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World Knowledge Competitiveness Index 2008

Centre for International Competitiveness

Robert Huggins

Hiro Izushi

Will Davies

Luo Shougui

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Robert Huggins
Centre for International Competitiveness
Cardiff School of Management
University of Wales Institute, Cardiff

Hiro Izushi
Centre for International Competitiveness
Aston Business School
Aston University

Will Davies
Associate
Centre for International Competitiveness

Luo Shougui
College of Antai Economics and Management
Shanghai Jiao Tong University

Published by: Centre for International Competitiveness
Cardiff School of Management
University of Wales Institute, Cardiff
Colchester Avenue
Cardiff
CF23 9XR
Wales
United Kingdom

Telephone: +44 (0) 29 2041 7075

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Executive Summary

This report represents the fifth edition of the World Knowledge Competitiveness Index (WKCI), the first composite and relative measure of the knowledge economies of the world's leading regions. The WKCI is an integrated and overall benchmark of the knowledge capacity, capability and sustainability of each region, and the extent to which this knowledge is translated into economic value, and transferred into the wealth of the citizens of each region. As such, the competitiveness of a region will depend on its ability to anticipate and successfully adapt to internal and external economic and social challenges, by providing new economic opportunities, including higher quality jobs.

The 2008 edition of the WKCI compares 145 regions across 19 knowledge economy benchmarks (full data for all indicators across each of the 19 benchmarks in contained in the accompanying Excel spreadsheets). This represents an increase of twenty regions compared to the last edition in 2005: nine from Europe, eight from North America, and three from Asia Pacific. These new regions were selected on the basis of a survey of a wide range of regions appearing to be become more internationally competitive. This year's report also contains a special chapter on economic development in the three leading Chinese regions.

Once again, at the top of the index is the US metropolitan area of San Jose (248.3). The region, the home of Silicon Valley, continues to lead the WKCI rankings by some distance, due to its enormous investment in knowledge-intensive business development, in particular in the fields of high-technology engineering, computers, and microprocessors. Despite the onset of the dot-com crash earlier in the decade, San Jose has remained a clear leader across a number of knowledge employment sectors, as well as ranking amongst the top regions worldwide for investment in education and business R&D, as well as for corresponding economic output indicators such as productivity and earnings.

Remaining in second place in 2008 is the metropolitan area of Boston, a region which thrives on high levels of intellectual and financial capital. Boston, is of course, synonymous with higher education, and is home to eight research universities including Harvard and the Massachusetts Institute of Technology. Hartford moves further up the index to third, with its score boosted by very strong results for both R&D spending and private equity investment, which translate into a very strong productivity score: Hartford ranks as the highest region worldwide by productivity in our rankings. The neighbouring Connecticut region of Bridgeport, a new region in this year's index, enters in an impressive fourth place while San Francisco slips two places to fifth.

Stockholm moves up two places to sixth position, and the continued improvement of Stockholm's ranking has been based on gains across a range of indicators – in particular, business R&D spending, biotechnology and chemical sector employment, and higher education spending. Tokyo moves up from twenty-second to ninth position, while Shiga, West Sweden and West Netherlands all move into the top twenty. The new regions of Iceland and Pohjois-Suomi (Finland) diluting the influence of North American regions. The top twenty now contains thirteen US regions, five European regions and two Japanese regions.

At the foot of rankings we continue to find the Chinese, Indian and Eastern European regions – the lowest ranked being Bangalore, Mumbai and Hyderabad. Amongst the emerging regions in the index, Shanghai continues to perform best, increasing its ranking one again despite the entry of twenty new regions, mostly from Europe and the US. Shanghai is now ahead of the likes of Berlin and British Columbia, which shows how far the most developed amongst the Chinese regions has come in recent years. Also, our index of Regional Knowledge Intensity (a measure comparing the underlying knowledge base of a region in relation to its direct economic output) is headed by the Guangdong region of China.

CHAPTER ONE

This report represents the fifth edition of the World Knowledge Competitiveness Index (WKCI), the first composite and relative measure of the knowledge economies of the world's leading regions. The WKCI is an integrated and overall benchmark of the knowledge capacity, capability and sustainability of each region, and the extent to which this knowledge is translated into economic value, and transferred into the wealth of the citizens of each region. As such, the competitiveness of a region will depend on its ability to anticipate and successfully adapt to internal and external economic and social challenges, by providing new economic opportunities, including higher quality jobs.

The global importance of the concept of competitiveness has increased rapidly in recent years, with the issues surrounding it becoming, at the same time, both more empirically refined and theoretically complex. It was the research of Michael Porter that first defined national competitiveness as an outcome of a nation's ability to innovate in order to achieve, or maintain, an advantageous position over other nations in a number of key industrial sectors. Further work by Lester Thurow determined that it is primarily knowledge-based industries within which a nation need specialise in order to obtain a word-class standard of living for its citizens.

We define such competitiveness as referring to the capability of an economy to attract and maintain firms with stable or rising profits in an activity, while maintaining stable or increasing standards of living for those who participate in it. This makes clear that competitiveness is not a zero-sum game, and does not rely on the shifting of a finite amount of resources from one place to another. However, competitiveness does involve balancing the different types of advantages that one place may hold over another – the range of differing strengths that the socio-economic environment affords to a particular place compared to elsewhere.

While the competitiveness of both nations and regions will be intrinsically bound to their economic performance, there exists a growing consensus that competitiveness is best measured in terms of the 'assets' of the local business environment – such as the level of human capital, the degree of innovative capacity and the quality of the local infrastructure – which affect the propensity of a region to achieve competitive advantage in technologically leading-edge and growing sectors of activity. In other words, competitiveness is increasingly being measured in terms of creativity, knowledge and environmental conditions, rather than purely based on accumulated wealth.

The 2008 edition of the WKCI compares 145 regions across 19 knowledge economy benchmarks (full data for all indicators across each of the 19 benchmarks in contained in the accompanying Excel spreadsheets). This represents an increase of twenty regions compared to the last edition in 2005: nine from Europe, eight from North America, and three from Asia Pacific. These new regions were selected on the basis of a survey of a wide range of regions appearing to be become more internationally competitive. This year's report also contains a special chapter on economic development in the three leading Chinese regions.

The results of our analysis are combined to produce a composite index of knowledge competitiveness. The series of benchmarks we establish identify the relative strengths and weaknesses of regional economies in terms of their knowledge capacity, capability and utilisation. The focus on the global benchmarking of regions is highly relevant, since there is an increasing appreciation that it is regions, rather than whole nations, that are competing in the global knowledge-based economy. Here we define the knowledge-base of an economy as:

> 'the capacity and capability to create and innovate new ideas, thoughts, processes and products, and to translate these into economic value and wealth.'

The importance of the concept of competitiveness is now firmly embedded within economic policymaking around the world. As such, measuring, understanding and analysing competitiveness at a number of geographic levels has become a vital factor in creating an informed dialogue, and can contribute to a policy environment attuned to enhancing the economic performance of nations and regions across the world.

To this end, we have selected those indicators currently available that enable a quantitative comparison of the competitiveness of an economy: these include levels of labour productivity, investment in research and development activities, expenditure on education, levels of employment and economic activity rates, ICT infrastructure density, access to private equity, and employment in 'knowledge-based' sectors. These so-called knowledge-based sectors primarily concern high-technology manufacturing and knowledge-based services such as telecommunications, IT services, and research and development activities.[1]

Conceptualising the Knowledge Economy

The conceptual model we employ to analyse regional knowledge economies, as illustrated by Figure 1.1, is a multi-linked cycle model representing knowledge creation and utilisation as well as capacity building. The model reflects the latest thinking on the innovation process, which sees it as a process whereby agents in different domains (e.g. departments/divisions of private firms, universities, research laboratories and governments) interact with one another through feedback loops. We extend this thinking to the regional level and add a component that reproduces and sustains the whole system's innovative capacity.

The model consists of four key components: (1) Capital Inputs; (2) Knowledge Economy Production; (3) Regional Economy Outputs (including Knowledge Economy Outputs); and (4) the Sustainability Link. Each of these components, with the exception of Knowledge Economy Production, has representative variables, while Knowledge Economy Production is regarded as a production function that transforms Capital Inputs into Regional Economy Outputs.

Capital Inputs consist of four groups: Knowledge Capital, Human Capital, Financial Capital, and Physical Capital. Until recently, economists tended to account for economic outputs, or growth, of geographic areas via measurements of 'capital' and 'labour'. 'Capital' refers to physical units of, or fixed investments in, production such as land, plants, machinery and equipment, while 'labour' is defined by the number of 'heads' in employment (or working population). Under this framework, a residual that cannot be explained by these two factors is often seen as an indicator of technical change.

This traditional accounting model has given way to new models resulting from to two key developments in economic theory: human capital theory and endogenous models of economic growth. Human capital theory recognises skills and expertise gained through education and training as investment made by, and embodied in, individuals. This is a departure from the traditional models of economic growth that do not distinguish any differences between individuals. Endogenous economic growth theory views the accumulation of knowledge as a key source of long-run economic growth, and acknowledges the creation of knowledge by private-sector firms, through Schumpeterian competition (i.e. temporary monopoly of economic gains deriving from new knowledge by its inventor), as an internal (i.e. endogenous) factor.

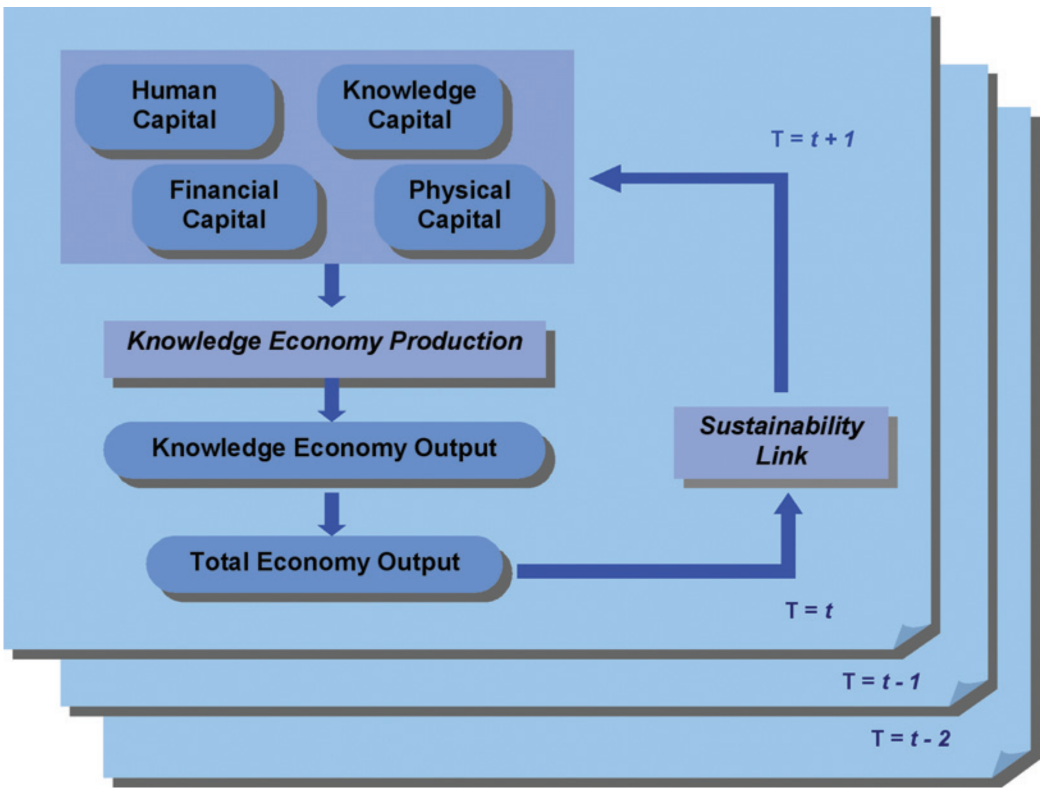
The four groups of Capital Inputs in our model incorporate these developments in economic theory. While Physical Capital refers to capital in the traditional parlance of economics, Financial Capital emphasises the liquidity of financial resources mobilised into new areas of growth and knowledge (e.g. products, sectors, industries) through sources such as venture capital. Knowledge Capital is the raw material of the knowledge economy, referring to the region's capacity for, or its resources aimed at, creating new ideas. Ideas in this realm are not necessarily created with consideration for commercial applications, with the sources of such new ideas ranging from universities and research establishments to firms, individuals and other organisations. Included as a form of Knowledge Capital is the intermediary throughput produced during the course of converting knowledge into commercial values. Finally, Human Capital indicates the capacity of individuals in a region to create, understand and utilise knowledge for the creation of commercial values.

The combination of the four types of capital within the region results in the production of knowledge-based goods and services containing high value-added. These knowledge-based goods and services, which we term Knowledge Economy Outputs, form part of the total outputs of the region's economic activity, i.e. Regional Economy Outputs. The distinction between Knowledge Economy Outputs and Regional Economy Outputs signifies our assumption that innovative knowledge outputs embodied in goods and services are not always translated evenly into the wealth a region's inhabitants will enjoy.

The cycle is completed by the requirement for Knowledge Sustainability. Unless part of the wealth created is re-invested into Capital Inputs, and particularly Knowledge Capital and Human Capital, to support their reproduction and further development, the medium to long-term prosperity of a regional economy will be undermined.

[1] Although it is clear that knowledge utilisation is not confined to any particular sectors of activity, in terms of the best available means of analysis and measurement we are required to work on the assumption that the intensity of knowledge utilisation is higher in certain sectors of activity than others.

Conceptualising the Regional Knowledge Economy **Figure 1.1**



Research Design

The key factor underlying the selection of regions for benchmarking is their relative gross domestic product (GDP) per capita. In the main, those regions included in the WKCI are those that have achieved the highest output per capita across the globe during the recent period. However, there are a number of exceptions in the case of Asian regions, which although they do not currently have a GDP per capita as high as many of their North American and European counterparts, they have experienced a level of output growth that can be said to merit their inclusion. The same is true of the Baltic regions of Latvia, Lithuania and Estonia which, although still relatively poor by European standards, have displayed significant potential through their recent rates of knowledge-based economic growth. Of the 145 regions contained in the index there are 63 representatives from North America, 54 from Europe and 28 from Asia and Oceania. For the purposes of this report, Israel is included under Asia Pacific on the basis that it is not a Eurostat region.

European Regions
Brussels, Belgium
Vlaams Gewest, Belgium
Baden-Württemberg, Germany
Bayern, Germany
Berlin, Germany
Bremen, Germany
Hamburg, Germany
Hessen, Germany
Niedersachsen, Germany
Nordrhein-Westfalen, Germany
Saarland, Germany
Schleswig-Holstein, Germany
Denmark
Estonia*
Noreste, Spain
Comunidad de Madrid, Spain
Île de France, France
Centre-est, France
Southern and Eastern, Ireland
North West, Italy
Lombardia, Italy
North East, Italy
Emilia-Romagna, Italy
Central, Italy
Lazio, Italy
Lithuania*
Luxembourg
Latvia*
North, Netherlands
East, Netherlands*
West, Netherlands
South, Netherlands
East, Austria
West, Austria
Etela-Suomi, Finland
Lansi-Suomi, Finland*
Pohjois-Suomi, Finland*
Stockholm, Sweden
Ostra Mellansverige, Sweden*
South, Sweden
Smaland Medoarna, Sweden
West, Sweden
Eastern, UK
London, UK
South East, UK
South West, UK*
Scotland, UK
Switzerland
Norway
Prague, Czech Republic
Bratislavsk_, Slovak Republic
Budapest, Hungary
Iceland

North American Regions
Akron, US*
Atlanta-Sandy Springs-Marietta, US
Austin-Round Rock, US
Baltimore-Towson, US
Boston-Cambridge-Quincy, US
Bridgeport-Stamford-Norwalk, US*
Buffalo-Niagara Falls, US
Charlotte-Gastonia-Concord, US
Chicago-Naperville-Joliet, US
Cincinnati-Middletown, US
Cleveland-Elyria-Mentor, US
Colorado Springs, US*
Columbus, US
Dallas-Fort Worth-Arlington, US
Denver-Aurora, US
Detroit-Warren-Livonia, US
Durham, US*
Grand Rapids, US
Greensboro-High Point, US
Hartford, US
Houston-Sugar Land-Baytown, US
Indianapolis, US
Jacksonville, US
Kansas City, US
Las Vegas-Paradise, US
Los Angeles-Long Beach-Santa Ana, US
Louisville, US
Memphis, US
Miami-Fort Lauderdale-Miami Beach, US
Milwaukee-Waukesha-West Allis, US
Minneapolis-St. Paul-Bloomington, US
Nashville-Davidson--Murfreesboro, US
New York-Northern New Jersey-Long Island, US
Oklahoma City, US*
Orlando-Kissimmee, US
Oxnard-Thousand Oaks-Ventura, US*
Philadelphia-Camden-Wilmington, US
Phoenix-Mesa-Scottsdale, US
Pittsburgh, US
Portland-Vancouver-Beaverton, US
Providence-Fall River-Warwick, US*
Raleigh-Cary, US
Richmond, US
Riverside-San Bernardino-Ontario, US
Rochester, US
Sacramento--Arden-Arcade--Roseville, US
Salt Lake City, US
San Antonio, US
San Diego-Carlsbad-San Marcos, US
San Francisco-Oakland-Fremont, US
San Jose-Sunnyvale-Santa Clara, US
Sarasota-Bradenton-Venice, US*
Seattle-Tacoma-Bellevue, US
St. Louis, US
Tampa-St. Petersburg-Clearwater, US
Virginia Beach-Norfolk-Newport News, US
Washington-Arlington-Alexandria, US
Alberta, Canada
British Columbia, Canada
Manitoba, Canada
Ontario, Canada
Quebec, Canada
Saskatchewan, Canada

Asia/Oceania Regions
New South Wales, Australia
Victoria, Australia
Western Australia
Israel
New Zealand
Tochigi, Japan
Tokyo, Japan
Kanagawa, Japan
Toyama, Japan
Shizuoka, Japan
Aichi, Japan
Shiga, Japan
Kyoto, Japan
Osaka, Japan
Seoul, Korea
Ulsan, Korea
Hong Kong
Singapore
Taiwan
Shanghai, China
Beijing, China
Tianjin, China*
Guangdong, China*
Jiangsu, China*
Zhejiang, China*
Shandong, China*
*Denotes new region

The European regions in the WKCI are based on the European Union's definition of regional units, NUTS-1. Due to this definition, some nations are included as regions (i.e. Denmark and Luxembourg). In addition, three non-EU member countries, Switzerland, Norway and Iceland (new addition to the WKCI 2008) are included in the analysis and are treated as regions. Among the European Union's new EU-10 nations, three regions – Bratislava in the Slovak Republic, Budapest in Hungary and Prague in the Czech Republic – are included in the index. Three of the other new European nations – Latvia, Lithuania and Estonia – are also newly included this year as region-states. Other new European regions included this year are: Lansi-Suomi and Pohjois-Suomi in Finland, the South West of the UK, Ostra Mellansverige in Sweden and East Netherlands. All of these were added to the WKCI following strong performances in the 2006 edition of the European Competitiveness Index. The NUTS-1 region of Southern and Eastern Ireland also replaces Ireland, which was previously included as a region-state.

For the US, regions are again based on the metropolitan statistical areas (MSAs) classification, following the overhaul of the previous consolidated metropolitan statistical areas (CMSAs) classification prior to the 2005 edition of the WKCI. As defined by the US Census Bureau, MSAs consist of areas with a substantial population centre and adjacent counties having a high degree of economic homogeneity. Compared with counties, cities and states, the MSAs analysed in this study are more robust regional units for economic analysis as they reflect the boundaries of clusters of firms in related industries. New MSAs included this year, based on an analysis of both current levels and growth rates of per capita GDP, are: Akron in the state of Ohio, Bridgeport-Stamford-Norwalk in Connecticut, Colorado Springs in Colorado, Durham in North Carolina, Oklahoma City in Oklahoma, Oxnard-Thousand Oaks-Ventura in California, Providence-Fall River-Warwick in the states of Massachusetts and Rhode Island, and Sarasota-Bradenton-Venice in Florida.

The Canadian regions are based on their defined provincial units. The Asian/Oceanic regions consist of prefectures in Japan and defined city or provincial boundaries for most other nations, as well as the inclusion of Taiwan, Singapore and New Zealand as region-states. New regions included this year are predominately Chinese which reflects the rates of economic growth in the country's coastal areas. These are Guangdong province on the South coast of China, and Jiangsu, Shandong and Zhejiang provinces, all on the east cost of China. The region of Pearl River Delta, which includes Guangdong province, was dropped this year because of better data availability at the provincial level, which better reflects the definition of the regional economic unit.

