following Glaeser et al (1992), we measured Marshall-Arrow-Romer externality by the ratio of number of regional ICT industry employees to the number of regional employees in the electrical components and equipment industries. The Marshall-Arrow-Romer externality highlights industrial specialization within a region. Each firm in the cluster enjoys the benefits of saving investment costs by specializing within a narrow area of the value-added chain. Similar firms within the clusters find ways to differentiate themselves by locating unique market niches that have not been filled by other firms.

We set a regression of the TFP equation of firms in a trans-log format and summarize the above discussion in Equation (5):

$$TFP = F(SIZE, RDL, LKL, ARD, ARDR, COM, JO) \dots\dots\dots(5)$$

5.4 Empirical Results

Table 16 Variable Definitions and Sample Statistics

Variables	Definitions	Mean	Std. Dev.
TFP	TFP for 1999	-0.236	0.608
SIZE	Firm size in terms of number of employees, taken natural logarithm	3.233	1.427
RDL	Firm's R&D intensity, per capita R&D expenditure, in terms of NT thousand	0.086	0.245
LKL	Capital-labor ratio for each firm, taken natural logarithm	6.552	1.359
ARDR	Regional R&D intensity, per capita R&D expenditure, in terms of NT thousand	0.0573	0.018
COM	Regional Porter's externalities, measured by the ratio of number of regional firms to the total number of employees in the region.	1.169	0.383
JO	Marshall-Arrow-Romer externality, measured by the ratio of number of regional ICT employees to the number of regional employees for the electrical components and equipment industries.	0.306	0.155
number of observations		2,054	

Source: The data of "the annual manufacturing-plant survey in 1999," MOEA.

We now turn to an examination of the determinants for ICT productivity in Chinese Taipei for 1999. To re-evaluate the determinants of the TFP, firm and regional-specific attributes are taken into consideration in this paper, with a summary of the variable definitions being provided in Table 16. There are 2,054 samples used in the empirical study.

Table 17 presents the GLS empirical results of the TFP regression. One common problem unaccounted in a cross-sectional estimation is heteroskedasticity. The Breush-Pagan χ^2 statistics indicate the existence of significant heteroskedasticity problems in the linear model. This study applies the White (1980) method of estimation with heteroskedasticity in the least squares model with the unknown variance-covariance matrix.

industry. However, this paper looks at ICT industry only. The adjuster terms can be ignored.

Table 17 Estimation of ICT Firm's TFP in Chinese Taipei, 1999

	(1)	(2)
Constant	0.613*** (4.71)	0.980*** (16.66)
SIZE	0.113*** (11.44)	0.112*** (11.76)
RDL	0.183*** (2.34)	0.173** (2.28)
LKL	-0.248*** (-25.58)	-0.249*** (-25.66)
ARDR	2.236*** (2.45)	-
COM	0.137*** (2.63)	-
JO	0.223*** (3.72)	-
\bar{R}^2	0.381	0.376
F test	83.20***	205.13***
Log-Likelihood	-1401.348	-1410.586
Breusch-Pagan $\chi^2(1)$	283.03	278.21***
Number of Observations	2,054	2,054

Notes:

- a All regressions include three dummy variables for three-digit SIC industries.
- b Figures in parentheses are t-statistics calculated by coefficients and White standard errors.
- c *** represents statistical significance at the 1 percent level, ** at the 5 percent, and * at the 10 percent

The overall indications from the empirical results presented in Table 17 point to the important role played by regional attributes in determining ICT firm's TFP. These results may indicate that the collectiveness of the cluster provides firms with some advantages. As in earlier studies, the emergence of industrial clusters is recognized as shaping and driving the competitiveness of firms within clusters at both national and global levels. Two out of three types of agglomeration externalities classified by Glaeser et al (1992) is supported empirically.

Capital intensity in terms of their correlation to firms' TFP is underlined in this research. The coefficient of LKL is negative and statistically significant, revealing that firms with greater capital-intensity have lower productivities. This is because capital intensity is quasi-fixed in nature and firms with high capital intensity have a lower capability of achieving optimal factor allocation. The empirical results on the capital intensity accord with other empirical works, such as Sharma et al (2000) on Nepal, Yean (1997) on Malaysia, and Datta (2003) on the telecommunication sector in the US, that firms with higher capital intensities usually suffer the risk of over-investment and have lower productivities.