Selecting the Indicators

In deciding what indicators to use in our analysis, the key concern was to develop an analysis which incorporated data available and comparable at the local, regional and national levels, thereby providing visible yardsticks of economic strength and weaknesses that go beyond the usually narrow focus on macroeconomic performance. To create a single composite measure of regional competitiveness, a number of different modes of creating the index, and the variables to be included, were considered. In addition, the analysis that follows in later chapters also examines the association between different variables, and links these variables through a chain of inputs, outputs and outcomes, thereby attempting to reflect the link between macroeconomic performance and the underlying sources of competitiveness, be it stocks or investments in knowledge, innovative capacity, ICT infrastructure, financial capital, and so on. In selecting the appropriate variables, consideration also had to be given towards the overall 'value' of the indicators, and their relative effectiveness as a performance measure. The selected variables analysed can be usefully divided into five components: human capital, financial capital, knowledge capital, regional economy outputs and knowledge sustainability. The variables selected for the analysis are as follows:

HUMAN CAPITAL COMPONENTS

Knowledge economies compete on value and innovation, rather than costs alone. As regions make the transition to knowledge economies, we would expect increases in the number and proportion of knowledge-based businesses and employment. In general terms, higher levels of R&D activity most often define knowledge-based sectors. Consequently, knowledge-based sectors have a higher potential for innovation and competitive advantage. We consider that due to their requirements for R&D and innovation, these sectors have a higher propensity for developing a knowledge-driven economy, and that the outputs from these sectors are more likely to generate knowledge spillovers for the rest of the regional economy. High activity rates and managerial density are also considered strong indicators of the strength of the human capital stock in a region. As such, human capital indicators are:

- Employment in IT and Computer Manufacturing per 1,000 employees
- Employment in Biotechnology and Chemicals per 1,000 employees
- Employment in Automotive and Mechanical Engineering per 1,000 employees
- Employment in Instrumentation and Electrical Machinery per 1,000 employees
- Employment in High-Tech Services per 1,000 employees
- Economic Activity Rate
- Number of Managers per 1,000 employees

In this year's report we have switched the denominator for the human capital indicators (except for economic activity rate) from inhabitants to employees, as the latter shows a more accurate density of specific employment types in comparison to the total.

KNOWLEDGE CAPITAL COMPONENTS

Investment and employment in research and development activities signal the strength of efforts to develop and exploit new technology, software and ideas in order to enlarge the knowledge base. Similarly, the number of patents can be used to indicate how successful a region is in converting knowledge into potentially commercially valuable products and processes. By utilizing this range of innovation variables we avoid the potential distortions that may be introduced by looking at any individual variable in isolation. For example, while R&D expenditure provides a very good indication of innovative activity, some sectors rely more heavily on capital-intensive R&D activities than others. A composition of indicators seeks to dampens any distortions. As such, knowledge capital indicators are:

- Per Capita Expenditures on R&D performed by Government
- Per Capita Expenditures on R&D performed by Business
- Number of Patents Registered per one million inhabitants

REGIONAL ECONOMY OUTPUTS

Economic performance indicators are clearly vital components of competitiveness, and are usually the most established and well-known measures used. The WKCI analyses the following indicators of economic performance:

- Labour Productivity
- Mean Gross Monthly Earnings
- Unemployment Rates

FINANCIAL CAPITAL COMPONENTS

Without a high stock of human capital and innovation capacity, a region will not be able to generate innovative new businesses. However, given the presence of such factors the commercialization of new ideas still relies on the availability of finance, in particular venture capital finance, which can enable a region to maximise the returns on its R&D and human capital investments. As such, the following indicator is included in the WKCI:

- Per Capita Private Equity Investment

KNOWLEDGE SUSTAINABILITY

Future human and knowledge capital is embodied within those individuals currently undertaking education. Although strong regions will be able to attract talent from elsewhere, in the long-term reinvestment of returns in local human capital through education will help to ensure a region's knowledge economy maintains a sufficient flow of human capital. Likewise local investment in ICT infrastructure is also fast becoming a necessity in order to transfer knowledge effectively and efficiently in today's electronic world. As such, the following indicators of knowledge sustainability are included:

- Per Capita Public Expenditures on Primary and Secondary Education
- Per Capita Public Expenditures on Higher Education
- Secure Servers per one million inhabitants
- Internet Hosts per 1,000 inhabitants
- Broadband Access per 1,000 inhabitants

Creating the Composite World Knowledge Competitiveness Index

In order to create the composite World Knowledge Competitiveness Index all data are first converted so that the mean and variance of each variable is set at zero and one respectively. After the standardisation, a multivariate data reduction technique called factor analysis is applied to the data set. Factor analysis is used to simplify complex and diverse relationships that exist among a set of observed variables by uncovering common dimensions or factors that link together the seemingly unrelated variables, and consequently provide insights into the underlying structure of the data. In general, these dimensions are uncorrelated with one another.

To extract the common part of variations among the original variables (i.e. commonalities), an extraction method called image factoring is employed. The dimensions obtained are then rotated. A rotation method called varimax is used with Kaiser normalisation. While identifying common dimensions of the underlying structure, factor analysis also shows the location of each case (i.e. region in this study) within the underlying structure, by providing the case's scores for the dimensions identified. We use these scores for the dimensions as sub-composite indices.

Subsequently, we aggregate these sub-composite indices with a view to obtaining a single composite. A quantitative analytical technique called Data Envelopment Analysis (DEA) is used to obtain a single composite index from the above sub-composite indices. DEA is a linear programming technique originally developed for the estimation of the relative efficiency of a set of units (called decision making units, DMUs) producing a set of outputs from common inputs. It neither assigns weights to variables with any dependent variable chosen a priori, nor assigns weights set a priori. Instead, it seeks a set of weights for each unit that maximises a weighted sum of variables, with the constraint that no units have a weighted sum larger than one. As a result, each unit receives a score between 0 and 1. This process is repeated for all units in the data set, giving each unit a score unique to each iteration. Finally a geometric mean of all the scores is taken for each unit, providing a DEA score.

The DEA model can be stated as follows. Let x_{ij} (i = 1, ..., m) be the scores of m sub-composite indices for region j (j = 1, ..., n). A composite score of region j, denoted here as C, is then maximised as:

$$\text{Max } C_j = (V_1 x_1 + \dots + V_m x_{mj})$$

subject to:

$$(V_1 x_1 + \dots + V_m x_{mj}) \leq 1 \qquad j = 1, \dots, n.$$

$$V_i > 0 \text{ for all } i.$$

Let us denote the maximised composite score for region j as C_j (max j). While C_j (max j) is obtained for region j, other regions also gain composite scores under the weights $V_1, \dots, V_m$ that are set to maximise the region j's score. They can be denoted as C_1 (max j), C_2 (max j), $C_n \dots$, (max j).

This maximisation process is undertaken for all regions in the data set. As a result, each region receives n composite scores, one of which is obtained from maximisation of its own composite score. Finally a geometric mean of C_j (max 1), C_j (max 2), …, C_j (max j) …, C_j (max n) is taken for region j, providing a DEA score of region j (j = 1, ..., n).

As noted above, DEA scores range from zero to one. To facilitate a more intuitive understanding, we convert DEA scores to ones whose average is 100 with a variance similar to variances of the original variables. For this, we first convert original variables so that their averages become 100 (i.e. divide the scores of regions for each variable by its average and then multiply them by 100). We then take a geometric mean of the variances of the converted variables, which we denote by $(\text{variance})_{\text{original}}$. Finally, we standardise DEA scores for regions 1 to n, multiply them by $(\text{variance})_{\text{original}}$, and add 100. The obtained scores, whose average equals 100, still maintain relative distance between regions but have a variance similar to the original variables.

In the following analysis and data presentation all scores are converted into the figures whose average is 100, facilitating an intuitive understanding of the regions' positions in our league table. Also, please note the abbreviation n/a refers to a lack of relevant data.

A ranking change followed by * indicates a change in data source or methodology that we now consider to be more reliable than that adopted in previous years.

Chapter 2:
The Rankings: World Knowledge Competitiveness Index 2008

CHAPTER TWO

Throughout this report we make the case that economic competitiveness should be analysed in terms of stocks and investments in knowledge, with a firm focus on regions. But why analyse regions? With advances in telecommunications and information technologies allowing the instantaneous transfer of information, regardless of location, it might appear logical to consider that geography would be an increasingly less important issue in economic analysis. In fact, in a number of ways the reverse is true. Whilst it has become possible for firms and individuals to source work far more widely, the geographic concentration of related resources and industries, in particular of knowledge-intensive activities, remains one of the most striking features of any nation or region, especially in the most advanced economies. Furthermore, whilst the historic factors influencing location, such as proximity to inputs and markets, are being undercut, the ability to source from anywhere is also, paradoxically, increasing the importance of local competition - in many respects, globalisation is reinforcing localisation. This 'location paradox' is explained by Michael Porter as follows:

Anything that can be efficiently sourced from a distance has essentially been nullified as a competitive advantage in advanced economies. Information and relationships that can be accessed through fax and email are available to everyone. Although global sourcing mitigates disadvantages, it does not create advantages . . . paradoxically, the most enduring competitive advantages in a global economy seem to be local.

For Porter, these localised productivity advantages of agglomeration, such as access to specialised inputs, employees, information, and institutions, will encourage firms to cluster and reinforce these clusters over time, as new firms become attracted by the same advantages of concentration. Also, many of the factors that increase current productivity will also encourage innovation within the cluster, and therefore increase the productivity growth of firms. For example, access to specialised information via personal relationships will, over time, provide localised advantages for firms in perceiving new technological opportunities and new buyer needs. Thus, as traditional forms of advantage become nullified, competitive advantage lying outside companies – that is, in the business environment in which they are located – increase in importance.

The growing theoretical support for this concept of localised competition lends considerable weight to the use of both data analysis and a policy approach at the regional, rather than the national, level. This is not to dismiss the fact that in some circumstances a 'region' still remains a somewhat arbitrary level of analysis, but given that we can never possibly define, let alone find data for, identically integrated economic areas, then clearly as a geographic unit of analysis the use of sub-national geographic units ('regions') will bring us much closer in line with the nature of competition and the appropriate role of government in economic development activity.

[2] Porter, M. (2000): 'Location, Competition, and Economic Development: Local Clusters in a Global Economy', Economic Development Quarterly, 14: 15-34.

World Knowledge Competitiveness Index 2008 — **Table 2.11**

Rank	Region	Knowledge Competitiveness Index 2008	Rank 2005	Change in Rank 2005-08
1	San Jose-Sunnyvale-Santa Clara, US	248.3	1	0
2	Boston-Cambridge-Quincy, US	175.3	2	0
3	Hartford, US	175.1	4	1
4	Bridgeport-Stamford-Norwalk, US	174.7		
5	San Francisco-Oakland-Fremont, US	160.8	3	-2
6	Stockholm, Sweden	151.8	8	2
7	Seattle-Tacoma-Bellevue, US	151.3	5	-2
8	Providence-Fall River-Warwick, US	147.1		
9	Tokyo, Japan	147.0	22	13
10	San Diego-Carlsbad-San Marcos, US	146.1	7	-3
11	Los Angeles-Long Beach-Santa Ana, US	144.4	10	-1
12	Shiga, Japan	140.9	57	45
13	Grand Rapids, US	140.0	6	-7
14	Iceland	139.8		
15	Detroit-Warren-Livonia, US	138.1	15	0
16	West, Sweden	137.9	37	21
17	Oxnard-Thousand Oaks-Ventura, US	137.1		
18	Sacramento--Arden-Arcade--Roseville, US	133.6	11	-7
19	West, Netherlands	132.4	77	58
20	Pohjois-Suomi, Finland	132.1		
21	Minneapolis-St. Paul-Bloomington, US	131.7	13	-8
22	Portland-Vancouver-Beaverton, US	129.7	18	-4
23	Etela-Suomi, Finland	129.1	20	-3
24	Kanagawa, Japan	128.6	81	57
25	Durham, US	127.7		
26	Colorado Springs, US	124.4		
27	Singapore	123.1	78	51
28	Switzerland	122.5	44	16
29	Île de France, France	121.8	29	0
30	Toyama, Japan	120.5	80	50
31	Osaka, Japan	119.6	72	41
32	Riverside-San Bernardino-Ontario, US	119.3	16	-16
33	Philadelphia-Camden-Wilmington, US	117.7	17	-16
34	Luxembourg	116.9	58	24
35	New York-Northern New Jersey-Long Island, US	116.8	12	-23
36	Denmark	116.7	51	15
37	Tochigi, Japan	116.1	73	36
38	South, Sweden	115.2	46	8
39	Greensboro-High Point, US	113.5	40	1
40	Lansi-Suomi, Finland	112.5		

World Knowledge Competitiveness Index 2008 *(continued)* **Table 2.11**

Rank		Knowledge Competitiveness Index 2008	Rank 2005	Change in Rank 2005-08
41	Washington-Arlington-Alexandria, US	112.4	23	-18
42	Austin-Round Rock, US	112.3	19	-23
43	Kyoto, Japan	111.9	96	53
44	Milwaukee-Waukesha-West Allis, US	111.2	24	-20
45	Denver-Aurora, US	110.7	14	-31
46	Chicago-Naperville-Joliet, US	109.4	28	-18
47	Brussels, Belgium	109.4	45	-2
48	Israel	109.3	86	38
49	Baltimore-Towson, US	108.9	27	-22
50	Rochester, US	108.8	9	-41
51	Shizuoka, Japan	106.8	71	20
52	Dallas-Fort Worth-Arlington, US	106.6	21	-31
53	Taiwan	106.5	99	46
54	Eastern, UK	106.1	62	8
55	Baden-Württemberg, Germany	106.0	54	-1
56	Aichi, Japan	105.6	75	19
57	Ostra Mellansverige, Sweden	105.3		
58	Phoenix-Mesa-Scottsdale, US	103.3	38	-20
59	Buffalo-Niagara Falls, US	102.8	25	-34
60	Virginia Beach-Norfolk-Newport News, US	102.5	48	-12
61	East Netherlands	102.1		
62	Cleveland-Elyria-Mentor, US	101.9	39	-23
63	Bayern, Germany	101.8	65	2
64	Indianapolis, US	101.7	32	-32
65	North, Netherlands	101.6	89	24
66	Raleigh-Cary, US	100.7	31	-35
67	Charlotte-Gastonia-Concord, US	100.7	41	-26
68	South, Netherlands	100.0	50	-18
69	Ulsan, Korea	100.0	113	44
70	Houston-Sugar Land-Baytown, US	99.9	26	-44
71	Richmond, US	99.9	33	-38
72	Pittsburgh, US	99.3	43	-29
73	Vlaams Gewest, Belgium	99.1	79	6
74	South East, UK	98.9	55	-19
75	Norway	98.6	52	-23
76	Ontario, Canada	98.5	66	-10
77	Hessen, Germany	97.9	67	-10
78	Columbus, US	96.0	30	-48
79	East, Austria	94.7	70	-9
80	Salt Lake City, US	94.3	34	-46
81	Akron, US	93.0		
82	Hamburg, Germany	92.4	76	-6
83	Quebec, Canada	92.2	85	2
84	Southern and Eastern, Ireland	91.2		
85	Alberta, Canada	91.0	98	13
86	Kansas City, US	90.0	42	-44
87	Centre-est, France	89.7	82	-5
88	San Antonio, US	89.4	47	-41
89	Cincinnati-Middletown, US	89.2	36	-53
90	Memphis, US	88.9	61	-29
91	St. Louis, US	88.8	49	-42
92	Nashville-Davidson--Murfreesboro, US	87.6	59	-33
93	Bremen, Germany	86.4	95	2
94	Louisville, US	86.1	53	-41
95	Atlanta-Sandy Springs-Marietta, US	85.9	35	-60
96	Lombardia, Italy	85.7	84	-12
97	West, Austria	85.2	90	-7
98	Tampa-St. Petersburg-Clearwater, US	85.1	64	-34
99	Victoria, Australia	82.9	88	-11
100	North West, Italy	82.6	101	1
101	Smaland Medoarna, Sweden	81.8	97	-4
102	London, UK	81.4	56	-46
103	Orlando-Kissimmee, US	81.2	60	-43
104	New South Wales, Australia	81.2	91	-13
105	South West, UK	81.0		
106	Jacksonville, US	80.8	63	-43
107	Seoul, Korea	80.7	120	13
108	Western Australia	80.5	93	-15
109	Las Vegas-Paradise, US	80.1	68	-41
110	Shanghai, China	79.4	112	2
111	Berlin, Germany	78.7	87	-24
112	British Columbia, Canada	77.4	105	-7
113	Nordrhein-Westfalen, Germany	77.4	94	-19
114	Sarasota-Bradenton-Venice, US	77.3		
115	Miami-Fort Lauderdale-Miami Beach, US	76.4	69	-46
116	Niedersachsen, Germany	76.4	103	-13
117	Emilia-Romagna, Italy	75.4	102	-15
118	Manitoba, Canada	73.7	100	-18
119	North East, Italy	72.7	107	-12
120	Hong Kong	72.6	118	-2
121	Saskatchewan, Canada	72.3	104	-17
122	Oklahoma City, US	71.5		
123	Lazio, Italy	70.4	106	-17
124	Scotland, UK	70.4	83	-41
125	Comunidad de Madrid, Spain	68.5	92	-33
126	Central, Italy	66.4	114	-12
127	Noreste, Spain	65.7	108	-19
128	Budapest, Hungary	65.5	121	-7
129	Schleswig-Holstein, Germany	64.8	109	-20
130	Tianjin, China	61.3	122	-8
131	Guangdong, China	60.4		
132	Prague, Czech Republic	60.3	116	-16
133	Saarland, Germany	58.1	111	-22
134	New Zealand	55.1	110	-24
135	Beijing, China	48.9	119	-16
136	Bratislavsk_, Slovak Republic	48.8	117	-19
137	Estonia	43.9		
138	Jiangsu, China	30.2		
139	Lithuania	27.5		
140	Zhejing, China	26.5		
141	Latvia	20.8		
142	Shandong, China	20.6		
143	Mumbai, India	5.5	123	-20
144	Hyderabad, India	5.3	125	-19
145	Bangalore, India	5.0	124	-21

The scores and ranks for the World Knowledge Competitiveness Index (WKCI) 2008 are shown by Table 2.1, which also highlights the change in ranks from the 2005 index. The WKCI represents the overall picture for the benchmarked regions, and the trends taking place across these regions between the 2005 and 2008 reports.

Once again, at the top of the index is the US metropolitan area of San Jose (248.3). The region, the home of Silicon Valley, continues to lead the WKCI rankings by some distance, due to its enormous investment in knowledge-intensive business development, in particular in the fields of high-technology engineering, computers, and microprocessors. Despite the onset of the dot-com crash earlier in the decade, San Jose has remained a clear leader across a number of knowledge employment sectors, as well as ranking amongst the top regions worldwide for investment in education and business R&D, as well as for corresponding economic output indicators such as productivity and earnings. This is also supported by high quality research facilities (for example, Stanford University), which boosts the regions patents score, and heavy government investment in R&D (for example, NASA).

This all translates into San Jose being a highly developed and concentrated knowledge economy, as demonstrated by the high levels of productivity, high earnings and very high employment in sectors such as the IT and instrumentation manufacturing industries. The recognised potential of the region is further emphasised by the extent of the region's lead in private equity availability, a clear market signal that Silicon Valley remains the place to invest when it comes to high-tech business opportunities. The success of San Jose, therefore, reflects an economy within which knowledge is an integral part of production.

Remaining in second place in 2008 is the metropolitan area of Boston (175.3), a region which thrives on high levels of intellectual and financial capital. Boston, is of course, synonymous with higher education, and is home to eight research universities including Harvard and the Massachusetts Institute of Technology. It is estimated that the direct impact of these universities adds an extra US$7.4bn to regional economic output. The indirect impacts in terms of skills, innovation and interaction with business are less easy to quantify, but are evident in the region's high ranking for research and development activity and patent registration.

Hartford (175.1) moves further up the index to third, with its score boosted by very strong results for both R&D spending and private equity investment, which translate into a very strong productivity score: Hartford ranks as the highest region worldwide by productivity in our rankings. The neighbouring Connecticut region of Bridgeport (174.7), a new region in this year's index, enters in an impressive fourth place while San Francisco (160.8) slips two places to fifth. These top five regions between them underline the significant concentration of knowledge competitiveness in northern California and Southern New England.

Nevertheless, while the US regions remain out in front at the top of the rankings this year's WKCI also suggests a further strengthening of competitiveness in the leading knowledge centres outside of the US. In the 2004 WKCI the top fourteen positions on the index were taken by US regions, and in 2005 it was the top seven, while this year that figure has been reduced to the top five due to the continued rise of Stockholm (151.8), which climbs again up to sixth position. The continued improvement of Stockholm's ranking has been based on gains across a range of indicators. This catch-up with the leading US regions is not confined to Stockholm either: Tokyo (147.0) moves up very strongly this year to ninth position, while Shiga (140.9), West Sweden (137.9) and West Netherlands (132.4) all move into the top twenty. The new regions of Iceland (139.8) and Pohjois-Suomi (132.1) also enter in the top twenty, which now contains thirteen US regions, five European regions and two Japanese regions.

While the US continues to be most prominent at the top of the rankings, it is hard to find too many US regions that have risen by more than a few places, which suggests that the gap with Europe and Asia is beginning to narrow, if not across the board then at least amongst the leading global knowledge centres. Looking at the top 50 in the rankings the majority of the rising regions are European or Asia-Pacific: notable examples include Singapore, which moves up to 27th, and the Western European region-states of Switzerland, Denmark and Luxembourg, which all move up strongly in the top 50.