Table 17 also presents the empirical results of R&D intensity, the coefficient of which is positive and significant on the TFP, indicating that firms undertaking R&D investment will reap subsequent rewards in terms of their own TFP. The empirical results for RD are generally consistent with earlier studies, such as Luh and Chang (1997), Datta (2003), and Liu and Wang (2003), in which R&D investments are viewed as important sources for improving TFP.

The empirical result shows that the effect of ICT firms' size on TFP is significant, indicating economies of scale (Liu and Wang, 2003; Datta, 2003). In other words, there exist scaled economies in which a firm or a plant with a higher scale can enjoy a higher TFP.

Theoretical attempts, such as Alfred Marshall's, to formalize agglomeration effects have focused on three mechanisms that yield positive feedback loops: inter-firm technological spillovers, specialized labor, and intermediate inputs. In this paper, parts of the argument can be supported. Table 17 shows that the coefficient of ARDR, regional innovation activities and inter-firm technological spillovers, upon firms' productivity is statistically significant and positive. The

empirical result is in line with our assumption that productivity can be improved through regional innovative activities. To some extent, the empirical results may enrich the content of the 'site-selection' literature that has focused mainly on the geography of new R&D facilities and investment by MNCs, for example (Frost and Zhou, 2000; Dambrine, 1997; Voelker and Stead, 1999). MNCs tend to locate their R&D in relatively technologically specialized host regions, as a means of gaining access not only to foreign centers of excellence, but also to take advantage of localized knowledge spillovers for enhancing their productivities.

Table 17 further shows the coefficient of COM to be significant and positive in the TFP equation, indicating that regions with more competitive pressure force regional firms to boost productivity more aggressively. That is, Porter's externalities, stemming from regional rivalry, lead to simultaneous competition and collaboration in offering innovative products and services, and further establish a sustainable competitive advantage in the dimensions of technology, workforce, production methods, delivery time, quality, and resource procurement.

Table 17 further shows the coefficient of JO to be significant and positive in the TFP equation, indicating that regions with more specialized labor benefit productivity. Each firm in the cluster with higher JO enjoys the benefit from saving investment costs by specializing within a narrow area of the value-added chain. The empirical results are in line with the body of literature on industrial clusters, in which a pooled market for workers with specialized skills, argued by Alfred Marshall's external economies.

Finally, we further perform a model specification test to examine whether the regional factors matter for the determination of a firms' productivity. The null hypothesis is that the regional factors play no role for firms' TFP. The empirical outcomes in Table 17 are shown in column (2). The alternative hypothesis is that some regional factors have effect upon firms' productivities. In other words, based on Equation (4), we can formalize the above idea as follows,

$$H_0: \beta_1 = \beta_2 = \beta_3 = 0$$

$$H_a: \text{at least } \beta_i \neq 0, i=1, 2, 3.$$

We solve a log-likelihood $\chi^2(3) = 18.476$, for which the statistically significantly result rejects the null hypothesis at 1 percent. This empirical result shows that the regional factors in industrial clusters cannot be ignored in calculating productivity.

5.5 Conclusions

This chapter uses micro data on Chinese Taipei's electronics industry to measure TFP in exploring how companies' heterogeneities and regional conditions affect firm productivity. We examine whether, beside a firms size, production technologies, and R&D investments, the roles played by the attributes of industrial clusters relate to the firms' productivities.

Apart from the traditional approach based on administrative regions, we propose a multivariate-cluster analysis to conclude the optimal populations of ICT industrial sectors and outlining the boundaries of each industrial clusters. Various regional attributes stemming from industrial clusters can be explored in this study.

Furthermore, a firm's total factor productivity equation is employed to empirically examine whether, in addition to firm-specific factors, regional factors can be significant determinants. A general conclusion from our empirical examination is that firms with higher-capital intensity have lower productivities. This may indicate that capital intensity is quasi-fixed in nature, and that firms with higher capital intensity suffer from the difficulty of promoting allocation efficiency with regard to their production factors. The economic implication behind this finding is that encouraging the adoption of capital-intensive production methods, as a means of driving firms' competitiveness seems to come at the cost of a loss of productivity for firms.