The Japanese regions are also noticeable for their improvements this year (which partly reflects the use of more comparable employment statistics which had previously under-estimated relative productivity of the Japanese regions).[3] Tokyo continues to lead amongst the Japanese regions by some way, due to its strong employment figures for high-tech services along with very high patenting rates and strong output indicators, in particular earnings. The strength of other leading Japanese regions, such as Shiga (9th) and Kanagawa (24th) reflects regional economies that are concentrated around niche knowledge sectors. Shiga, for example, ranks top amongst all regions for instrumentation and electrical engineering employment, and second only to San Jose for IT and computer manufacturing.

At the bottom of the WKCI rankings we continue to find the Chinese, Indian and Eastern European regions – the lowest ranked being Bangalore, Mumbai and Hyderabad (123rd). Amongst the emerging regions in the index, Shanghai continues to perform best, increasing its ranking one again despite the entry of twenty new regions, mostly from Europe and the US. Shanghai is now ahead of the likes of Berlin and British Columbia, which shows how far the most developed amongst the Chinese regions has come in recent years. It is also worth noting the size of the economies this relates to, e.g. the Shanghai population is now over 20 million people. This indicates that the advances in absolute terms we are seeing are very significant.

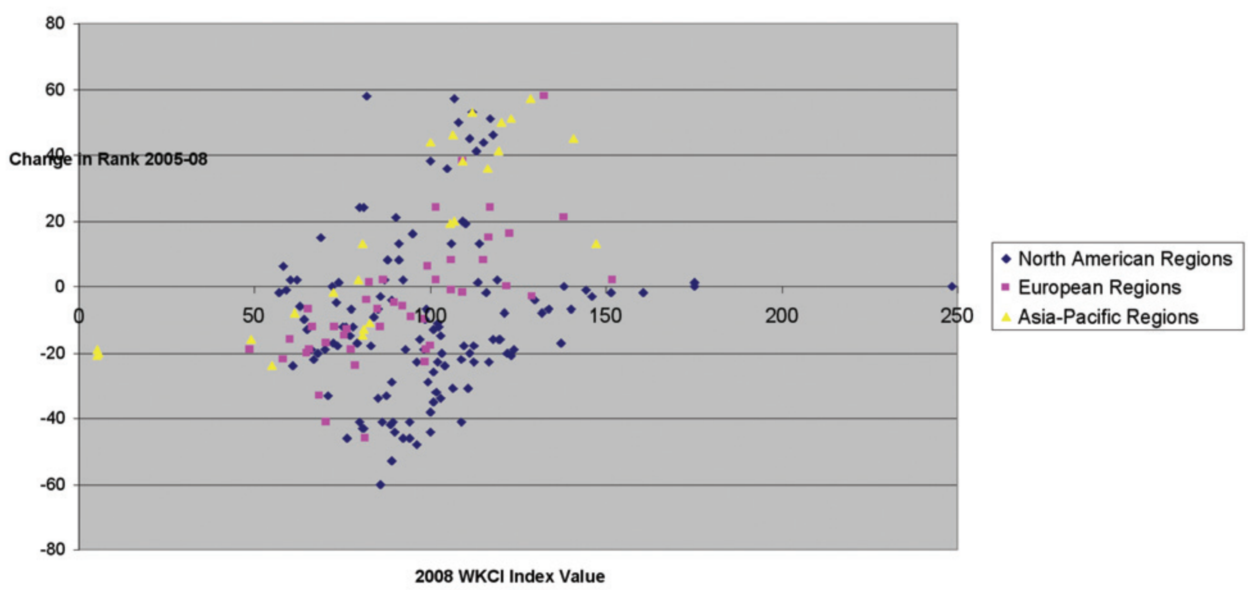
The only other regions to move up in the bottom fifty are Seoul, which gains thirteen places, and North West Italy, which gains one place. At the bottom of the index the progress of the newly included Baltic regions – Latvia, Lithuania and Estonia – will be interesting to follow, given the rapid increase in knowledge investments in these countries following the end of the Soviet era, and EU enlargement.

Taking a more comprehensive look at relative regional performance and change since 2005, Figure 2.1 provides a representation of how each region (grouped by North America, Europe and Asia-Pacific regions) benchmarked by WKCI performs in terms of overall index value and change in rank between 2005 and 2008. The trends highlighted

[3] Full-time equivalent (FTE) employment statistics were used for Japan in 2005, however since it is not considered feasible to accurately estimate FTE data for all European and US regions FTE statistics have not been used for any regions in this year's index

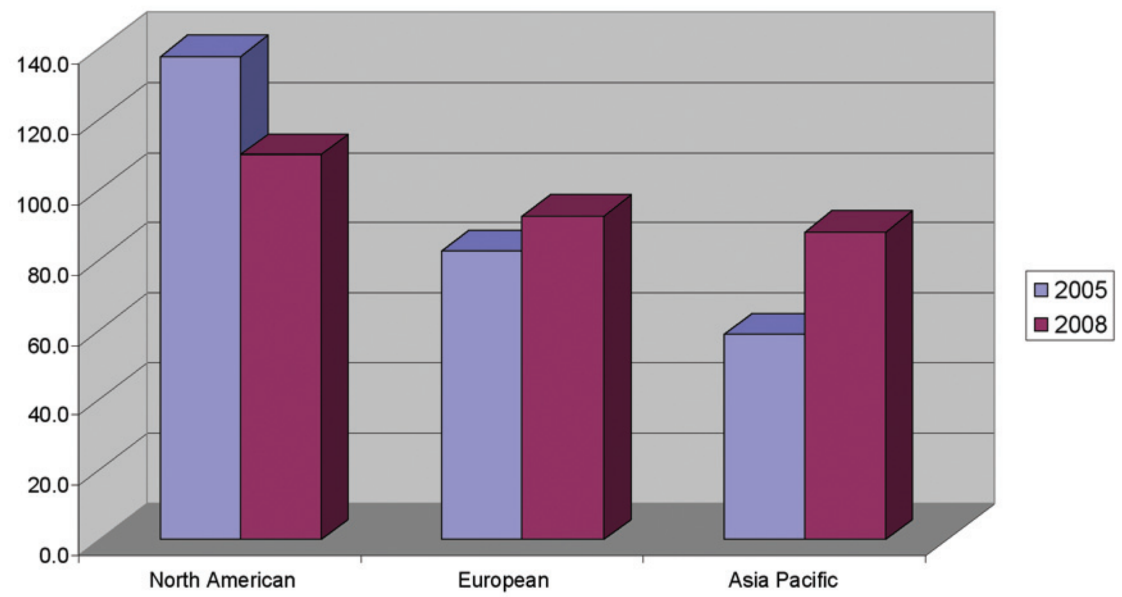
above shows through more clearly in this chart, i.e. of those regions that improved their ranking by more than twenty positions, many Asia-Pacific regions. Among those regions that fell by more than twenty places, the vast majority are North American along with a few from Europe. Although few major gains were made in Europe, it appears that around as many moved up in the rankings as down. Also interesting to note in Europe is the apparent divergence in scores, with those regions already higher up the rankings rising further, while those towards the lower end move down further. Similarly, although less pronounced, trends can be seen for North America and Asia Pacific. The most desirable quadrant of Figure 2.1 to clearly be situated is the top right, with a WKCI score above average and a rising change in rank. Tokyo, West Sweden and Shiga are the regions that stand out most clearly in this quadrant this year.

Change in Rank on the WKCI 2005-2008 versus WKCI 2008 Index Value by Continent **Figure 2.1**



The average continental bloc scores of regions comprising the WKCI 2008 and the change since 2005 are further illustrated by Figure 2.2, which shows that while North American regions remain the most competitive on average, the European and Asia-Pacific regions in the WKCI have been catching up since 2008. This is particularly true of the Asia-Pacific regions, which are now only slightly outrivaled on average by their European counterparts in the WKCI (note: that to enable comparability this year's new regions were not included in the calculation).

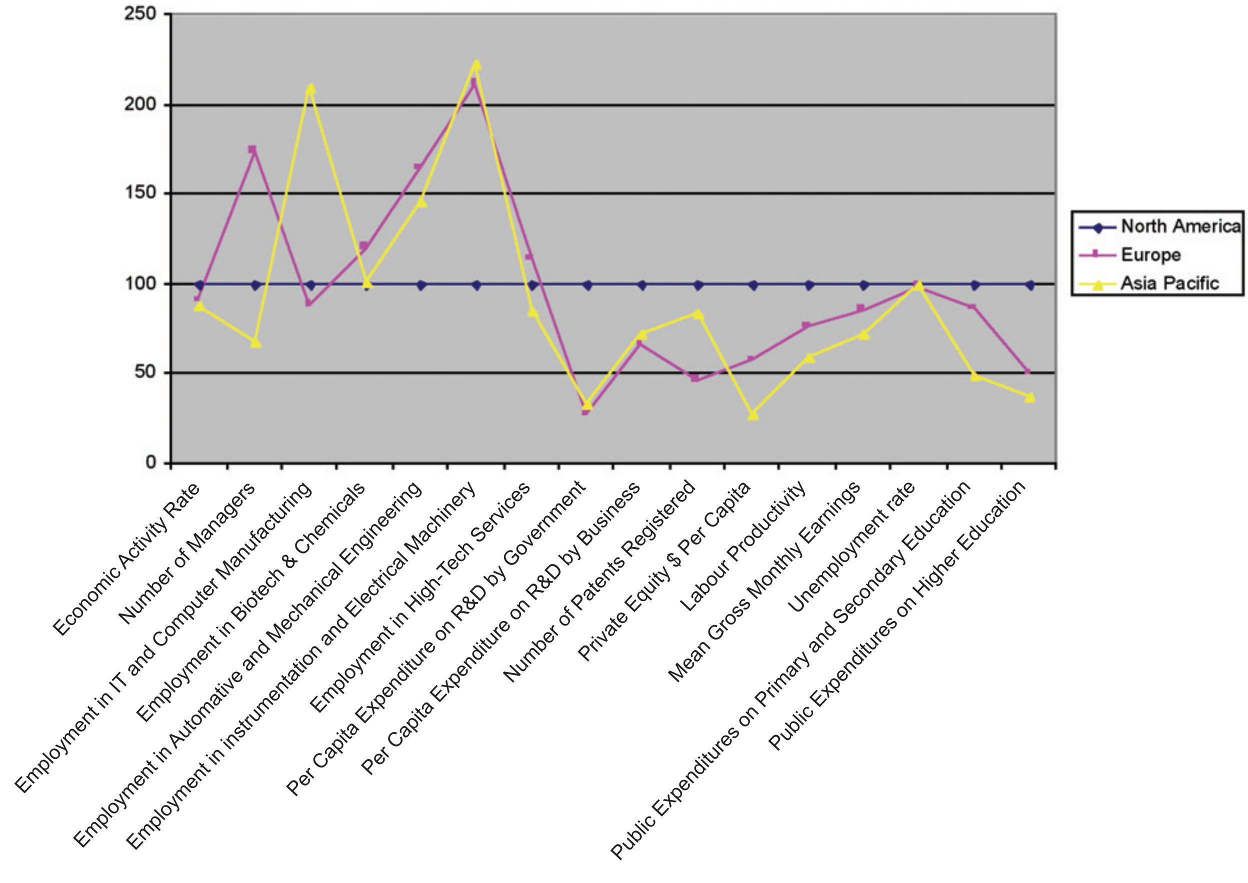
Comparing the World Knowledge Competitiveness Index 2005 and 2008 for Three Continents **Figure 2.2**



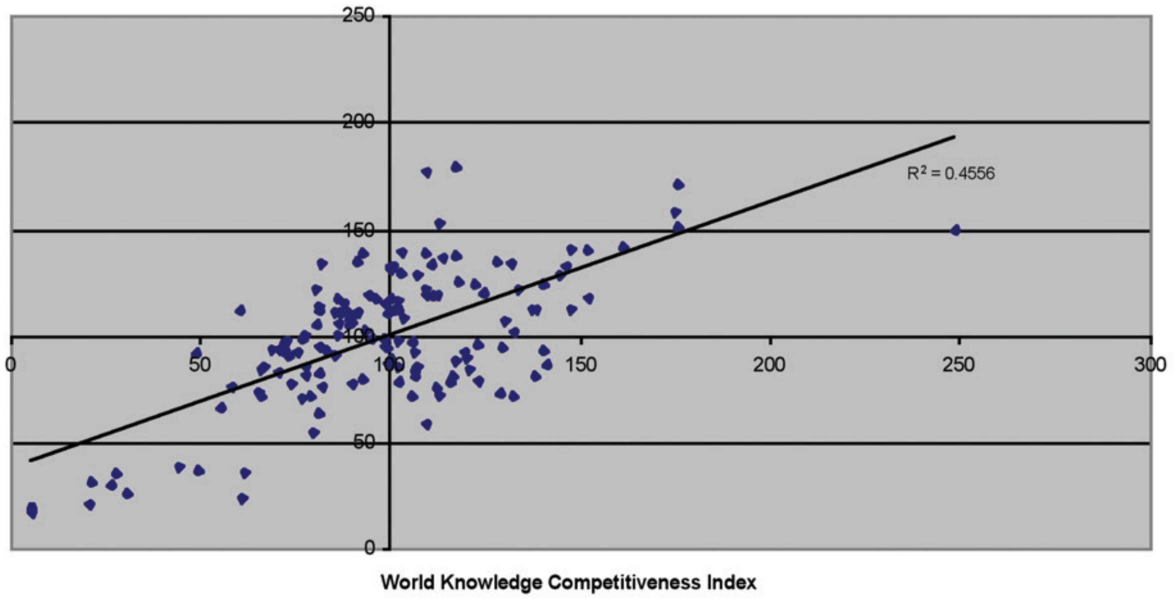
When we look at continental bloc comparisons across indicators, it is also clear that there are significant variations in the economic development models at work across the globe. The US regional development framework is far more reliant upon its investments in knowledge sustainability, in the form of educational expenditure and ICT infrastructure. Asian-Pacific regions tend to place a greater emphasis on mobilising human capital already within the workforce and investment in business-based innovation. Europe's model appears to be an under-performing version of that operating within the North American regions.

Figure 2.3 breaks down further the inter-continental scores for those variables where data is available at the regional

Comparing Knowledge Competitiveness Factor by Continental Bloc (Individual Variables) **Figure 2.3**



Relationship between GDP per capita and World Knowledge Competitiveness Index 2008 **Figure 2.4**



level, and therefore highlights inter-continental differences at the level of individual indicators. The figure shows that the leading European and Asian-Pacific regions outperform US regions in employment terms across a number of high-tech sectors. Asia-Pacific is particularly strong in IT and Computer Manufacturing, while both continents score significantly higher than North America in Instrumentation and Electrical Machinery. North America's strength comes from its spending on R&D and education, which is also emphasised by its higher patenting levels. Higher levels of private equity are also a notable North American advantage. In terms of economic output, Asia-Pacific attains lower scores than North America and Europe for labour productivity and earnings, and also lags behind North America and Europe in education expenditures.

Although North American regions do not show particular strength in input factors, they have the highest scores for economic output and knowledge sustainability factors, indicating their higher capability of transferring knowledge inputs into outputs, and the ability to establish sustainable growth. National level statistics also show that North America is the leading continent in terms of ICT infrastructure, providing excellent support for moving knowledge effectively and efficiently within and across regions.

Figure 2.4 highlights the association between GDP per capita and the World Knowledge Competitiveness Index across the 145 regions. The high r-squared statistic (i.e. coefficient of determination) of 0.46 indicates the importance of knowledge competitiveness to achieving the wealth and prosperity of regions.

Data from previous editions of the WKCI allows us to look at which regional economies have been growing most strongly over this period. In presenting this data we acknowledge that, particularly in the US, regional statistical boundaries have changed somewhat and therefore we cannot compare growth across all regions. However, looking at those regions that have remained spatially consistent does provide an insight into which regions have been growing most strongly in per capita economic terms over the four years during which this index has been produced.

As shown by Table 2.2, the Korean regions have been growing particularly strongly since the WKCI 2003. which has resulted in strong performances from both Ulsan and Seoul in this year's composite WKCI. In first place, Seoul has grown by a cumulative 47 percent over the four year period analysed, while Ulsan, in third place, has grown by over 34 percent. This substantial growth rate partly reflects a recovery from the Asian financial crisis, but also continued strong performance in high-tech, high value added sectors. These two regions are divided by Western Australia, which has grown by over 40 percent. Also performing impressively are the Eastern European regions of Bratislavsk_ and Praha in fourth and fifth place respectively, clearly benefiting significantly from increased investment following the EU enlargement. In Western Europe, Luxembourg and London lead the way. In both regions recent growth has been fuelled to a large extent by very strong financial services sector performance. In the US, Washington DC has shown the best performance of any city thanks to continued high government expenditure, particularly in the defence sector. However, it should be noted that the reclassification of the

Cumulative growth in GDP per Capita, 2003-08 – Top 50 Regions **Table 2.2**

Rank	Region	GDP per Capita – WKCI 2008 (US$)	Cumulative Growth WKCI 2003-08	Rank	Region	GDP per Capita – WKCI 2008 (US$)	Cumulative Growth WKCI 2003-08
1	Seoul, Korea	22,300	47.0%	26	Rochester, US	48,381	19.7%
2	Western Australia	36,785	40.2%	27	Aichi, Japan	34,112	19.5%
3	Ulsan, Korea	46,227	34.2%	28	Milwaukee-Waukesha-West Allis, US	41,561	19.2%
4	Bratislavsk_, Slovak Republic	32,103	33.5%	29	Alberta, Canada	47,146	18.9%
5	Praha, Czech Republic	39,011	31.3%	30	Los Angeles-Long Beach-Santa Ana, US	45,057	18.5%
6	Victoria, Australia	32,336	31.0%	31	Saskatchewan, Canada	32,200	18.4%
7	Hong Kong	34,200	30.9%	32	Philadelphia-Camden-Wilmington, US	43,780	18.2%
8	Luxemburg	62,330	29.9%	33	Lazio, Italy	32,731	18.0%
9	London, UK	46,815	29.7%	34	Kanagawa, Japan	25,661	17.7%
10	Washington-Arlington-Alexandria, US	53,335	28.5%	35	Vlaams Gewest, Belgium	30,593	17.4%
11	Taiwan	28,369	28.0%	36	Salt Lake City,US	41,673	17.3%
12	Virginia Beach-Norfolk-Newport News, US	45,239	27.2%	37	West-Nederland, Netherlands	35,523	17.2%
13	Shizuoka, Japan	30,086	25.4%	38	Tochigi, Japan	28,452	16.8%
14	Toyama, Japan	29,628	24.1%	39	San Diego, US	46,388	16.6%
15	Noreste, Spain	29,599	23.7%	40	Seattle, US	48,909	16.5%
16	Las Vegas-Paradise, US	42,590	23.1%	41	Brussels, Belgium	61,641	15.3%
17	Greensboro--High Point, US	47,646	22.4%	42	New Zealand	23,200	15.0%
18	Scotland, UK	29,173	22.2%	43	Pittsburgh, US	38,670	14.9%
19	South East, UK	33,002	21.5%	44	Detroit-Warren-Livonia, US	39,254	14.8%
20	Buffalo-Niagra Falls, US	48,689	21.5%	45	Tampa-St. Petersburg-Clearwater, US	38,814	14.8%
21	Comunidad de Madrid, Spain	32,813	21.5%	46	Eastern, UK	29,288	14.8%
22	Singapore	27,800	20.4%	47	Miami-Fort Lauderdale-Miami Beach, US	34,425	14.6%
23	Kyoto, Japan	26,486	20.1%	48	Nord Ovest, Italy	32,760	14.5%
24	Noord-Nederland, Netherlands	29,933	20.0%	49	Osaka, Japan	31,501	14.2%
25	Zuid-Nederland. Netherlands	31,178	19.8%	50	British Columbia, Canada	29,994	14.1%

MSA boundaries excluded a number of major cities from this comparison, including New York, San Francisco and Boston. Likewise, the Indian and Chinese regions, which we would have expected to have seen towards the top of this table, were unable to be included due to incomparable data between 2003-08.

Knowledge Intensity

The World Knowledge Competitiveness Index allows us to understand the relative means by which regions are able to compete in terms of their overall knowledge capacity, capability and utilisation. However, it does not tell us how influential these factors are compared with the overall economic performance and capacity of each region. In order to go someway towards analysing this influence we have established the Regional Ratio of Knowledge Intensity, which is calculated on the basis of each region's World Knowledge Competitiveness Index score relative to its index of GDP per capita. Knowledge intensity is simply the ratio of Knowledge Competitiveness/GDP per capita. As such, this measure compares the underlying knowledge base of a region in relation to its direct economic output and, as such, can arguably be used to some extent as an indicator of future economic potential.

Such a measure is the best available derivative of the relative importance of knowledge and knowledge-based activities to the overall economic performance and structure of each region. As shown by Table 2.2, the highest Ratio of Knowledge Intensity is found in the new region of Guangdong, China (2.40), followed by Israel (1.82) and Pohjois-Suomi (1.81). San Jose, the leader in 2005, slips slightly to sixth place (1.84). The top twenty regions shows a significant diversity, with Japanese, Chinese, Swedish and Finnish regions all ranking particularly high under this measure. North American regions perform less well, with only San Jose making the top twenty.