Evidence that there are regional advantages, rooted in industrial clustering, to firms' productivity within the ICT industry is significant. That is, firms within a region with various abundant externalities of an industrial cluster enjoy higher productivity. Industrial agglomeration externalities enable firms within a cluster to enjoy higher growth and competitiveness, and these three types of externality have pointed to some important dimensions in the competitiveness of industrial clusters. There are three types of externalities considered in this paper: innovational, Porter's, and Marshall-Arrow-Romer externalities. Generally, a χ^2 test for ICT industrial clusters in Chinese Taipei was performed to witness that each firm's competitiveness cannot be only attributed to its own attributes, but also its regional conditions, including innovational activities, market competition, and specialization.

The policy implication of the empirical results is as follows: Firms within a region can share a common dependence on research, innovation, knowledge and regional industry-specific assets. With respect to public policies, governments' investment in regional innovation (R&D) systems seems to be increasingly important for promoting firms' TFP for the knowledge-based economy. Furthermore, empirical evidence also shows that competition pressure within industrial clusters enables regional firms to improve their productivity more aggressively. This implies that regional market deregulation to reduce market entry barriers can result in the facilitation of regional advantages.

6. CONCLUSIONS AND POLICY IMPLICATIONS

6.1 Conclusions

By examining the development of industrial clustering within the APEC region, the two-year study, which began in 2003, is to: (i) explore the factors contributing to the successful formation of industrial clusters and the overall effects of industrial clustering on productivity; (ii) gain an understanding of the organization and networking of industrial clusters; and (iii) highlight the interrelationships that exist between industrial clustering and innovation. The important findings of this study are summarized as follows:

1. **Innovation and Growth as the Two Ingredients:** Industrial clustering occurs not only in high-tech industries, but also in so-called traditional industries. It appears that innovation and growth are the two most important elements in the formation of an industrial cluster. Innovation provides the dynamics for competition and restructuring. Innovation also underlines the benefits of knowledge sharing, which is the basic reason for firms to congregate together. When innovation stops, the industrial cluster is likely to go into a decline and firms in the cluster start to dislocate, which is the inversion process of clustering. Meanwhile, growth is important both in terms of inducing new entry and facilitating a division of labor within the industry. Growth in most cases is demand-driven and therefore linking (or access) to the major market is the key to the formation of an industrial cluster. In short, an industrial cluster is characterized by innovation internally, and by growth externally.
2. **Indigenous Skills for Developing Human Resources:** Human resources are indispensable to the build-up of innovation capability. The case of Hsinchu Science-Based Industrial Park (HSIP) demonstrates the importance of brain circulation in the development of an industrial cluster. An economy that invests in human resources may not be able to utilize them fully because of the lack of opportunities and therefore it may suffer from a brain drain. But as the economy develops, the human resources that have been deposited elsewhere found their way back, prompting a "reverse" brain drain. When the economy develops more, it may even attract skilled labor from foreign countries, therefore benefiting from the human resources investments made by other economies. It is noticeable that human resources that are repatriated or borrowed from abroad are always insufficient to support the operations of an industrial cluster, as they have to be complemented by indigenous skills. In fact, indigenous skills are pivotal in leveraging foreign-based skills. Indigenous skills are the core of location advantage that underlines the formation of an

industrial cluster. In the case of HSIP, foreign-based skills brought product innovations, but they contributed little to management of production or marketing of products. Product innovations brought about from abroad are likely to be a one-shot event, and need to be appended by internal R&D to set off an innovation cycle. As time goes by, indigenous skills play an increasing role in innovations within the cluster.