The following chapters unpack the scores for the regions for the individual variables constituting the WKCI.

Regional Ratio of Knowledge Intensity in 2008, Top 50 Regions — **Table 2.2**

Rank 2008	Region	Index 2008	Change in Rank 2005-08	Rank 2008	Region	Index 2008	Change in Rank 2005-08
1	Guangdong, China	2.40		26	Stockholm, Sweden	1.28	-24
2	Israel	1.82	39	27	Riverside-San Bernardino-Ontario, US	1.27	-17
3	Pohjois-Suomi, Finland	1.81		28	Switzerland	1.26	-10
4	Kanagawa, Japan	1.74	49	29	Eastern, UK	1.25	-3
5	West, Sweden	1.69	1	30	Seoul, Korea	1.25	89
6	San Jose-Sunnyvale-Santa Clara, US	1.65	-5	31	Shizuoka, Japan	1.23	23
7	Tianjin, China	1.64	111	32	Detroit-Warren-Livonia, US	1.22	-21
8	Shiga, Japan	1.62	16	33	Oxnard-Thousand Oaks-Ventura, US	1.20	
9	Lansi-Suomi, Finland	1.54		34	Portland-Vancouver-Beaverton, US	1.20	-20
10	Singapore	1.53	30	35	North, Netherlands	1.18	47
11	Iceland	1.49	-11	36	Boston-Cambridge-Quincy, US	1.16	-31
12	Kyoto, Japan	1.46	66	37	Quebec, Canada	1.15	44
13	South, Sweden	1.46	-4	38	Centre-est, France	1.14	28
14	Ostra Mellansverige, Sweden	1.45		39	Baden-Württemberg, Germany	1.13	-10
15	Shanghai, China	1.43	86	40	San Francisco-Oakland-Fremont, US	1.13	-32
16	Tochigi, Japan	1.41	34	41	Grand Rapids, US	1.12	-37
17	Toyama, Japan	1.41	55	42	Vlaams Gewest, Belgium	1.12	25
18	Etela-Suomi, Finland	1.35	-5	43	Jiangsu, China	1.12	
19	Osaka, Japan	1.32	43	44	South, Netherlands	1.11	-28
20	Beijing, China	1.31	94	45	Los Angeles-Long Beach-Santa Ana, US	1.11	-30
21	Denmark	1.31	4	46	Estonia	1.10	
22	Taiwan	1.30	55	47	Bridgeport-Stamford-Norwalk, US	1.09	
23	Providence-Fall River-Warwick, US	1.29		48	San Diego-Carlsbad-San Marcos, US	1.09	-45
24	East Netherlands	1.29		49	Berlin, Germany	1.08	9
25	West, Netherlands	1.29	60	50	Sacramento--Arden-Arcade--Roseville, US	1.08	-38

Economic activity, or participation, rates measure the availability of human capital in an economy. A healthy level of human capital input is necessary for a high level of knowledge production and provides a basis for further knowledge investment. In addition, high levels of activity suggest that the benefits of the production process are spread widely across the population. High participation, therefore, is necessary not only for knowledge economy production, but also for a vibrant and cohesive society. A low level of activity suggests a lack of social and economic inclusion, and a high economic dependency burden across society as a whole.

While demographic factors are particularly important, the level of activity is also determined by the openness and flexibility of the labour market, the effects of the social security and welfare systems, and a mix of demographic and cultural factors. Effective labour market and welfare systems allow the greatest possible freedom and opportunity for people to be economically active, and take full advantage of the demographic context.

Straight in at the top of the economic activity rankings (see Table 3.1) is Iceland (index score of 128.7), one of the new WKCI regions this year. Iceland enjoys a persistent excess demand for labour, resulting in negligible unemployment and high activity rates amongst both men and women of all ages. In second place is Stockholm (121.5), another economically vibrant region whose economic activity rate ranking has been steadily improving, which has also been the case in West Sweden (115.3) and Smaland Medoarna (111.2). Outside of northern Europe the top of the index is dominated by North American regions, with Minneapolis (120.6) in third position and Alberta (117.1) in fourth. An interesting observation for this index is the seeming climatic influence on activity rates, with the vast majority of the top twenty being located in relatively high-latitude regions. In the US, of course, this is quite evident in the prevalence of southerly migration amongst retirees.

As shown in Table 3.2, Western Australia (108.1) ranks top amongst the Asia-Oceania regions, which as a group rank relatively low for this indicator. The Japanese and Chinese regions have both tended to see their rankings declining, although in the latter case this is influenced to a considerable extent this year by the availability of more accurate data.

Economic Activity - Top Twenty Regions in 2008 — **Table 3.1**

Rank	Region	Index 2008	Change in Rank 2003-08
1	Iceland	128.7	
2	Stockholm, Sweden	121.5	5
3	Minneapolis-St. Paul-Bloomington, US	120.6	0
4	Alberta, Canada	117.1	8
5	Salt Lake City, US	116.4	1
6	Denver-Aurora, US	116.4	5
7	Austin-Round Rock, US	115.4	-3
8	Norway	115.3	11
9	West, Sweden	115.3	25
10	Indianapolis, US	114.0	10
11	Washington-Arlington-Alexandria, US	113.7	14
12	Cleveland-Elyria-Mentor, US	113.2	49
13	Dallas-Fort Worth-Arlington, US	111.8	-4
14	Atlanta-Sandy Springs-Marietta, US	111.5	-4
15	Smaland Medoarna, Sweden	111.2	22
16	Columbus, US	111.0	1
17	Boston-Cambridge-Quincy, US	110.8	21
18	Raleigh-Cary, US	110.5	-3
19	Charlotte-Gastonia-Concord, US	110.2	-5
20	Grand Rapids, US	110.2	-15

(Labour Force as a percentage of working age population)

Economic Activity - Top Twenty Asia-Oceania Regions in 2008 — **Table 3.2**

Rank	Region	Index 2008	Change in Rank 2005-08
1	Western Australia	108.1	-2
2	Zhejing, China	106.7	-
3	Israel	106.1	60
4	New Zealand	106.1	-22
5	Victoria, Australia	102.6	-18
6	Shizuoka, Japan	101.2	22
7	Singapore	101.0	-35
8	Toyama, Japan	100.0	23
9	Aichi, Japan	100.0	24
10	New South Wales, Australia	99.7	-26
11	Tochigi, Japan	98.9	19
12	Ulsan, Korea	97.8	-30
13	Beijing, China	97.7	-91
14	Shiga, Japan	97.3	21
15	Seoul, Korea	96.3	-40
16	Kanagawa, Japan	95.4	10
17	Kyoto, Japan	93.0	8
18	Taiwan	92.2	-29
19	Osaka, Japan	91.7	5
20	Tokyo, Japan	91.1	-17

(Labour Force as a percentage of working age population)

The number of managers per 1000 employees provides some indication of the concentration of knowledge workers in an economy. Managers, professionals and high-end technical workers are a vital part of the knowledge production process. There is increasing recognition of the role played by these workers as a source of innovation and whose responsibility it is to stimulate investment and growth. These workers include the 'creative class' of employees whose value is specifically their intelligence. Although knowledge workers have a role to play in all industries, clusters are usually found in new industries and highly knowledge-intensive industries and services. Managers are usually the employees that find efficient ways of working with new technology, and are a vital stimulus in the diffusion of such technologies. Their importance is recognised by the fact these workers not only provide the highest value-added to an economy but also receive the highest level of financial remuneration.

Overall this is an index dominated by the European regions, which are found in fifteen of the top twenty places in the rankings. Top of these are the UK regions of Eastern (520.0)

Number of Managers - Top Twenty European Regions in 2008 — Table 3.3

Rank	Top 20 European Regions	Index 2008	Change in Rank 2005-08 (based on all 145 regions)	Rank	Top 20 European Regions	Index 2008	Change in Rank 2005-08 (based on all 145 regions)
1	Eastern, UK	520.0	4	11	Vlaams Gewest, Belgium	197.5	7
2	South East, UK	350	0	12	Emilia-Romagna, Italy	197.1	87*
3	South Netherlands	344.0	-2	13	Lombardia, Italy	197.1	68*
4	Southern and Eastern, Ireland	296.1	-	14	Comunidad de Madrid, Spain	172.3	-9
5	Budapest, Hungary	242.8	-	15	East Netherlands	171.7	-
6	North West, Italy	232.7	56*	16	Bratislavský, Slovak Republic	171.0	-15
7	Île de France, France	224.2	0	17	Prague, Czech Republic	163.1	-11
8	Estonia	208.9	-	18	Latvia	161.3	-
9	South West, UK	201.2	-	19	Baden-Württemberg, Germany	155.6	-5
10	Pohjois-Suomi, Finland	200.2	-	20	Etela-Suomi, Finland	154.5	24

(Managers per 1000 employees)

Number of Managers - Top Twenty North American Regions in 2008 — Table 3.4

Rank	Top 20 North American Regions	Index 2008	Change in Rank 2005-08 (based on all 145 regions)	Rank	Top 20 North American Regions	Index 2008	Change in Rank 2005-08 (based on all 145 regions)
1	Ontario, Canada	188.0	-4	11	Nashville-Davidson--Murfreesboro, US	100.5	-11
2	British Columbia, Canada	181.7	0	12	San Francisco-Oakland-Fremont, US	100.0	-5
3	Alberta, Canada	171.3	-6	13	Baltimore-Towson, US	95.2	-20
4	Quebec, Canada	156.7	-3	14	Memphis, US	92.0	-7
5	Manitoba, Canada	144.9	-5	15	Raleigh-Cary, US	90.1	-18
6	Saskatchewan, Canada	139.2	1	16	Hartford, US	89.9	-2
7	San Jose-Sunnyvale-Santa Clara, US	127.4		17	Oklahoma City, US	88.5	
8	Boston-Cambridge-Quincy, US	115.1	-16	18	Chicago-Naperville-Joliet, US	87.5	-15
9	Atlanta-Sandy Springs-Marietta, US	109.1	-1	19	Charlotte-Gastonia-Concord, US	87.3	-21
10	Washington-Arlington-Alexandria, US	104.5	-23	20	Bridgeport-Stamford-Norwalk, US	85.8	

(Managers per 1000 employees)

Number of Managers - Top Twenty Asia-Oceania Regions in 2008 — Table 3.4

Rank	Top 20 Asia-Oceania Region	Index 2008	Change in Rank 2003-08 (based on all 145 regions)	Rank	Top 20 Asia-Oceania Region	Index 2008	Change in Rank 2003-08 (based on all 145 regions)
1	Singapore	190.9	16	11	Tianjin, China	39.3	-
2	Hong Kong	130.5	55	12	Bangalore, India	36.7	-39
3	New South Wales, Australia	117.4	-23	13	Mumbai, India	36.7	-41
4	Israel	93.4	6	14	Hyderabad, India	36.7	-40
5	Taiwan	93.4	8	15	Tokyo, Japan	30.3	-68
6	Western Australia	88.6	-43	16	Toyama, Japan	26.6	-52
7	Guangdong, China	49.0	-	17	Osaka, Japan	24.2	-56
8	Seoul, Korea	47.9	-	18	Kanagawa, Japan	24.1	-61
9	Shanghai, China	45.6	-	19	Aichi, Japan	22.8	-51
10	Ulsan, Korea	39.9	-	20	Kyoto, Japan	22.5	-62

(Managers per 1000 employees)

and South East (350.0) England, which have both been in the top five since WKCI 2003 and are two of the most economically productive regions of the UK. As Table 3.3 shows, a number of the new European regions also score very well for this indicator, including Estonia (208.9), Pohjois-Suomi (200.2) and Latvia (161.3) (a number of Italian regions also perform strongly on the basis of an alteration in the classification of the underlying data).

In North America, the Canadian regions perform best for this indicator, with Ontario (188.0) and British Columbia (181.7) both ranking in the top fifteen regions overall. Of the US regions, the overall leading WKCI region San Jose (127.4) and Boston (115.1) are at the head of the field, which suggests that, although the US labour market seems to rely on a lower percentage of managerial positions than in Europe and Canada, there is still a strong correlation at the region level between density of managers and competitiveness with in the US.

In Asia-Oceania, Singapore (190.9) remains by far the highest ranked region for numbers of managers per employee, continuing to benefit from an inflow of managerial workers from abroad. Hong Kong (130.5) and New South Wales (117.4) also rank above the index average. Elsewhere rankings are generally low, particularly in Japan where the corporate structure, which lends itself to lower labour mobility within relatively large corporations, leads to a lower ratio of managers to workers than elsewhere.

Knowledge-Based Sectors and Employment

Knowledge economies compete on value and innovation, rather than costs alone. As regions make the transition to knowledge economies, we would expect increases in the number and proportion of knowledge-based employment. In order to analyse knowledge-based employment, we have established five broad groups of knowledge-based activity. Knowledge-based sectors are those sectors characterised by concentrations of high-end technology and intelligence, with the production process requiring high levels of investment and innovation. Firms in such industries deploy a significantly higher proportion of their resources to research and development and often provide increased value-added in terms of generating wealth. Overall, these sectors have the most 'knowledge intensive' production processes, with the importance of innovation and the efficiency of production providing an opportunity for competitive advantage to exist between regions. The outputs from these knowledge-intensive sectors can also increase productivity in other economic sectors and support the diffusion of knowledge.

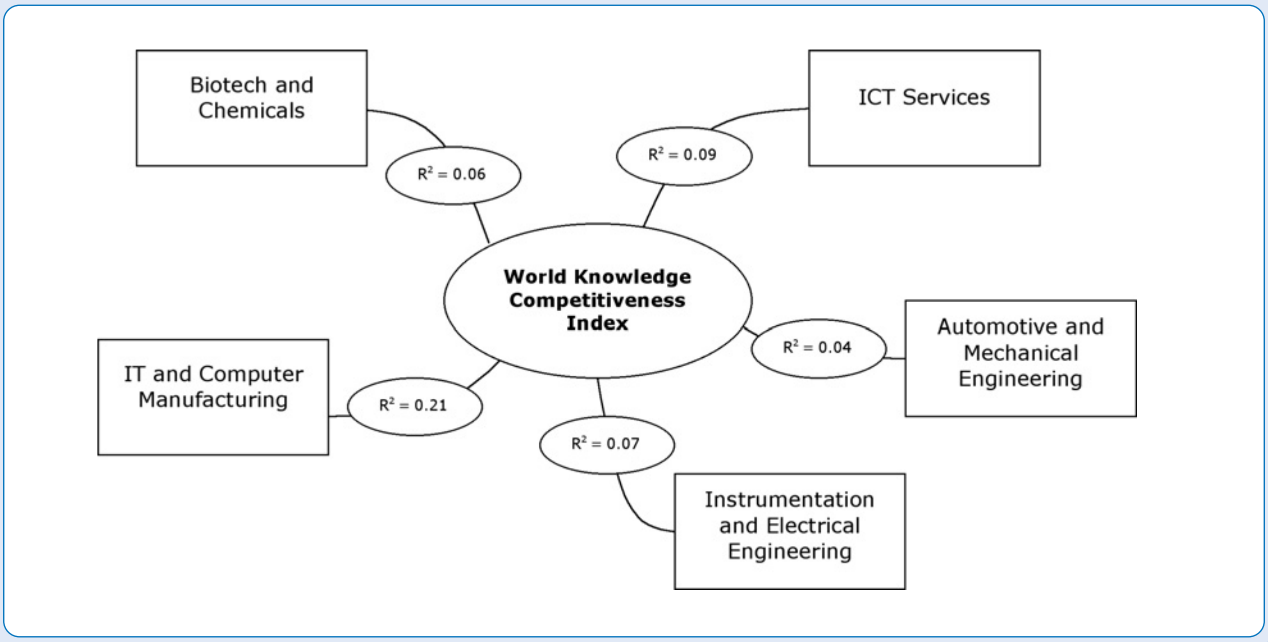
Our knowledge-based sectors consist of:

- **Biotechnology and chemical sectors** – pharmaceuticals, drugs, chemicals and chemical products.
- **IT and computer manufacturing** – communication equipment, computer and office equipment, electronic components and accessories.
- **Automotive and high-technology mechanical engineering** – motor vehicles and transport equipment, machine tools and equipment.
- **Instrumentation and electrical machinery** – precision and optical equipment, electrical transmission and distribution equipment, lighting and wiring equipment.
- **High-technology services** – software and computer related services, telecommunications, research, development and testing services.

Concentrations of knowledge-based industry necessarily suggest the existence of a knowledge-driven economy. Within such economies growth is dependent not only on the proliferation of human and physical capital resources, but is the output of innovation levels amongst a skilled workforce. Our sectoral indicators are a measure of knowledge capital inputs. Regions that perform well in these sectors are more likely to invest heavily in knowledge capital and would be expected to have high levels of factor productivity.

Figure 3.1 provides a sectoral decomposition of the relationship between the WKCI and knowledge employment

Relationship between the WKCI 2008 and Knowledge Employment by Sector **Figure 3.1**



for regions in the European Union-15 member states. Although all sectors are positively correlated with the main index, the most significant relationship is with the IT and computer manufacturing sector. Although many of the other sectors show relatively low levels of correlation, the relationship between the sum of employment in these knowledge sectors and the WKCI has a sample R-squared value of 0.21. This suggests that regional specialisation may be significant: i.e. a competitive region may become highly specialised in one or perhaps two knowledge sectors, but not all, thereby dampening the relationship between any one area of activity and overall knowledge competitiveness. For this reason, the WKCI covers a range of sectors, the inputs for which can be considered knowledge-intensive
It should be noted that this year the denominator for the knowledge employment data has been changed from population (sector employment per 1,000 inhabitants) to employment (sector employees per 1,000 total employees) in order to give a better indication of knowledge employment 'density' based on the overall workforce rather than population. Therefore, it should be kept in mind that ranking changes from 2005 to 2008 under these indicators are likely to reflect, in part, the change in denominator.

Biotechnology and chemicals production requires a highly skilled workforce. This is particularly true in the more developed economies where production tends to be concentrated on niche chemicals. This year the metropolitan area of Durham (476.4) enters the index in first position. Sometimes referred to as the "City of Medicine", Durham is a major US healthcare centre, home to more than 300 medical and health-related companies and medical practices, as well as the nationally renowned Research Triangle Park, as well as number of major universities including Duke. In second place is Rochester (422.9), a city in upstate New York that is home to more than 70 biotech companies, with a particular concentration in vision science and medical imaging. The city is a new entrant at the top the biotech index on the basis of data for this sector now being available for Rochester at the MSA level. These two cities are well ahead of the Japanese biotech centre of Toyama (272.6) in third place, while last year's leader Indianapolis (263.1), home to the huge Eli Lilly pharmaceutical corporation, moves down in the rankings to fifth.

Analysing the WKCI biotechnology and chemical sector index as a whole, it is interesting to see that there are large intra-national variations in employment, showing that business clustering in this sector appears to be taking place very much on a regional, rather than a national, basis. This lends support to the importance of competition at the regional level in innovative, knowledge-intensive sectors. There is also no major continental domination of the industry, as shown by Table 3.5, which demonstrates a relatively even geographic distribution between North America, Europe and Asia.

IT and computer manufacturing is another high value-added industry and continues to grow rapidly, having recovered from the brief but dramatic downturn of the dot-com crash.

Employment in the Biotechnology and Chemicals Sector - Top Twenty Regions in 2008 — **Table 3.5**

Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1	Durham, US	476.4	-
2	Rochester, US	422.9	-
3	Toyama, Japan	272.6	2
4	Oxnard-Thousand Oaks-Ventura, US	269.4	-
5	Indianapolis, US	263.1	-4
6	Hessen, Germany	253.8	-3
7	Lombardia, Italy	249.2	-5
8	Vlaams Gewest, Belgium	238.5	-1
9	Greensboro-High Point, US	227.0	-5
10	South Netherlands	204.9	7
11	Philadelphia-Camden-Wilmington, US	201.7	-2
12	South, Sweden	201.5	-1
13	Switzerland	196.1	-7
14	Taiwan	192.5	-2
15	Houston-Sugar Land-Baytown, US	189.5	-5
16	North West, Italy	186.0	64
17	Osaka, Japan	183.5	-4
18	Singapore	183.1	25
19	Southern and Eastern, Ireland	180.6	-
20	Centre-est, France	169.7	5

(Employees per 1000 employees)

Employment in the IT and Computer Manufacturing Sector - Top Twenty Regions 2008 — **Table 3.7**

Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1	San Jose-Sunnyvale-Santa Clara, US	1,233.2	0
2	Shiga, Japan	520.0	
3	Singapore	519.0	0
4	Austin-Round Rock, US	427.0	-2
5	Durham, US	394.5	
6	Pohjois-Suomi, Finland	376.0	
7	Guangdong, China	374.2	
8	Portland-Vancouver-Beaverton, US	352.4	-3
9	Shanghai, China	348.6	
10	Colorado Springs, US	346.8	
11	Kanagawa, Japan	316.6	-3
12	Tochigi, Japan	304.7	-6
13	Tianjin, China	300.1	
14	Toyama, Japan	293.2	-7
15	South Netherlands	288.8	-6
16	Stockholm, Sweden	233.1	11
17	Taiwan	229.7	-6
18	Kyoto, Japan	214.7	-2
19	Phoenix-Mesa-Scottsdale, US	187.8	-4
20	Etela-Suomi, Finland	182.1	6

(Sector employees per 1000 total employees)

This is also the sector which shows the highest correlation with overall knowledge competitiveness, as indicated by Figure 3.1. This year the metropolitan area of San Jose (1,233.2), the leading region in the composite WKCI, is again the leader of the IT and computer manufacturing index. With over one in every ten employees working in the IT and computer manufacturing sector in the region – over twelve times the index average – the index demonstrates San Jose's strength in this sector, where the clustering effect of global manufacturers such as Hewlett Packard, Sun Microsystems, Intel, and many more, continues to develop highly knowledge-intensive employment.