3. **Clusters Enhancing Industry Restructuring:** The HSIP and the Hamamatsu case of Japan also demonstrate the possibility of industry restructuring within a cluster when the growth engine slows down. A cluster develops on the basis of a rapidly growing industry. As the growth rate slows down, there is a possibility for the cluster to switch to other industries to catch on a new growth engine. The ability to do so appears to hinge on the technological capability within the cluster and a reliable market linkage. In the case of HSIP, the cluster has switched from a computer-centered development path in the 1980s to an integrated circuit (IC)-centered development path in the 1990s. The market linkage can be easily struck because the two industries are vertically related. While the IC industry emerged, the computer industry was there to provide a consumption base for its products. The recent emergence of the liquid crystal display (LCD) industry followed the same pattern of industrial restructuring.
4. **Subcontracting and Vertical Disintegration:** It is apparent that subcontracting is a prevalent practice within the cluster. Subcontracting allows firms in the cluster to realize economies of scale while maintaining the flexibility of production. Horizontal differentiation is an important characteristic of a cluster, as it allows for product competition and knowledge sharing. Subcontracting also allows for vertical disintegration within the cluster, which in turn, brews specialized suppliers. Marshall (1890) believes that specialized suppliers are the major benefit-generator of a cluster. In the case of HSIP, subcontracting is more attractive to export firms and more likely to be associated with larger firms. This suggests that linkages to a large, export market tend to facilitate vertical disintegration, which in turn, allows individual firms to grow larger. Subcontracting relationships may also be arranged with firms outside the cluster boundary, but in this case the contract tends to be long-term. The ability to subcontract appears to have reduced the entry barriers to potential firms, as more entries have been observed in industrial clusters than in other places. Easier entry means more competition, which sets off the dynamics of the industry.
5. **Agglomeration and Firm Productivities:** Our study also shows that industrial clustering improves the productivity of individual firms. Both Porter externality and Marshall-Romer externality seem to be working for the benefits of the member firms in a cluster. Porter externality is based on local rivalry, which is characterized by horizontal differentiation of products. Marshall-Romer externality is based on the benefits of industry size and labor-pooling effects. Although the two externalities differ in nature, they probably exist simultaneously in a cluster. If firms in a cluster are more productive than those outside the cluster, it naturally follows that firms that locate too distant from the cluster will be driven out of the industry by competition. On the other hand, a potential firm should choose to locate in a cluster if it decides to enter the industry at all. This, of course, is the main driving force for agglomeration. Once the agglomeration force is at work, a cluster will be automatically formed.

6.2 Policy Implications

1. **Having no One-size-fit-all Successful Formula:** Industrial clustering can be a useful policy for regional as well as national economic development. In an industrial cluster, the government, universities and firms form a complementary network to facilitate continuous industrial growth, upgrading and restructuring. As an industrial cluster establishes a regional competitive advantage that allows itself to absorb technologies, create new technologies, diffuse knowledge, and retain skilled workers. National endowments create industrial districts, but it afterwards takes some policy efforts to transform an industrial district into an industrial cluster. To keep in mind, there is no one-size-fit-all formula for successful industrial clustering and therefore an economy should allow its comparative advantage to determine what industries to be put in a cluster. Benefits of industrial clustering apply to

both high-tech and traditional industries and there is no reason why developing countries cannot benefit from industrial clustering even if they lack the ability to develop a high-tech industry.

2. **Improving Investment Infrastructures:** Infrastructure such as electricity, water, telecommunications, and living environment are important to pull potential firms and human skills together. For developing countries that lack the resources to embark on a full-blown infrastructure development, it may be useful to concentrate the effort in a small region. After a cluster emerges in the region, then the area can be gradually expanded to include adjacent regions.
3. **Developing Human Resources:** Human resources seem to be an indispensable ingredient in the formation of an industrial cluster. Although part of the human resources can be obtained from abroad, the availability of local-sourced human resources is crucial to the operations of the cluster. Therefore, investment in human resources is an absolute necessity for any economy that is interested in developing an industrial cluster. There is no evidence that training institutions such as universities have to be located near the cluster, but geographical proximity appears to be useful in terms of facilitating knowledge diffusion. Public institutions devoted to industry-specific training of human resources also prove to be useful in accelerating skill formation in preparation for cluster development.
4. **Building Innovation Capabilities:** Innovation is an important element in the operation of an industrial cluster. Without the capability to innovate, an industrial cluster will soon be on the decline and firms will begin to disperse and relocate to other regions. This capability has to be owned by firms themselves; public institutions can help but they cannot replace private efforts. This implies that a cluster may be developed initially by borrowing foreign technologies but eventually the sustainability of the cluster has to depend on indigenous technologies. Without the indigenous technologies, a cluster can only be an enclave at best. In other words, foreign investment is not enough to create a sustainable industrial cluster. The government has to make sure that indigenous technologies can be accumulated along with the formation of an industrial cluster.
5. **Linking to Sources of Growth:** Growth is also a very important element in an industrial cluster. Growth leads to an increase in the number of firms and it drives horizontal differentiation of products. Without significant growth in market demand, a cluster will never emerge. Therefore linkage to a growing market is essential to the formation of a cluster. For most developing countries, the major growing markets are often in the developed countries, and therefore the ability to export to these markets is critical to the success of an industrial cluster. In this regard, foreign direct investment is useful in bringing about the linkage to the export market. But foreign investment is usually insufficient to set a cluster in motion for it lacks the dynamics of innovation. Domestic firms have to be a part of the export drive, making their own linkage to the major markets. Sometimes personal connections such as returned engineers from the major markets also help.
6. **Removing the Barriers to Vertical Disintegration and Subcontracting:** Vertical disintegration is a norm in industrial clusters. Vertical disintegration allows specialized suppliers to reap the benefits of economies of scale, which is an important driving force for agglomeration. There is no apparently effective policy to prompt vertical disintegration in the industry. Vertical disintegration is a result of competition and the need to cut production costs through subcontracting and out-sourcing. The only meaningful policy in this regard is to ensure that competitive force is at work in the industry. The government should not attempt to protect the incumbent firms or to create a situation that brews monopoly. Even if the domestic firms have a dominant position in the world market, it is useful to make them contestable. The prevalence of subcontracting and out-sourcing arrangements in an industrial cluster not only allow specialized suppliers to emerge, but also reduce the cost of entry. As the entry barrier is lowered, more firms will compete in the industry, which drives the dynamic process of clustering. The empirical evidence has shown that entry barriers are lower in the industries that are more geographically concentrated. Therefore industrial clustering is also useful in promoting competition and incubating small and medium

enterprise (SMEs). The government can adopt some proactive policies to attract specialized suppliers in the cluster if they are absent for the reason of location-specific entry barriers. Any missing links in the production chain tends to limit the development of an industrial cluster.

7. **Enhancing Productivity:** The fact that firms in an industrial cluster are more productive than their counterparts outside the cluster suggests that clustering is also a process in which inefficient firms are eliminated and the surviving firms are increasingly concentrated geographically over time. It suggests that a government policy aiming at relocating existing firms to economically disadvantageous region, such as low-income areas, is probably counter-productive. Only the declining industries in which agglomeration effects stop operating will the existing firms start to disperse and to seek lower-cost regions for relocation. A more sensitive policy for the disadvantageous regions is to find new ingredients such as human resources to attract location-specific industries that will eventually develop into a cluster. If this is not feasible then the alternative would be to develop the region into a satellite cluster for the existing clusters. As long as geography matters in industrial development, it is more important to link the regions to a manufacturing center or a market center rather than to lure existing firms away from a successful cluster.

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ACRONYMS

ACRONYMS

AIT	Agreement On Internal Trade	OEM	Original Equipment Manufacturer
API	Advanced Passenger Information	PDC	Penang Development Corporation
APP	Advanced Passenger Processing	PSDC	Penang Skills Development Centre
CER	Closer Economic Relations	R&D	Research And Development
CICIC	Canadian Information Centre for International Credentials	S&T	Science and Technology
CPS	Current Population Survey	SBFE	State Bureau of Foreign Experts
EU	European Union	SMES	Small And Medium Enterprises
FDI	Foreign Direct Investment	SOEs	Small Open Economies
GPN	Global Production Network	TFP	Total Factor Productivity
HP	Hewlett-Packard	TSMC	Taiwan Semiconductor Manufacturing Company
HQP	Highly-Qualified People	TTMRA	Trans-Tasman Mutual Recognition Arrangement
HRST	Human Resources In Science And Technology	TTTA	Trans-Tasman Travel Arrangement
HSBP	Hsinchu Science-Based Park	UMC	United Microelectronics Company
HSIP	Hsinchu Science-Based Industrial Park	US-CIS	US Citizenship And Immigration Services
HSMP	Highly Skilled Migrants Programme	VCs	Venture Capitalists
IC	Integrated Circuit	WTO	World Trade Organisation
IMR	Internationally Mobile Resource		
IT	Information Technology		
ITRI	Industrial Technology Research Institute		
LCD	Liquid Crystal Display		
M&A	Mergers And Acquisitions		
MNCS	Multinational Corporations		
MNES	Multinational Enterprises		
MOEA	Ministry Of Economic Affairs		
OBMs	Original Brand Manufacturers		
ODMs	Original Design Manufacturers		



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