Elsewhere there has been little change. Shiga (520.0) moves up two places to second place while Austin (474.8), the index leader in 2004 and home to Dell computers, moves down to fourth place. Clusters of IT manufacturing remain particularly prevalent in East Asia, especially Singapore (519.0) and a number of Chinese and Japanese regions. Of note is the number of new regions in this year's top twenty, indicating that IT and computer manufacturing is often strong in up and coming knowledge centres. Amongst these is the Finnish region of Pohjois-Suomi (376.0), the only European region in the top ten.

The automotive and mechanical engineering sector provides high-technology employment and requires high levels of technological investment. As such, regions that are strong in this sector also tend to have relatively high levels of business R&D investment and patenting rates, both of which can have positive spillovers for other sectors in the region.

The reputation of Germany and Japan in automotive production is again borne out in our rankings, which between them have nine of the top twenty regions in this index. This year Aichi (411.7) and Baden Württemberg (357.8) trade places at the top of the rankings. Both are renowned global automotive centres. Aichi has the highest industrial output of any Japanese prefecture and is home to the vast Toyota Motor Corporation, as well as a number of other plants operated by the likes of Mitsubishi and Suzuki. Baden Württemberg, considered by some to be the home of the automobile industry,[4] is the hub of the German automobile industry, and employment in the sector remains resilient despite gradual outsourcing to Eastern Europe.

Elsewhere on the index the Swedish regions are noticeable for their strong performance on this year's automotive and mechanical engineering index, with West Sweden (302.0) – home to the Volvo and Saab brands – moving up seven places to fourth and Smaland Medoarna (290.4) moving up sixteen places to fifth. Of the North American regions, Detroit (266.1), the city that has for so long been synonymous with the US car industry, remains the strongest performer, although its position has continued to decline gradually since the WKCI began.

The instrumentation and electrical engineering sector utilises some of the most high-technology production techniques available. Similarly, the sector requires a supply of suitably skilled labour, providing high value equipment for a range of

[4] Gottlieb Daimler and Karl Benz invented the motorbike and the four wheel automobile in the region's capital, Stuttgart

Employment in the Automotive and Mechanical Engineering Sector - Top Twenty Regions 2008 — **Table 3.8**

Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1	Aichi, Japan	411.7	1	11	Emilia-Romagna, Italy	231.0	-1
2	Baden-Württemberg, Germany	357.8	-1	12	Tochigi, Japan	230.0	3
3	Shizuoka, Japan	348.0	1	13	Noreste, Spain	223.6	0
4	West, Sweden	302.0	7	14	Shiga, Japan	219.5	6
5	Smaland Medoarna, Sweden	290.4	16	15	Seattle-Tacoma-Bellevue, US	205.7	1
6	Saarland, Germany	282.9	6	16	Niedersachsen, Germany	202.4	-9
7	Detroit-Warren-Livonia, US	266.1	-1	17	South, Sweden	200.2	n/a
8	Ostra Mellansverige, Sweden	244.1	-	18	Kanagawa, Japan	198.9	14
9	Bayern, Germany	240.7	-4	19	Lansi-Suomi, Finland	198.1	-
10	Hartford, US	233.9	4	20	North East, Italy	191.0	-2

(Sector employees per 1000 total employees)

Employment in the Instrumentation and Electrical Machinery Sector - Top Twenty Regions 2008 — **Table 3.9**

Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1	Shiga, Japan	382.2	8	11	Guangdong, China	238.9	-
2	Baden-Württemberg, Germany	304.9	1	12	Lombardia, Italy	229.4	0
3	Tochigi, Japan	304.5	5	13	Aichi, Japan	225.7	0
4	Singapore	302.0	n/a	14	Kyoto, Japan	223.5	1
5	Switzerland	300.3	-3	15	Budapest, Hungary	217.4	1
6	Shizuoka, Japan	296.4	0	16	North West, Italy	204.2	15
7	San Jose-Sunnyvale-Santa Clara, US	295.8	-3	17	Centre-est, France	202.2	5
8	Milwaukee-Waukesha-West Allis, US	274.5	-3	18	North East, Italy	201.3	-1
9	Bayern, Germany	251.6	2	19	Emilia-Romagna, Italy	189.7	0
10	Shanghai, China	240.3	-	20	Hessen, Germany	182.7	1

(Sector employees per 1000 total employees)

'front line' industries. The Japanese region of Shiga (382.2) moves up eight places to become this year's leader in instrumentation and electrical engineering employment (see Table 3.9). Shiga is home to a wide variety of major high tech companies in this sector such as Toray Industries and Canon. Baden-Württemberg (304.9) moves up to second place, suggesting it is using its automobile base to increasingly diversify into other high value added manufacturing sectors. Accurate data is now also available for Singapore (302.0), which enters in fourth place by virtue of an electronics industry that accounts for almost half of total industrial output. Other notable new entrants are the Chinese regions of Shanghai (240.3) and Guangdong (238.9), demonstrating that these leading Chinese regions are beginning to move into sectors towards the top of the value chain.

The WKCI's high-technology service sector index represents the density of employment in the following: telecommunications services; IT support; data processing; computer software; and research and scientific development. All are sectors which require innovative businesses and a pool of well educated workers, as illustrated earlier in Figure 3.1 which showed the relatively high correlation between high-tech service employment and the composite WKCI.

This year Île de France (336.4), the region which covers the capital Paris, moves to the top of the rankings. The Paris region has a very high density of knowledge employment across many sectors, but moves to the top of rankings based on particularly high telecoms and computer service employment. Lazio (301.2) moves up to second place (following some reclassifications of Italian statistics), while San Jose (279.3) remains in third place, demonstrating its very high knowledge employment across the service and manufacturing sectors. Of the new regions, Beijing (173.9) and Durham (166.8) both enter in the top fifteen.

A notable point of interest in the high tech service index is the extent of geographic dispersion among the top regions. Remarkably, fourteen different nations are represented in the top twenty, which strongly suggests that each nation tends to have a central 'pole' region which provides the base for the high-tech service sector in that nation, rather than national specialisation in these sectors. These regions tend to be centred around a nation's economic centre: Paris, Toyko Stockholm, Brussels, Beijing, Prague, and so on.

Why do we get greater regional dispersion in high tech services as opposed to high-tech manufacturing? Firstly, in high-tech manufacturing sectors, such as automotives or pharmaceuticals, high fixed costs create a barrier to entry that will tend to create an oligopolistic market structure, dominated by a few big players. As such, employment in these sectors will be heavily concentrated in areas where major firms locate, and thus regional or even global markets will be dominated by a handful of centres that are able to service the whole geographic area. In contrast, low fixed costs means that the success of service firms will be much less dependent on increasing returns to scale, enabling smaller firms to compete successfully in many areas. Secondly, service providers remain far more nationally-oriented than manufacturers: in Europe, for example the service sector still accounts for only 20 percent of trade between member states, despite accounting for 70 percent of the EU's GDP.

Employment in the High Tech Service Sector - Top Twenty Regions 2008 **Table 3.9**

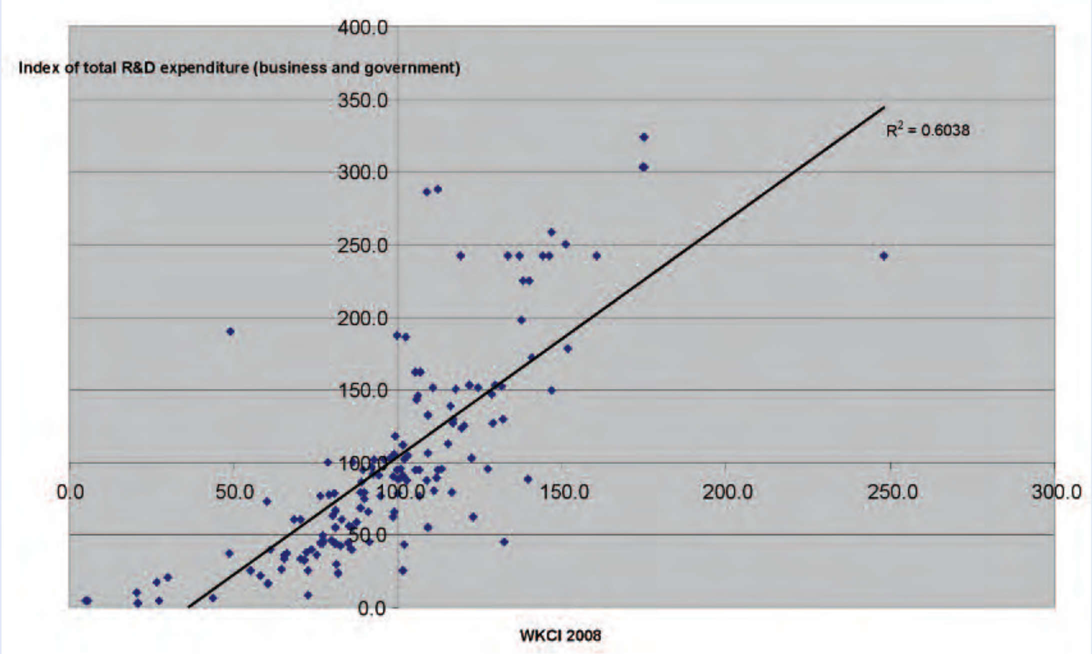
Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1	Île de France, France	336.4	7	11	Beijing, China	173.9	
2	Lazio, Italy	301.2	30*	12	South East, UK	173.0	-3
3	San Jose-Sunnyvale-Santa Clara, US	279.3	0	13	West, Netherlands	167.6	13
4	Washington-Arlington-Alexandria, US	264.9	0	14	Budapest, Hungary	166.9	17
5	Comunidad de Madrid, Spain	252.8	8	15	Durham, US	166.8	
6	Tokyo, Japan	249.0	-5	16	Central, Italy	165.1	96*
7	Stockholm, Sweden	237.8	-5	17	San Francisco-Oakland-Fremont, US	162.2	-3
8	Brussels, Belgium	206.6	33	18	Kansas City, US	161.2	-6
9	Nordrhein-Westfalen, Germany	180.7	n/a	19	Kanagawa, Japan	154.9	2
10	Prague, Czech Republic	175.5	-3	20	New South Wales, Australia	151.9	10

(Sector employees per 1000 total employees)

Knowledge capital refers to a region's capacity for creating new ideas and transforming these ideas to create commercial value. Investment in research and development activity is a key indicator of the efforts to develop and exploit new technology, software and ideas in order to enlarge the knowledge base. These research and development indicators have been broken down according to the two major sectors participating in such activity – business and government. There are some disadvantages to using this indicator as it may fail to take account of the R&D activities of firms where innovation occurs 'outside of the laboratory' or R&D department. Secondly, differences in R&D intensity across regions and nations will depend on differences in the mix of industries within the area. Nevertheless, R&D expenditure indicators remain some of the best available measures of an economy's ability to develop knowledge and translate it into high value-added economic output. The extent of the correlation between total R&D expenditure (business and government) and knowledge competitiveness is demonstrated by Figure 4.1.

Table 4.1 ranks public/government R&D expenditure per head. Government expenditure on R&D is usually focused on developing the science base, supporting the full benefits of research that cannot always be adequately captured by the private sector. This index has seen little movement since 2005, reflecting the relatively stable rates of public sector expenditure. The Washington DC metropolitan area (815.9) remains at the top of the rankings for the fifth year running by virtue of the US capital region's continuing disproportionate share of federal R&D budgets, in particular in health and defence. Neighbouring Baltimore (744.8)

Relationship between total R&D Expenditure per Capita at the Regional Level and the WKCI 2008 **Figure 4.1**



remains in second, reflecting the strength of government R&D spending in the state of Maryland. The rest of the top twenty continues to be dominated by US regions, reflecting the continued strength of government-sponsored research in the US, which during the 1990s had been declining due to a fall in military-related R&D. The only non-US region is Beijing (534.8), in third place, having been the only top region to have moved significantly up the rankings since 2005.

The top ranking European region is Lazio (158.2) although the region has fallen five places down to 22nd in the rankings overall. Prague (157.4) also moves down, although government expenditure on R&D remains very high relative to the size of the Czech budget. Elsewhere, most leading European regions have seen there ranking decline, the exceptions being Bratislavsk_ which has risen thirty places to 58th and Central Italy, rising 42 places to 62nd overall.

Outside of China the Asia-Pacific regions have also seen their rankings decline since 2005, as shown by Table 4.3. The wide disparity in government R&D expenditure is also notably in the Asia-Pacific top twenty, ranging from five times the index average in top ranked Beijing to less than one-sixth the index average in Zhejing, Toyama and Aichi.
Business expenditure on R&D is a key measure of the extent

Per Capita Research and Development Expenditure by Government – Top Twenty Regions 2008 — Table 4.1

Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1	Washington-Arlington-Alexandria, US	815.9	0	11	San Diego-Carlsbad-San Marcos, US	257.3	1
2	Baltimore-Towson, US	744.8	0	12	Oxnard-Thousand Oaks-Ventura, US	257.3	
3	Beijing, China	534.8	11	13	Riverside-San Bernardino-Ontario, US	257.3	-3
4	Richmond, US	441.8	-1	14	San Jose-Sunnyvale-Santa Clara, US	257.3	-6
5	Virginia Beach-Norfolk-Newport News, US	438.9	-1	15	Los Angeles-Long Beach-Santa Ana, US	257.3	-4
6	Boston-Cambridge-Quincy, US	398.3	-1	16	Sacramento--Arden-Arcade--Roseville, US	257.3	-3
7	Providence-Fall River-Warwick, US	314.5		17	Seattle-Tacoma-Bellevue, US	196.0	-10
8	Hartford, US	313.1	-2	18	Denver-Aurora, US	185.8	-2
9	Bridgeport-Stamford-Norwalk, US	313.1		19	Colorado Springs, US	185.8	
10	San Francisco-Oakland-Fremont, US	257.3	-1	20	Phoenix-Mesa-Scottsdale, US	171.5	-5

Per Capita Research and Development Expenditure by Government – Top Twenty European Regions 2008 — Table 4.2

Rank	Top 20 European Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 European Regions	Index 2008	Change in Rank 2005-08
22	Lazio, Italy	158.2	-5	75	Comunidad de Madrid, Spain	72.9	-27
23	Prague, Czech Republic	157.4	-5	77	Budapest, Hungary	67.0	-28
27	Berlin, Germany	139.6	-8	78	Stockholm, Sweden	64.8	-9
28	Bremen, Germany	122.7	-5	80	Baden-Württemberg, Germany	62.4	-23
29	Iceland	112.6		82	South East, UK	59.9	-7
44	Île de France, France	103.7	-17	83	East Netherlands	57.9	
58	Bratislavsk_, Slovak Republic	87.3	30	84	Luxembourg	54.1	0
59	Hamburg, Germany	86.9	-19	85	West, Netherlands	52.2	-20
62	Central, Italy	83.3	42	86	Eastern, UK	51.0	-9
65	Etela-Suomi, Finland	79.6	-40	87	Norway	50.6	-17

(Expenditure per capita in USD - PPP adjusted)

Per Capita Research and Development Expenditure by Government – Top Twenty Asia-Pacific Regions 2008 — Table 4.3

Rank	Top 20 Asia-Pacific Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Asia-Pacific Regions	Index 2008	Change in Rank 2005-08
3	Beijing, China	534.8	11	101	Singapore	35.9	-10
24	Shanghai, China	155.0	47	103	Israel	35.2	-6
49	Tokyo, Japan	95.3	-12	105	Kanagawa, Japan	33.1	-10
63	Taiwan	80.2	-28	106	New South Wales, Australia	32.5	-34
73	Ulsan, Korea	76.1	-11	109	Jiangsu, China	30.4	
74	Seoul, Korea	76.1	-13	110	Tochigi, Japan	30.2	-12
76	Tianjin, China	68.2	26	119	Osaka, Japan	17.5	-12
88	Victoria, Australia	47.8	-15	121	Zhejing, China	16.5	
92	New Zealand	40.8	-12	122	Toyama, Japan	16.4	-12
93	Western Australia	40.7	-19	123	Aichi, Japan	16.2	-12

(Expenditure per capita in USD - PPP adjusted) to which businesses are developing and exploiting new technology and ideas. Expenditure on R&D by industry has been shown to generate important positive externalities for other firms, and for society as a whole, which facilitates the utilisation and transfer of knowledge. The level of investment by business, as opposed to the public sector, is a strong barometer of the level of innovative activity within regions and the extent to which technology is driving process development.

Similar to government R&D expenditure, the top regions by business R&D expenditure are predominantly American. This year Hartford (299.9) moves up again and is now in first position. Boston (298.2) also moves up two places to third, further emphasising the strength of business R&D investment in southern New England. Seattle (267.7), the index leader in 2005, slips five places this year to sixth, just ahead of West Sweden (264.5), the only non-American region in the top fifteen.

While business R&D in the US is relatively concentrated in the North East and South West, in Europe it is more widely distributed, with ten different nations represented in the top twenty. The Swedish regions perform particularly well, with West Sweden (264.5) and Stockholm (216.3) holding the first two places by some distance, as well as two other

Per Capita Research and Development Expenditure by Business – Top Twenty Regions 2008 **Table 4.4**

Rank	Top 20 Regions	Index 2008	Change in Rank 2003-08	Rank	Top 20 Regions	Index 2008	Change in Rank 2003-08
1	Hartford, US	299.9	2	9	Los Angeles-Long Beach-Santa Ana, US	236.6	0
1	Bridgeport-Stamford-Norwalk, US	299.9		9	San Francisco-Oakland-Fremont, US	236.6	-2
3	Boston-Cambridge-Quincy, US	298.2	2	9	Oxnard-Thousand Oaks-Ventura, US	236.6	
4	Grand Rapids, US	271.5	3	9	Riverside-San Bernardino-Ontario, US	236.6	-5
4	Detroit-Warren-Livonia, US	271.5	1	9	Sacramento--Arden-Arcade--Roseville, US	236.6	-2
6	Seattle-Tacoma-Bellevue, US	267.7	-5	16	Shiga, Japan	227.0	0
7	West, Sweden	264.5	-3	17	Stockholm, Sweden	216.3	-15
8	Providence-Fall River-Warwick, US	238.3		18	Shizuoka, Japan	212.4	2
9	San Diego-Carlsbad-San Marcos, US	236.6	3	19	Aichi, Japan	210.9	0
9	San Jose-Sunnyvale-Santa Clara, US	236.6	-2	20	Kanagawa, Japan	185.4	6

(Expenditure per capita in USD - PPP adjusted)

Per Capita Research and Development Expenditure by Business – Top Twenty European Regions 2008 **Table 4.5**

Rank	Top 20 Eurpoean Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Eurpoean Regions	Index 2008	Change in Rank 2005-08
1	West, Sweden	264.5	-3	11	Switzerland	135.5	1
2	Stockholm, Sweden	216.3	-15	12	Hessen, Germany	127.4	-7
3	Eastern, UK	178.0	4	13	South East, UK	120.7	-7
4	Île de France, France	170.0	-11	14	Lansi-Suomi, Finland	118.5	-44
5	Baden-Württemberg, Germany	169.8	-8	15	Ostra Mellansverige, Sweden	117.0	
6	Pohjois-Suomi, Finland	161.8		16	South Netherlands	115.3	-18
7	Luxembourg	155.3	-17	17	Denmark	96.3	-8
8	South, Sweden	149.4	-13	18	Hamburg, Germany	92.8	11
9	Etela-Suomi, Finland	143.0	-18	19	Bremen, Germany	92.5	6
10	Bayern, Germany	136.2	-10	20	East, Austria	91.9	-19

Per Capita Research and Development Expenditure by Business – Top Twenty Asia Pacific Regions 2008 **Table 4.6**

Rank	Top 20 Asia-Pacific Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Asia-Pacific Regions	Index 2008	Change in Rank 2005-08
1	Shiga, Japan	227.0	0	11	Ulsan, Korea	79.0	-1
2	Shizuoka, Japan	212.4	2	12	Seoul, Korea	79.0	-3
3	Aichi, Japan	210.9	0	13	Taiwan	74.8	0
4	Kanagawa, Japan	185.4	6	14	Beijing, China	72.6	3
5	Tochigi, Japan	175.3	7	15	Singapore	71.4	-5
6	Tokyo, Japan	167.0	4	16	Western Australia	70.4	3
7	Israel	164.8	4	17	Victoria, Australia	64.2	-1
8	Toyama, Japan	161.4	7	18	New South Wales, Australia	62.2	-3
9	Osaka, Japan	158.7	3	19	Shanghai, China	50.8	9
10	Kyoto, Japan	117.1	7	20	Tianjin, China	29.9	-3

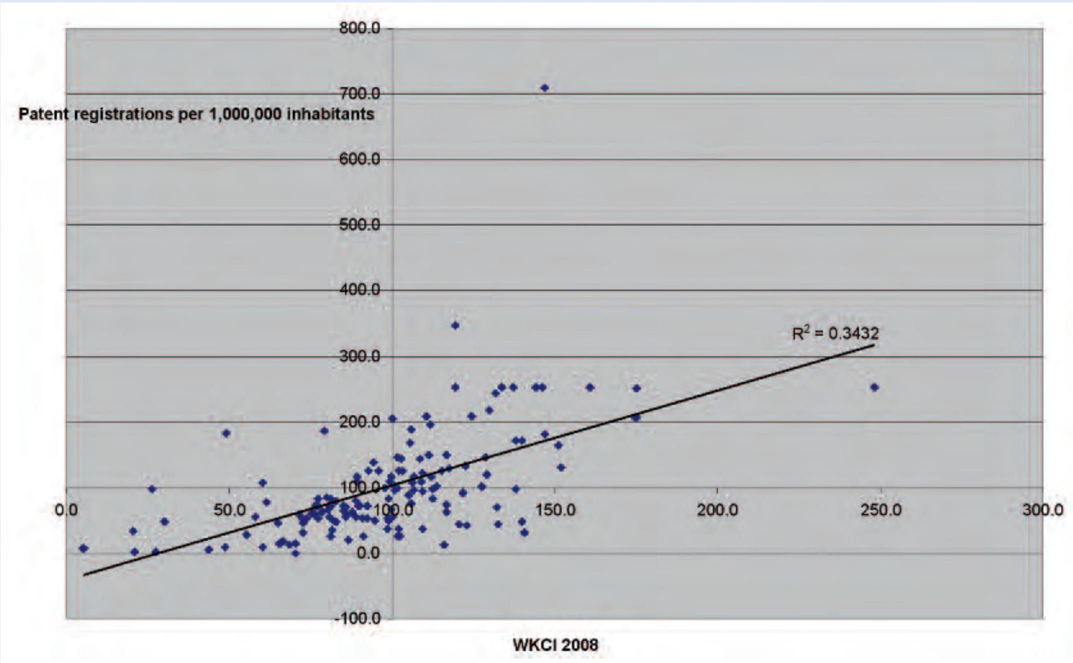
Swedish regions making the top fifteen. Germany also ranks well, with five regions in the top twenty, led by Baden Württemberg (169.8). However, few European regions have performed well compared to 2005, a trend particularly noticeable amongst the Finnish and Swedish regions.

In Asia, Japanese regions are clearly at the head of business R&D investment, led by four regions which also make the top twenty overall: Shiga (227.0), Shizuoka (212.4), Aichi (210.9) and Kanagawa (185.4). The Japanese regions have also all seen their rankings maintained or improved since 2005. Lower down the table Shanghai (50.8) is also notable for a strong rise in its ranking.

Along with R&D investment, the generation of new ideas within the WKCI is represented by levels of patent registration, as the nearest proxy to direct indicators of knowledge formation and knowledge capitalisation. The number of patents can be used to indicate how successful a region is in converting knowledge into potentially commercially viable products and processes. This indicator is not perfect as patents are an indicator of invention not innovation, and it may be a better indicator for some industries rather than others. For example, automotive companies are more likely to patent than those firms working in financial services. However, there does appear to be a significant relationship between patenting rates and broader knowledge competitiveness; a fact illustrated by the strong correlation seen in Figure 4.2.

Looking at the leading regions for this indicator, Table 4.7 illustrates that, as with other indicators of knowledge capital, patent registrations across the WKCI regions are dominated by US regions, with the notable exception of the two Japanese regions of Tokyo (708.7) and Osaka (346.9) which occupy the first two positions on the index by some distance. The Californian MSAs make up most of the rest of the top 10, followed by a number of other US regions from the North East, North West and Colorado. South Netherlands (205.3) and Baden-Württemberg (187.4) are the only European regions in the top twenty, which also includes the Asia-Pacific regions of Kyoto (196.2) and Shanghai (186.0).

Relationship between Patent Registrations per 1 million inhabitants and the WKCI 2008 — **Figure 4.2**



Index of Patent Registrations per 1 million inhabitants- Top Twenty Regions 2008 — **Table 4.7**

Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1	Tokyo, Japan	708.7	0	11	Minneapolis-St. Paul-Bloomington, US	243.1	-1
2	Osaka, Japan	346.9	1	12	Portland-Vancouver-Beaverton, US	217.0	2
3	San Jose-Sunnyvale-Santa Clara, US	252.3	1	13	Colorado Springs, US	208.5	
4	San Diego-Carlsbad-San Marcos, US	252.3	4	14	Denver-Aurora, US	208.5	-1
5	Los Angeles-Long Beach-Santa Ana, US	252.3	2	15	Bridgeport-Stamford-Norwalk, US	206.0	
6	San Francisco-Oakland-Fremont, US	252.3	0	16	Hartford, US	206.0	7
7	Riverside-San Bernardino-Ontario, US	252.3	-2	17	South Netherlands	205.3	32
8	Oxnard-Thousand Oaks-Ventura, US	252.3		18	Kyoto, Japan	196.2	12
9	Sacramento--Arden-Arcade--Roseville, US	252.3	0	19	Baden-Württemberg, Germany	187.4	25
10	Boston-Cambridge-Quincy, US	250.4	1	20	Shanghai, China	186.0	-18

Chapter 5: Financial Capital

In order for firms to compete in the knowledge economy, actors not only need the willingness to acquire knowledge capital but also the finance with which to do so. Here we benchmark the availability of private equity to businesses at the regional level as a measure of financial capital availability. Private equity funding is particularly important, as it is often concentrated in small or medium sized firms with the potential for growth. Such investments finance expansion in order for innovative firms to build up their human, physical and knowledge capital stocks. In addition, private equity includes venture capital and start-up investments, which tend to be in knowledge-based activities and significantly add to each region's business base.

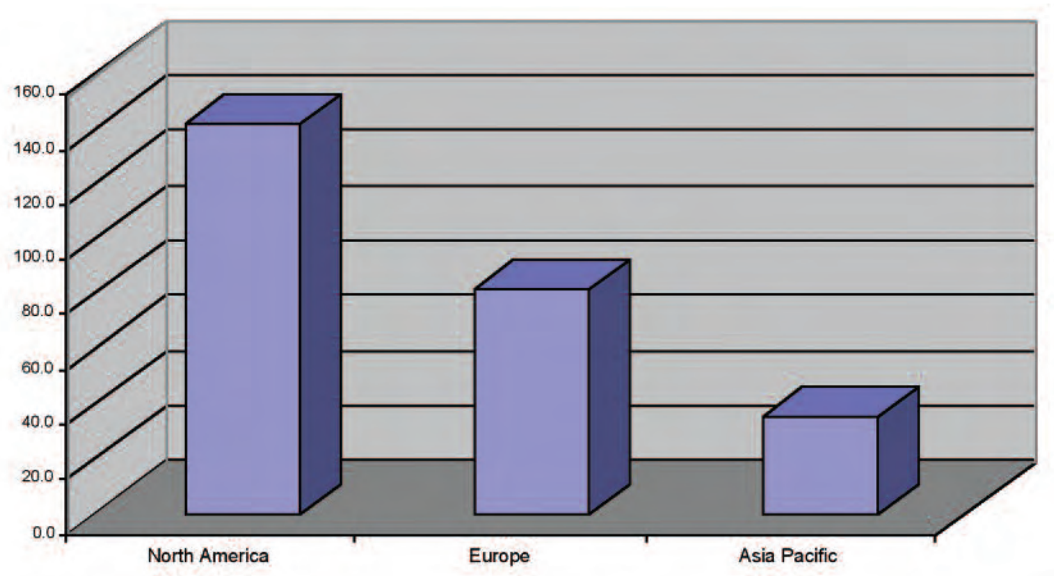
As shown by Table 5.1, US regions continue to provide the highest levels of private equity to their firms and occupy the top seven spots in the 2008 rankings. San Jose and San Francisco share the top spot, with both regions benefiting from the huge amount of venture capital available in and around Silicon Valley. These regions are a very long way ahead of San Diego (451.9), which moves up two places to third. The southern New England regions of Hartford, Boston, Bridgeport and Providence follow, all of which score over four times the index average. Outside of North America, a handful of European are competitive in terms of private equity: Stockholm, London and Paris all make the top ten.

Index of Private Equity Investment Capital Per Capita – Top Twenty Regions in 2008 — **Table 5.1**

Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1=	San Jose-Sunnyvale-Santa Clara, US	1,454.2	0	11=	Seattle-Tacoma-Bellevue, US	200.3	1
1=	San Francisco-Oakland-Fremont, US	1,454.2	0	11=	Portland-Vancouver-Beaverton, US	200.3	0
3=	San Diego-Carlsbad-San Marcos, US	451.9	2	13	Iceland	174.4	
3=	Hartford, US	413.8	-1	14	South East, UK	168.0	0
3=	Bridgeport-Stamford-Norwalk, US	413.8		15	Denver-Aurora, US	160.6	-9
3=	Boston-Cambridge-Quincy, US	413.8	-3	15=	Colorado Springs, US	160.6	
3=	Providence-Fall River-Warwick, US	413.8		17	West, Sweden	152.1	0
8	Stockholm, Sweden	346.5	-1	18	Quebec, Canada	148.6	-2
9	London, UK	285.0	-1	19	Israel	135.6	3
10	Île de France, France	284.2	-1	20	Singapore	128.8	5

Figure 5.1 compares average scores for private equity across the three continents. Asia-Pacific regions perform particularly poorly for this indicator, partly reflecting the business structure, but also suggesting a potential lack of capital investment for smaller and more dynamic firms. However, it should be noted that this comparison also reflects in part the relatively poor quality of data available for private equity for countries such as India and China.

Private Equity Investment Capital per Capita – Mean Average Index Score by Continent **Figure 5.1**



Labour productivity is an important measure of regional performance. It is a variable influenced by a wide range of factors such as sector make-up, workforce skills, investment in innovation and market competition. Productivity varies from GDP per capita and is partly a function of a region's economic activity and unemployment rates. The prosperity of all economies is highly dependent on their productivity rates.

As shown by Table 6.1, the highest productivity rate in this year's index is found in Hartford (185.2), some way ahead of San Jose (159.5) in second and Bridgeport (159.4) in third. The relative strength of the US in terms of output per employee is very clear in the table, which contains eighteen US regions out of the top twenty. Notable movers amongst the US regions are New York, Washington and Virginia Beach, which move up strongly into the top ten, as well as San Diego, Greensboro and Philadelphia, which all make significant gains to move into the top twenty. While the US regions have always been dominant under this indicator it should be noted that their lead has been further strengthened this year by the harmonization of data collection which previously had slightly favoured European and Japanese regions for which full-time equivalent estimates were available. Thus, under this more comparable approach only Luxembourg (132.6) and Brussels (132.5) maintain their positions in the top twenty.

In Europe (Table 6.2), Luxembourg and Brussels are followed in the rankings by Ile de France (129.0) and then the Dutch regions of North and West Netherlands. London (109.1) and Vlaams Gewest (108.0) are the only top twenty European regions that improve their ranking since 2005. While productivity comparisons between Europe and the US appear discouraging, it should be noted that a significant proportion of the difference reflects additional hours of work per employee. Comparisons between Europe and the US on the basis of productivity per hour show that while the US is still more productive, the extent of the 'genuine productivity' difference is exaggerated by the longer average working hours and fewer holidays taken by US workers.

Index of Labour Productivity (Output per Employee) – Top Twenty Regions 2008 — **Table 6.1**

Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1	Hartford, US	185.2	2	11	Providence-Fall River-Warwick, US	136.6	
2	San Jose-Sunnyvale-Santa Clara, US	159.5	3	12	Los Angeles-Long Beach-Santa Ana, US	136.1	3
3	Bridgeport-Stamford-Norwalk, US	159.4		13	Seattle-Tacoma-Bellevue, US	136.0	4
4	New York-Northern New Jersey-Long Island, US	147.4	6	14	San Diego-Carlsbad-San Marcos, US	134.4	10
5	Buffalo-Niagara Falls, US	142.8	8	15	Luxembourg	132.6	-13
6	Washington-Arlington-Alexandria, US	142.2	10	16	Brussels, Belgium	132.5	-15
7	Boston-Cambridge-Quincy, US	141.0	5	17	Greensboro-High Point, US	131.6	44
8	Rochester, US	140.2	3	18	Charlotte-Gastonia-Concord, US	131.1	4
9	San Francisco-Oakland-Fremont, US	139.7	-3	19	Durham, US	129.1	
10	Virginia Beach-Norfolk-Newport News, US	138.0	35	20	Philadelphia-Camden-Wilmington, US	129.0	10

Index of Labour Productivity (Output per Employee) – Top Twenty European Regions 2008 — **Table 6.2**

Rank	Top 20 Eurpoean Regions	Index 2008	Change in Rank 2003-08	Rank	Top 20 Eurpoean Regions	Index 2008	Change in Rank 2003-08
1	Luxembourg	132.6	-6	11	Vlaams Gewest, Belgium	108.0	7
2	Brussels, Belgium	132.5	-14	12	Stockholm, Sweden	105.3	-21
3	Île de France, France	129.0	-10	13	East Netherlands	103.4	
4	North, Netherlands	119.5	60*	14	Lombardia, Italy	101.8	-40
5	West, Netherlands	119.0	34*	15	Lazio, Italy	99.8	-25
6	Southern and Eastern, Ireland	117.1		16	North West, Italy	98.6	-36
7	Hamburg, Germany	113.1	-24	17	East, Austria	97.2	-33
8	Norway	111.6	-24	18	Hessen, Germany	97.0	-26
9	South Netherlands	111.5	36*	19	Etela-Suomi, Finland	95.3	-34
10	London, UK	109.1	1	20	Bayern, Germany	94.2	-11

(Output per Employee)

In Asia-Pacific (Table 6.3) the Korean city of Ulsan (119.1) leads by productivity, followed by a series of Japanese regions. Hong Kong (99.6) moves up strongly, although still falls a little below the index average, while the Asia-Pacific top ten is completed by the three Australian regions of New South Wales, Victoria and Western Australia.

It is important not just to assess output, but also how output is translated into wealth and prosperity for those individuals living within the WKCI regions. Earnings data indicate the relative wealth and standards of living within an economy, particularly the value-added generated from economic activity. It is also a strong proxy of the relative quality of jobs within an economy.

Table 6.4 indicates that although US regions perform very strongly under this indicator, European regions also fare much better than their performance in productivity index. At the top of the table, San Jose (208.7) remains in first place, although now closely followed by Tokyo (202.4), which moves up four places to second overall. Bridgeport (182.1) enters strongly in third followed by Ile de France (152.5), the leading European region. The rest of the top twenty is made up of a mixture of major world cities from the US, Europe and Japan.

Index of Labour Productivity (Output per Employee) – Top Twenty Asia-Pacific Regions 2008 — **Table 6.3**

Rank	Top 20 Asia-Pacific Regions	Index 2008	Change in Rank 2003-08	Rank	Top 20 Asia-Pacific Regions	Index 2008	Change in Rank 2003-08
1	Ulsan, Korea	119.1	-19	11	Taiwan	91.1	8
2	Tokyo, Japan	113.8	-41	12	Shizuoka, Japan	90.8	18
3	Shiga, Japan	104.6	33	13	Kyoto, Japan	89.8	14
4	Aichi, Japan	103.0	24	14	Tochigi, Japan	89.0	11
5	Kanagawa, Japan	102.9	42	15	Toyama, Japan	87.3	10
6	Osaka, Japan	101.6	8	16	Singapore	77.0	-15
7	Hong Kong	99.6	20	17	Israel	75.6	-51
8	New South Wales, Australia	99.1	0	18	New Zealand	66.1	-14
9	Western Australia	95.0	-2	19	Seoul, Korea	65.2	-13
10	Victoria, Australia	91.6	-4	20	Shanghai, China	58.1	-15

Index of Earnings (Mean Gross Monthly Earnings) – Top Twenty Regions 2008 — **Table 6.4**

Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1	San Jose-Sunnyvale-Santa Clara, US	208.7	0	11	Osaka, Japan	143.7	48
2	Tokyo, Japan	202.4	4	12	Durham, US	143.2	
3	Bridgeport-Stamford-Norwalk, US	182.1		13	Aichi, Japan	141.6	44
4	Washington-Arlington-Alexandria, US	160.9	1	14	London, UK	140.7	-3
5	Île de France, France	152.5	39	15	Luxembourg	140.2	-7
6	Hartford, US	152.0	4	16	Shiga, Japan	138.3	45
7	San Francisco-Oakland-Fremont, US	151.1	-4	17	Stockholm, Sweden	136.4	41
8	Boston-Cambridge-Quincy, US	148.6	-1	18	Kanagawa, Japan	136.3	75
9	New York-Northern New Jersey-Long Island, US	146.0	-5	19	West, Netherlands	132.3	41
10	Brussels, Belgium	145.9	-8	20	Shizuoka, Japan	131.3	53

(Mean Gross Monthly Earnings)

Indices of unemployment are shown in Tables 6.5, reverse ranked so that a high score indicates a low level of unemployment. In order to standardise the indexation method across all indices, this year the unemployment rate index is transformed using the simplified equation *100 minus unemployment rate*, thereby maintaining a linear transformation.

According to official statistics, Beijing (104.9) has the lowest rate of unemployment amongst the WKCI regions, followed by another Chinese region, Guangdong (103.5), in second place. Ulsan (103.0) remains in third place where it is joined by Iceland and followed in fifth by South West England in the UK (102.9). In the US, Washington DC (102.4) has the lowest unemployment rate thanks to high levels of public sector employment in the region.

At the other end of the index the continued problems of structural unemployment in Europe is apparent, with fourteen European regions in the bottom twenty. Six of these are German regions, including Berlin in last place with an unemployment rate of over 19 percent. Interestingly, a number of European regions at the wrong end of this index are actually amongst the better performers overall; examples include Ile de France, Lansi Suomi, Pohjois-Suomi and Brussels. This suggests that while unemployment inevitably represents an economically inefficient use of human resources, it does not necessarily seem to be a barrier for regions in maintaining competitiveness in the economy more broadly.

Index of Unemployment – Top Twenty Regions 2008 — **Table 6.5**

Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1	Beijing, China	104.9		11	West, Austria	102.4	-10
2	Guangdong, China	103.5		12	Emilia-Romagna, Italy	102.4	-10
3	Ulsan, Korea	103.0	0	13	Prague, Czech Republic	102.3	8
3	Iceland	103.0		14	Tianjin, China	102.3	0
5	South West, UK	102.9		15	Jiangsu, China	102.3	
6	Singapore	102.7	41	16	Richmond, US	102.2	1
7	Shandong, China	102.7		17	North East, Italy	102.2	-12
8	Eastern, UK	102.5	5	18	Virginia Beach-Norfolk-Newport News, US	102.1	1
9	Washington-Arlington-Alexandria, US	102.4	7	19	Lombardia, Italy	102.1	-13
10	South East, UK	102.4	2	20	Sarasota-Bradenton-Venice, US	102.0	

(unemployment rate – reversed)

Index of Unemployment – Bottom Twenty Regions 2008 — **Table 6.6**

Rank	Bottom 20 Regions	Index 2008	Change in Rank 2005-08	Rank	Bottom 20 Regions	Index 2008	Change in Rank 2005-08
126	Saarland, Germany	97.3	-17	136	Hyderabad, India	96.2	-18
127	Quebec, Canada	97.2	-8	137	Estonia	96.0	
128	Osaka, Japan	97.2	-16	138	Hamburg, Germany	95.4	-17
129	Schleswig-Holstein, Germany	96.9	-15	139	Latvia	95.3	
130	Lansi-Suomi, Finland	96.5		140	Israel	94.9	-18
131	Niedersachsen, Germany	96.5	-21	141	Pohjois-Suomi, Finland	94.5	
132	Île de France, France	96.4	-12	142	Lithuania	94.2	
133	Nordrhein-Westfalen, Germany	96.4	-20	143	Bremen, Germany	91.1	-20
134	Mumbai, India	96.2	-18	144	Brussels, Belgium	89.6	-20
135	Bangalore, India	96.2	-18	145	Berlin, Germany	86.8	-20

(unemployment rate – reversed)

Chapter 7:
Knowledge Sustainability Components

CHAPTER SEVEN

Knowledge sustainability represents each region's capacity for sustaining the long-term health of its knowledge creation and commercial exploitation capacities. In our model, this is represented by investment in future generations of knowledge workers and investment in ICT infrastructure. The five variables included are:

Investment in Future Knowledge
- Per Capita Public Expenditures on Primary and Secondary Education.
- Per Capita Public Expenditures on Higher Education.

National ICT Infrastructure
- Secure servers per one million inhabitants.
- Internet Hosts per 1,000 inhabitants.
- Broadband Penetration.

Investment in Future Knowledge

New theories of economic growth are based on the importance of human capital and the need for a skilled workforce that is able to adapt to and meet new business goals in an evolving economy. Future human and knowledge capital is embodied within those individuals undertaking education. Therefore, resources dedicated to education and training can be thought of as investment in knowledge. Sustained economic growth will depend on the quality of school and university graduates and their ability to produce, adapt, commercialise and utilise knowledge. Much of the expenditure on education is set by national budgets, particularly for compulsory primary and secondary education in Europe, while higher education expenditure is a reflection of the number and type of institutions within a region.

Table 7.1 highlights primary and secondary education expenditure per capita for the highest performing regions. The statistics continue to show that the leading European and US regions are closely matched when it comes to primary and secondary education expenditure. Luxembourg (232.1) remains ranked first, ahead of Ile de France (225.0) which moves up to second on the basis of regional data becoming available for French education expenditure. Norway (172.0) moves up to third place just ahead of New York (170.1) - the top US region - which falls two places to fourth. Elsewhere in the top twenty there remains an even balance of European and US regions, with little movement taking place since 2005, reflecting the stable nature of public expenditure.

Asia-Pacific regions compare unfavourably for primary and secondary education expenditure (Table 7.2). Western Australia (115.0), in 54th place overall, ranks highest on the continent followed by New South Wales (104.1) and Victoria (101.1). These are the only three Asia-Pacific regions that rank above the index average.

Table 7.3 illustrates investments in higher education. Again, as for primary and secondary education, we see a pattern of strong North American performance. European regions do not perform as strongly, the exceptions being Norway (248.8) which moves up to first in the rankings, and Ile de France (191.5) which moves up to sixth place. The other eighteen regions in the top twenty are North American, led by Seattle (246.6) which drops one place to second. Once again, no regions from Asia-Pacific make the top twenty (the highest being Taiwan in 35th place).

The extent of the apparent contribution of education investment to competitiveness more broadly is shown in Figure 7.1, which displays the correlation between total public education expenditure (primary, secondary and higher) per capita and scores in the WKCI 2008.

Index of Investment in Primary and Secondary Education (per capita public expenditure) – Top Twenty Regions 2008 **Table 7.1**

Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1	Luxembourg	232.1	0	11	Boston-Cambridge-Quincy, US	149.0	-3
2	Île de France, France	225.0	45	12	Providence-Fall River-Warwick, US	144.2	
3	Norway	172.0	8	13	Grand Rapids, US	143.8	-3
4	New York-Northern New Jersey-Long Island, US	170.1	-2	14	Detroit-Warren-Livonia, US	143.8	-5
5	Iceland	170.3		15	Smaland Medoarna, Sweden	142.2	-2
6	Hartford, US	166.9	-3	16	Ostra Mellansverige, Sweden	141.9	
7	Bridgeport-Stamford-Norwalk, US	166.9		17	West, Sweden	140.5	-3
8	Rochester, US	166.7	-4	18	South, Sweden	137.9	0
9	Buffalo-Niagara Falls, US	166.7	-4	19	Philadelphia-Camden-Wilmington, US	136.8	-3
10	Denmark	155.7	2	20	Brussels, Belgium	136.6	32

Index of Investment in Primary and Secondary Education (per capita public expenditure) – Top Twenty Asia-Pacific Regions 2008

Table 7.2

Rank	Top 20 Asia-Pacific Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Asia-Pacific Regions	Index 2008	Change in Rank 2005-08
54	Western Australia	116.1	37	116	Tochigi, Japan	71.4	-53
69	New South Wales, Australia	105.2	25	117	Tokyo, Japan	71.4	-25
75	Victoria, Australia	102.1	18	118	Toyama, Japan	71.4	-65
78	New Zealand	99.0	33	119	Osaka, Japan	71.4	-36
99	Hong Kong	84.0	10	120	Kyoto, Japan	71.4	-36
108	Taiwan	75.4	-1	125	Seoul, Korea	58.6	-11
112	Shiga, Japan	71.4	-58	129	Beijing, China	54.6	-8
113	Shizuoka, Japan	71.4	-35	130	Ulsan, Korea	50.9	-17
114	Aichi, Japan	71.4	-28	132	Singapore	45.9	-14
115	Kanagawa, Japan	71.4	-12	135	Shanghai, China	35.7	-16

Index of Investment in Higher Education (per capita public expenditure) – Top Twenty Regions 2008

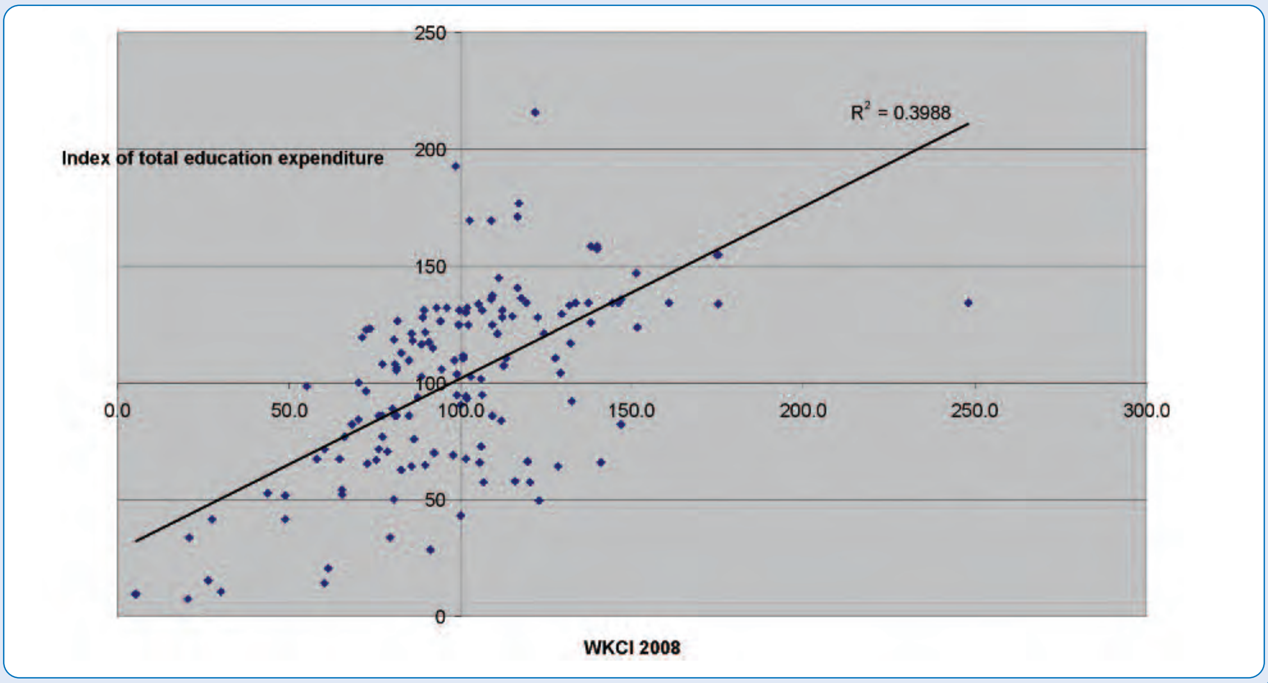
Table 7.3

Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08	Rank	Top 20 Regions	Index 2008	Change in Rank 2005-08
1	Norway	248.8	19	11	Quebec, Canada	173.5	46
2	Seattle-Tacoma-Bellevue, US	246.6	-1	12	Oklahoma City, US	172.4	
3	Salt Lake City, US	224.7	-1	13	New York-Northern New Jersey-Long Island, US	169.8	-2
4	Grand Rapids, US	198.5	0	14	San Diego-Carlsbad-San Marcos, US	162.1	-2
5	Detroit-Warren-Livonia, US	198.4	0	15	San Francisco-Oakland-Fremont, US	162.1	-2
6	Île de France, France	191.5	56	16	Sacramento--Arden-Arcade--Roseville, US	162.1	-2
7	Portland-Vancouver-Beaverton, US	188.1	-1	17	Los Angeles-Long Beach-Santa Ana, US	162.1	-2
8	Rochester, US	176.7	0	18	Riverside-San Bernardino-Ontario, US	162.1	-2
9	Buffalo-Niagara Falls, US	176.7	0	19	Oxnard-Thousand Oaks-Ventura, US	162.1	
10	Milwaukee-Waukesha-West Allis, US	175.3	0	20	San Jose-Sunnyvale-Santa Clara, US	162.0	-3

(Expenditure per capita in USD - PPP adjusted)

Relationship between Total Regional Education Expenditure per Capita and the Composite WKCI 2008

Figure 7.1



Chapter 7 - Knowledge Sustainability Components

ICT Infrastructure

In order to transfer knowledge effectively and efficiently across regions and nations a well–developed ICT infrastructure, particularly access to fast broadband telecommunications services, is required. Although broadband access data is unavailable for all our benchmarked regions and nations, the OECD has collected certain data at the national level for its member states. Also, in order to look in more detail at the ICT infrastructure, we have analysed the number of secure servers and Internet hosts per capita in the nations covered by the WKCI benchmarked regions. Secure servers utilise encrypted software for e-commerce transactions and the number of such servers within a nation gives a strong indication of the level of e-business undertaken.

Table 7.5 shows that the highest per capita level of secure servers is in Iceland (408.4), a country with arguably the most advanced ICT infrastructure in the World. The United States (323.6) in second place is well behind Iceland, but well ahead of Canada (228.4) in third place. China and India remain well behind the other nations, a clear example of the 'digital divide' that exists between the developing and developed worlds. In general, the ranking remain highly stable since WKCI 2005.

Index of Secure Servers per Capita — Table 7.4

Rank	Country	Index 2008	Change in Rank 2005-08	Rank	Country	Index 2008	Change in Rank 2005-08
1	Iceland	408.4		18	Japan	73.2	-1
2	United States	323.6	-1	19	Hong Kong	68.6	-1
3	Canada	228.4	-1	20	Israel	63.7	-1
4	New Zealand	196.7	-1	21	Estonia	42.3	
5	Luxemburg	194.8	-1	22	Belgium	41.9	-2
6	Australia	192.4	-1	23	Spain	32.0	-2
7	Switzerland	181.8	-1	24	France	29.4	-2
8	United Kingdom	163.2	-1	25	Latvia	19.4	
9	Sweden	150.2	-1	26	Taiwan	19.2	-3
10	Denmark	148.5	-1	27	Italy	16.2	-3
11	Ireland	143.3	-1	28	Czech Republic	14.7	-3
12	Norway	117.1	-1	29	Hungary	9.4	-3
13	Finland	114.7	-1	30	Lithuania	8.9	
14	Singapore	108.6	-1	31	Korea	8.7	-4
15	Netherlands	105.5	-1	32	Slovak Republic	5.4	-4
16	Austria	93.5	-1	33	India	0.2	
17	Germany	76.0	-1	34	China	0.1	-1

Index of Internet Hosts per Capita — Table 7.5

Rank	Country	Index 2008	Change in Rank 2005-08	Rank	Country	Index 2008	Change in Rank 2005-08
1	Iceland	369.2		18	Israel	79.6	-1
2	Denmark	274.6	-1	19	Luxemburg	63.2	-1
3	Finland	236.9	-1	20	United Kingdom	63.1	-1
4	Norway	223.9	-1	21	Estonia	47.5	
5	Netherlands	212.6	-1	22	France	45.4	-2
6	Sweden	173.4	-1	23	Germany	41.8	-2
7	Australia	143.7	-1	24	United States	39.6	-2
8	Belgium	141.4	-1	25	Czech Republic	31.2	-2
9	Taiwan	139.7	-1	26	Hungary	31.2	-2
10	Switzerland	138.7	-1	27	Ireland	28.2	-2
11	Austria	122.4	-1	28	Spain	27.9	-2
12	New Zealand	118.5	-1	29	Lithuania	27.7	
13	Singapore	117.6	-1	30	Latvia	25.8	
14	Hong Kong	111.1	-1	31	Slovak Republic	18.5	-4
15	Japan	102.5	-1	32	Korea	5.3	-4
16	Canada	102.4	-1	33	India	0.1	-4
17	Italy	95.0	-1	34	China	0.1	-4

As highlighted by Table 7.6, Iceland (228.8) also enters in first place under access to broadband services, although the previous leader Korea (213.3) is only marginally behind in second place. Data for this indicator is also now available for Taiwan (157.7) and Israel (156.3), both of which enter high up the national index. Data is also now available for India (0.1) which enters in last place below the Slovak Republic (9.4) and the Czech Republic (13.7). Perhaps the most interesting feature of Table 7.7 is the high range of scores even at a national level, revealing that broadband access is still highly variable across the globe. Also of note is the remarkable strength of China in this area, given its level of economic development relative to many other nations in the index.

Index of Broadband Penetration — **Table 7.6**

Rank	Country	Index 2008	Change in Rank 2005-08	Rank	Country	Index 2008	Change in Rank 2005-08
1	Iceland	228.8		18	United Kingdom	89.9	-4
2	Korea	213.3	-1	19	Austria	87.4	-4
3	Hong Kong	179.9	-1	20	Luxemburg	84.0	-4
4	Netherlands	162.8	-1	21	Estonia	73.8	
5	Denmark	161.0	-1	22	Germany	72.0	-4
6	Taiwan	157.7		23	Spain	72.0	-4
7	Israel	156.3		24	China	72.0	-7
8	Canada	152.5	-3	25	Italy	69.4	-5
9	Switzerland	148.2	-3	26	Australia	66.0	-5
10	Singapore	138.5		27	New Zealand	40.3	-5
11	Belgium	133.6	-4	28	Hungary	30.8	-5
12	Finland	128.5	-4	29	Ireland	29.1	-5
13	Japan	128.5	-4	30	Lithuania	26.3	
14	Norway	127.6	-4	31	Latvia	20.3	
15	Sweden	124.2	-4	32	Czech Republic	13.7	-7
16	United States	111.4	-4	33	Slovak Republic	9.4	-7
17	France	90.8	-4	34	India	0.1	-1

WKCI 2008 Data Sources

North American sources

US Census Bureau (http://www.census.gov/)
Bureau of Labour Statistics (http://www.stats.bls.gov/)
US Patent and Trademark Office (http://www.uspto.gov/)
US Conference of Mayors (http://www.usmayors.org/)
Bureau of Economic Analysis (http://www.bea.doc.gov/)
Department of Education (http://www.ed.gov/)
National Science Foundation (http://www.nsf.gov/)
National Center for Education Statistics (http://www.nces.ed.gov/)
Price Waterhouse Coopers, Money Tree Survey (http://www.pwcmoneytree.com/moneytree/index/)
Statistics Canada (http://www.statcan.ca)
Canada's Venture Capital & Private Equity Association (http://www.cvca.ca/)

Europe sources

Eurostat (http://europa.eu.it/comm/eurostat/)
European Patent Office (http://www.european-patent-office.org/)
UK Office for National Statistics (http://www.statistics.gov.uk/)
Swiss Federal Statistics Office (http://www.statistik.admin.ch/)
Statistics Norway (http://www.ssb.no/)
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Martin et al. (2003) Regional Venture Capital Policy: UK and Germany Compared, Anglo-German Foundation for the Study of Industrial Society

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Statistics Canada (http://www.statcan.ca)
The Statistics Bureau of Japan (http://www.stat.go.jp)
Australian Bureau of Statistics (http://www.abs.gov.au)
IP Australia (http://www.ipaustralia.gov.au)
Statistics New Zealand (http://www.stats.govt.nz)
New Zealand Ministry of Education (www.minedu.govt.nz)
Israel Central Bureau of Statistics (http://www.cbs.gov.il)
Korea National Statistical Office (http://www.nso.go.kr)
Statistics Singapore (http://www.singstat.gov.sg/)
National Statistics of Taiwan (http://www.stat.gov.tw/)
Hong Kong Census and Statistics Department (http://www.info.gov.hk/censtatd/)
National Bureau of Statistics of China (http://www.stats.gov.cn/)
Beijing Statistical Information Net (http://www.bjstats.gov.cn/)
Shanghai Statistics (http://www.stats-sh.gov.cn/)
Statistics Tianjin (http://www.stats-tj.gov.cn/)
Guangdong Statistical Information Net (http://www.gdstats.gov.cn/)
Guangzhou Statistical Information Net (http://www.gzstats.gov.cn/)
Census of India (http://www.censusindia.net/)
Indian Ministry of Statistics and Programme Implementation (http://mospi.nic.in/)
Directorate of Economics and Statistics, Government of Maharashtra (http://www.maharashtra.gov.in/intranet/Deswebpage/)
Mumbai Metropolitan Region Development Authortity (http://www.mmrdamumbai.org/)
Directorate of Economics and Statistics, Government of Karnataka (http://des.kar.nic.in/)
Government of Andhra Pradesh (http://www.ap.gov.in/)
Bombay First (http://www.bombayfirst.org/)

Figures of purchasing power parities used to harmonise monetary values are available from:

OECD (http://www.oecd.org/std/ppp/)
World Bank (http://www.worldbank.org/data/)

Other sources include:

United Nations Conference on Trade and Development (http://www.unctad.org/)
OECD (http://www.oecd.org/)
Asian Development Bank (http://www.adb.org/)
UNESCO (http://www.unescostat.unesco.org)

Chapter 8:
Regional Evolution and Knowledge Diffusion: Evidence from China's Three Leading Regions by Robert Huggins and Luo Shougui

1. Introduction

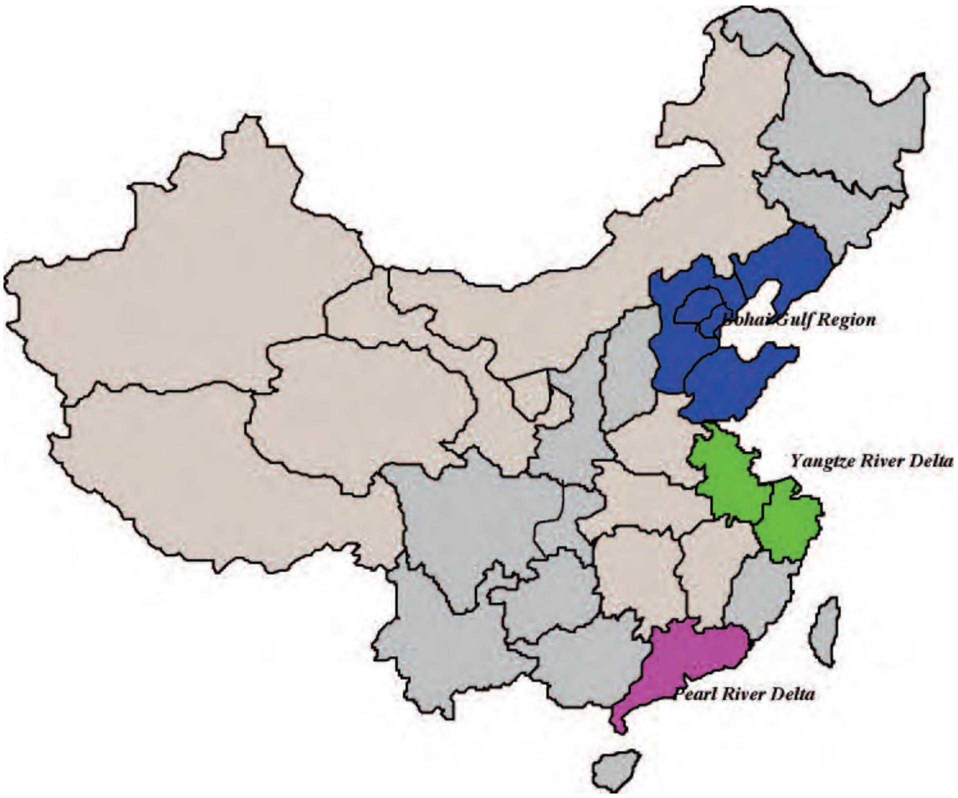
For the past thirty years, the development of the Chinese economy has shown distinct characteristics which can be generalised as constituting reform and opening-up to the outside world. Reform refers to the change from the highly centralised planned economy to a market economy, and opening-up refers to the change from an extremely closed economy to a more globally integrated economy, which can be termed a socialist market economy. Given China's size, there are highly significant regional differences in economic and social conditions, resulting in different growth models. Since reforming and opening-up to the world in 1970, the Chinese economy has developed rapidly. Gross Domestic Product (GDP) increased from US$129.43 billion in 1978 to US$9971.76billion in 2006, increasing by 26.8% annually, with GDP per capita increasing 41.3[5] times . In the past thirty years, China has instigated a number of regional development strategies (Lin, 1999; Li, 2004; Lu and Wang, 2002; Groenewold et al, 2007). The Chinese government has focused its strategies on developing the East Coastal region, due to more advantageous physical and economic conditions (Friedmann, 2006).

Furthermore, development within the East Coastal region is also unbalanced across three relatively independent regions consisting of the Pearl River Delta (PRD), the Yangtze River Delta (YRD) and the Bohai Gulf region (BGR) (Figure 1). Within these regions, it is also possible to distinguish between the 'broad' and 'narrow' definition of the region. The narrow sense of the Pearl River Delta (nPRD) consists of 9 cities, and extends to 14 in the broader sense, with the broad sense of the Pearl River Delta (bPRD) being identical to the province of Guangdong. The narrow sense of the Yangtze River Delta (nYRD) consists of 16 cities surrounding Shanghai; and in the broad sense the Yangtze River Delta (bYRD) region consists of Jiangsu province, Zhejiang province and Shanghai. The narrow sense of the Bohai Gulf region (nBGR) consists of 15 cities surrounding Beijing; and in the broad sense the Bohai Gulf region (bBGR) consists of Shandong province, Liaoning province, Hebei province, Beijing and Tianjin.

In this chapter, we mainly analyse the three regions in the broad sense. The three regions include 9 provinces or municipalities covering 9.5% surface area and 35.3% of the total Chinese population in 2006, accounting for 60.3% of total GDP. GDP per capita is 1.7 times higher than the national average, highlighting the significance of these regions (Table 1). This chapter focuses on the differing models of technology and knowledge diffusion in driving economic growth in each of these regions The chapter is divided to six sections, with the second, third and fourth analysing the prevailing models in each of the regions, while the fifth provides a comparative analysis across the regions. The final section summarises the major findings and discusses their implications.

[5] In calculating exchange rate we use the Chinese domestic balance price for international trade in 1978 and World Bank purchasing power parity (PPP) for 2006. 1978: 1US dollar=2.80RMB Yuan; 2006: 1US dollar=2.10RMB Yuan.

The Location of Three Regions **Figure 1**



Area, Population and GDP for the Three Regions (2005) **Table 1**

Region	Area (km²)	Population (million persons)	GDP (US $ billion)	GDP per capita (US $ billion)
Three Regions Total	911,447	462.07	5,260.49	11,384.62
BGR	520,906	228.82	2,247.90	9,823.88
YRD	210,741	141.4	1,947.51	13,773.06
PRD	179,800	91.85	1,065.07	11,595.75
National Total	**9,600,000**	**1,307.56**	**8,718.32**	**6,667.63**

Source: National Bureau of Statistics of China, China Statistical Yearbook-2006, Beijing: China Statistics Press, 2006

2. Bohai Gulf Region: Government Driven Model

2.1 Regional Socio-Economic Characteristics

The BGR is a region with the richest knowledge resources and most intensive R&D facilities, including Beijing. In total, 382 of the 1,794 (21.3%) universities in China are located in the BGR. It is also the location for many of the most prestigious universities, including 29 of the 72 universities affiliated with the Ministry of Education, as well as China's top two universities: Tsinghua University and Peking University and 28 of Chinese top 100 universities (Wu S.L, 2007). The region accounts for 22.3% of Chinese college students, with Beijing and Tianjin having the highest density of students across China's 31 provinces. The region has a significant edge in science and technology development, with 42 of the 91 institutes of Chinese Academy of Science (most important R&D institutes) located in the region, along with R&D activities of the region's universities. These universities and research institutions provide a competitive advantage to the region, especially in terms of human capital development. In relation to higher education attainment, more than 7% of the population has received education to junior college level or above, which is higher than the national average level by 27.3%, just behind the YRD (Table 3). In total, 29.6% of the nation's R&D researchers are based in the region, with the aggregate number of scientists and engineers accounting for 28.3% of China's total (Table 4).

Comparison of Higher Education Activity across the Three Regions(2005) **Table 2**

Regions	Universities or colleges (1) Total	Universities or colleges (1) affiliated with the Ministry of Education	Top100 (2)	Enrolment of students (3)
BGRs	**382**	**29**	**28**	**3,484,464**
__**Beijing**	78	22	16	548,270
__**Tianjin**	42	2	2	331,553
__**Shandong**	99	2	5	1,171,284
__**Liaoning**	76	2	2	659,351
__**Hebei**	87	1	3	774,006
PRD	**101**	**2**	**6**	**874,686**
__**Guangdong**	101	2	2	874,686
YRD	**240**	**16**	**23**	**2,253,722**
__**Shanghai**	59	8	8	442,620
__**Jiangsu**	114	7	14	1,159,795
__**Zhejiang**	67	1	1	651,307
Other 22 provinces	1,071	25	43	12,140,913
National Total	**1,794**	**72**	**100**	**15,617,767**

Source: (1) China Education on Line, http://www.eol.cn/article/20040706/3109656.shtml
(2) Wu S.L. (2007) Guide to university and college entrance 2007, Beijing: China Statistical Publishing House.
(3) National Bureau of Statistics of China. (2006) China Statistical Yearbook-2006, Beijing: China Statistics Press.

Comparison of Educational Attainment across the Three Regions (2005) **Table 3**

Regions	Population Aged 6 and Over	Proportion of Junior Secondary School /%	Proportion of Senior Secondary School /%	Proportion of College and Higher Level /%
BGRs	**2,853,161**	**43.06**	**13.89**	**7.08**
__**Beijing**	196,019	32.15	25.13	24.49
__**Tianjin**	132,069	37.94	21.10	14.08
__**Shandong**	1,146,600	41.85	12.59	4.44
__**Liaoning**	532,275	45.87	13.72	8.34
__**Hebei**	846,198	46.27	12.04	4.73
PRD	**1,144,620**	**40.41**	**15.40**	**5.81**
Guangdong	1,144,620	40.41	15.40	5.81
YRD	**1,777,783**	**37.42**	**15.15**	**7.74**
__**Shanghai**	227,240	35.87	24.92	17.84
__**Jiangsu**	939,782	39.45	14.74	6.80
__**Zhejiang**	610,761	34.87	12.14	5.42
Other 22 provinces	**10,10,2791**	**36.94**	**11.22**	**4.72**
National Total	**15,878,355**	**38.35**	**12.44**	**5.56**

Source: National Bureau of Statistics of China, China Statistical Yearbook-2006, Beijing: China Statistics Press, 2006

Comparison of Science and Technology Talent across the Three Regions(2005) **Table 4**

Regions	R&D personnel Number (1000 employees)	R&D personnel Number/per 1000 inhabitants	Scientists & engineers Number (1000 employees)	Scientists & engineers Number/per 1000 inhabitants
BGRs	**403.3**	**1.76**	**726**	**3.17**
__**Beijing**	171	11.12	283	18.40
__**Tianjin**	33.4	3.20	61	5.85
__**Shandong**	91.1	0.99	177	1.91
__**Liaoning**	66.1	1.57	121	2.87
__**Hebei**	41.7	0.61	84	1.23
PRD	**119.4**	**1.30**	**224**	**2.44**
__**Guangdong**	119.4	1.30	224	2.44
YRD	**275.1**	**1.94**	**530**	**3.75**
__**Shanghai**	67	3.77	138	7.76
__**Jiangsu**	128	1.71	228	3.05
__**Zhejiang**	80.1	1.64	164	3.35
Other 22 provinces	**567**	**0.67**	**1081**	**1.27**
National Total	**1364.8**	**1.04**	**2561**	**1.95**

Source: China S&T Statistics, http://www.sts.org.cn/sjkl/kjtjdt/data2006/
(2) Wu S.L. (2007) Guide to university and college entrance 2007, Beijing: China Statistical Publishing House.
(3) National Bureau of Statistics of China. (2006) China Statistical Yearbook-2006, Beijing: China Statistics Press.

2.2 Analysis of the Regional Economic Growth model

There are clearly historical explanations for these human resource, education and science and technology advantages. Northern China, with the capital Beijing as the central and most planned economy, is an important receiver of national investment. For example, the Liaoning province of the region was a key investment target during the 1950s, receiving 1.45 billion RMB in 1950-1952, 20% of the aggregate investment for the nation during the period. In 1953-1957, during the period of the first Five-year Plan, when heavy industry development was accelerated, 24 of the 156 national key projects were located in Liaoning province. Beijing has been the key region receiving investment, particularly economical, educational and R&D investment.

During the 1990s, China focused more on the development of technology and education. 'The decision on accelerating the development of technology by The CPC Central Committee and State Council' published in 1995 proposed the strategy of strengthening the nation by the development of technology and education. The government realised the international competence of Chinese economy was weak, and set the strategy in place to develop science and technology and promote industrial upgrading. The main methods consisted of increasing R&D investment in universities and other related research institutions, and promoting the cooperation and networks between enterprises and the research institutions to accelerate technology upgrading through knowledge transfer. The Chinese Academy of Science affiliates in the region also received a significant proportion of these investments. In recent years, government R&D investment in the region has continued to grow and on a per capita basis is ranked third across the globe, although private sector R&D expenditure remains relatively low.

As shown by Table 5, there are significant differences in the structure of R&D expenditure across Beijing, Shanghai and Guangdong. Enterprises account for 61.1% of total R&D expenditure in Shanghai and 89.9% in Guangdong, but only 15.1% in Beijing. In general, the BGR region receives a considerable proportion of the government's R&D investment, with most investment consisting of technological and financial allocations by central government. However, the proportion of expenditure by local government is significantly lower in BGR than in YRD or PRD.

The higher investment in science and technology by government in the BGR results in universities and research institutions facilitates higher levels of R&D and technological development. In order to understand the diffusion of the knowledge it important to assess the extent to which it is being commercialised through activities such as patenting and licensing, contract research, or creating spin-off companies (Kroll and Liefner, 2007; Huggins, 2008). At present the legal system in China, in terms of intellectual property rights, has not yet transformed to a stage where patenting and licensing is a feasible option for many universities. In the case of BGR, such is the extent of government research funding to universities and research institutions, that most are not 'reliant' on forming industrial collaborations, which are generally weakly developed. As a result, the development of spin-off companies has become the most viable option for many researchers in BGR seeking to commercialise their knowledge or technology.

Comparison of R&D Expenditure Structure in Beijing, Shanghai and Guangdong (2005) — **Table 5**

Region	Total R&D Expenditure (US$)	Independent Research Institutions		Institutions of Higher Education Sub-total		Large & Medium-sized Enterprises Sub-total	
		Amount	Proportion %	Amount	Proportion %	Amount	Proportion %
Beijing	13,519	9,528	70.5	1,915	14.2	2,076	15.4
Shanghai	9,242	2,351	25.4	1,242	13.4	5,649	61.1
Guangdong	10,501	420	4.0	637	6.1	9,445	89.9
National Total	**105,010**	**26,864**	**25.6**	**12,686**	**12.1**	**65,461**	**62.3**

Source: China S&T Statistics, http://www.sts.org.cn/sjkl/kjtjdt/data2006/
Note: the amounts in shown in this table excludes expenditure by other institutions and organisations.

Comparison of Science and Technology Expenditure by Local Government across the Three Regions(2005) — **Table 6**

BGRs		YRD		PRD	
Municipalities or Provinces	Proportion by Local Government %	Municipalities or Provinces	Proportion by Local Government %	Municipalities or Provinces	Proportion by Local Government %
Beijing	37.6	Shanghai	79.3	Guangdong	83.8
Tianjin	13.7	Jiangsu	36.7		
Shandong	26.5	Zhejiang	50.0		
Liaoning	28.0				
Hebei	11.2				

Source: China S&T Statistics, http://www.sts.org.cn/sjkl/kjtjdt/data2006/

From the 1990s onwards, universities and research institutions in BGR have began to develop spin-off firms, with support from the government, such as permission to list these firms on Chinese stock markets. In 2005, 24 companies affiliated to universities are listed on stock markets, with 9 of them located in BGR, including spin-off from Peking University and Tsinghua University (Table 7). Alongside these listed firms there are a host of other smaller non-listed smaller spin-off firms. Alongside the universities, the Chinese Academy of Science has 489 companies affiliated to it, a number of which have received private sector investment, with investors including the Chinese-owned Lenovo Group, which bought out much of IBM's hardware activities in 2004.

This model of development can be considered government-driven due to the roots of knowledge investment residing with central government, but furthermore government has undertaken other roles such as constructing development zones as a means of stimulating further knowledge diffusion. BGR accounts for 23,728 of the nation's 41,990 high-technology enterprises and 32.1% of high-technology employment and 26% of gross output (Table 8). While BGR has a traditional resource superiority of other Chinese regions, with an industrial structure dependent on the production of crude salt, crude oil, soda ash, caustic soda, steel and glass (Li, 2004), its most recent evolution has incorporated the innovative activities of universities, research institutions, and development zones. In general, the development of BGR is operating along two-dimensions: one consisting of government supported knowledge diffusion and innovation, and another that continues to operate in a more traditional manner unexposed to new developments occurring in the region.

Stock Listed University Spin-Off Firms in the Bohai Gulf Region (2005) — Table 7

Name of Companies	University Affiliation	Sub-Regional Location
China Hi-Tech Co., Ltd.	Tsinghua University, Peking University and other 34 Universities	Mainly in Beijing
Shenyang Nuesoft Co., Ltd.	North East University	Liaoning
Beijing Tianqiao Beida Jade Bird Sci-Tech Co., Ltd.	Peking University	Beijing
Founder Technology Group Corp	Peking University	Beijing
Tsinghua Tongfang Co., Ltd.	Tsinghua University	Beijing
Unisplendour Corporation Ltd.	Tsinghua University	Bejing
Shandong Shanda Wit Science and Technology Co., Ltd.	Shandong University	Shandong
Tianjin Xinmao Technology Co., Ltd.	Tianjin University	Tianjin
Tianjin Guangyu Development Co., Ltd.	Nankai University	Tianjin

Source: Shanghai Stock Exchange, Shenzhen Stock Exchange, 2006.

Comparison of High-Technology Enterprises across the Three Regions (2005) — Table 8

Development Area	Number of Enterprises (Units)	Number of Employees Employees	Gross Output Value (US$ billion)	Total Income (US$ billion)	Exports (US$ billion)
BGRs	23,728	1,672,518	358.32	503.69	19.78
PRD	2,423	546,448	200.52	210.67	27.911
YRD	3,281	834,375	347.91	389.29	51.42
Other 22 provinces	15,854	2,696,696	767.25	870.41	79.26
National total	**41,990**	**5,211,960**	**1,378.93**	**1,638.84**	**111.65**

Source: National Bureau of Statistics of China, China Statistical Yearbook-2006, Beijing: China Statistics Press, 2006

3 The Pearl River Delta: FDI driven model

3.1 Regional socio-economic characteristics

The PRD is one of the three most developed regions of China. In 2005, Guangdong province covered only 1.9% of the surface area of China, but accounted for 7% of the population, 12.2% of national GDP, and 13.5% of the savings of the Chinese population. PRD has developed an export-oriented economy, with the sum of imports and exports, as well foreign capital, the highest of all provinces in China. In 2005, the imports and exports of Guangdong Province amounted to US$428 billion, accounting for 30% of the total Chinese value. Between 1979 and 2005, total foreign investment was US$163 billion, 20% of national total, with the region the location for 58,762 enterprises with foreign investment (23% of the Chinese total). Guangdong Province was in many ways the pilot region for Chinese reform, which has subsequently provided it a range of institutional advantages that have stimulated rapid economic development (Xie and Costa, 1991). Between1978 and 2005, the GDP of Guangdong Province grew more than thirty-fold (at constant prices), with an average annual growth of 13.7%, while China's GDP grew twelve-fold at an average annual rate was 9.6%, Guangdong was 4.1 percentage points higher than the national average level annually. Guangdong's economy grew especially fast during the period 1990-2000, with an average annual GDP growth of 15.2%, above the 10.4% rate experienced by China as a whole (Figure 2). This resulted in Guangdong's contribution to national GDP rising from 5.1% in 1978 to 13.7% by 2005 (Figure 3).

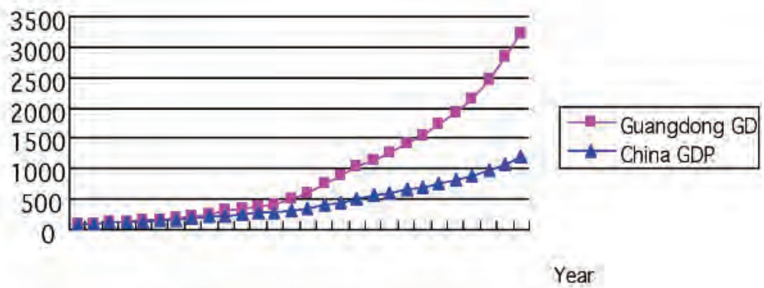
Compared to it outstanding economic growth, development of PRD's science and technology base, as well as educational improvement, has been relatively moderate. The number of inhabitants in Guangdong receiving college and higher level education is 5.8% of inhabitants, only slightly higher than the national rate of 5.6% (Table 2). There are 14,622 students studying in college per 1 million inhabitants in the region, which is almost 10% below the national average level, with Guangdong ranking only 15th across China's 31 provinces, autonomous regions and municipalities, and well below student enrolment rates in YRD and BGR (Table 9).With regard to science and technology personnel, numbers of both R&D and Scientists and Engineers per capita is only 25% higher than the national average (Table 3), well below the proportion of knowledge workers in YRD and BGR.

Comparison of Numbers of College Students across the Three Regions (2005) **Table 9**

Regions	College students per million inhabitants
PRD	14,622
YRD	21,992
BGRs	21,111
National Total	**16,126**

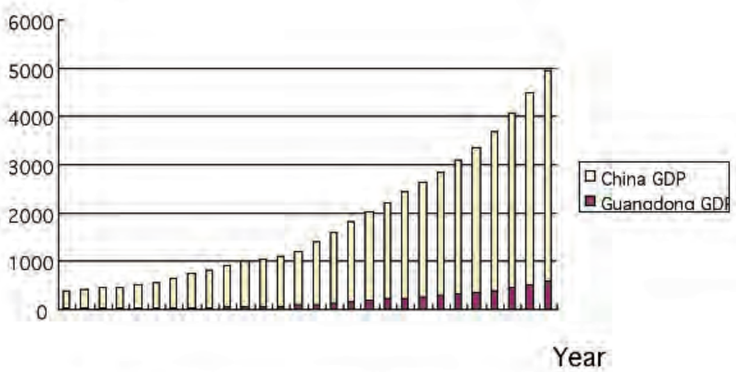
Source: National Bureau of Statistics of China, China Statistical Yearbook, Beijing: China Statistics Press, 2006

Comparison of GDP growth between Guangdong and China **Figure 2**



Source: (1)National Bureau of Statistics of China, China Statistical Yearbook, Beijing: China Statistics Press, 2006.
(2)Guangdong Statistics Bureau, Guangdong Statistical Yearbook, Beijing: China Statistics Press, 2006.

Contribution of GDP growth of Guangdong to China **Figure 3**



Source: (1)National Bureau of Statistics of China, China Statistical Yearbook, Beijing: China Statistics Press, 2006.
(2)Guangdong Statistics Bureau, Guangdong Statistical Yearbook, Beijing: China Statistics Press, 2006.

3.2 Analysis of Regional Economic Growth Model

Historically, the economic history of PRD is almost the opposite of BGR. Before reform and opening, this region is best described by Chinese saying *Yiqiong erbai:* poverty and blankness. Under the central planning system, Guangdong was given a very low priority in terms of resource allocation, mainly due to its relatively weak industrial foundation and the government's concern with its geographical proximity to Hong Kong and Taiwan, which in the Chinese leadership's view were bases for external hostile forces to subvert the communist regime (Vogel, 1989). In 1978, Guangdong's GDP per capita was 367 yuan, a little lower than the national average of 377 yuan, and lower than of both YRD (604 yuan) and BGR (482 yuan). In 1980, the industrial sector accounted for only 36.3% of the province's national income, much lower than the national average of 48.9%.

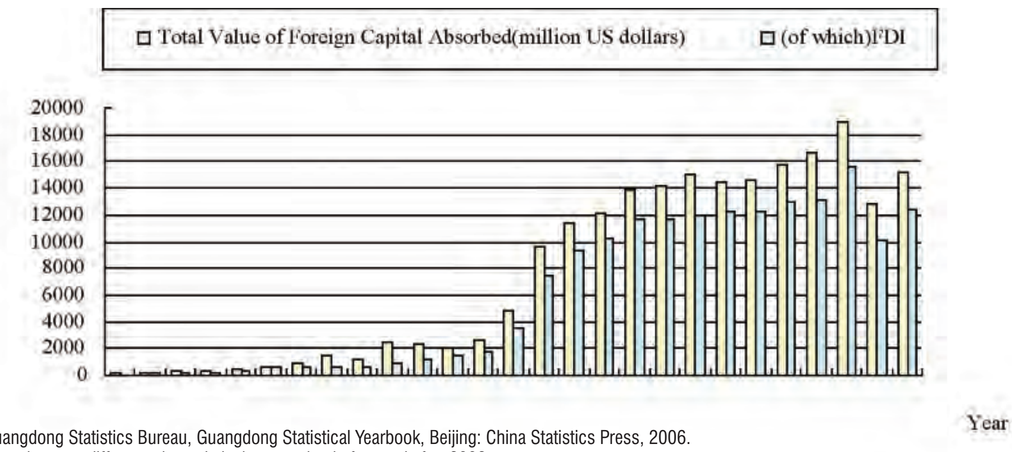
Dialectically, this under-development was considered by government to possess numerous advantages for testing new reforms and modes of openness (Chairman Mao Zedong stating: *there being no burden for a sheet of blank paper, so new and beautiful pictures can be drawn on* it) and in 1978 when China first chose the path towards reform PRD was decided upon as the pilot area. Three of the four special economic zones established in 1980 - Shenzhen, Zhuhai, and Shantou - are in Guangdong province (the other Xiamen is in Fujian province) and among the 14 opened coastal port cities established in 1984, two cities - Guangzhou and Zhanjiang – in PRD were included. As part of its pilot status, Guangdong was granted a range of "special polices and flexible measures", with the region playing the role of both a testing ground and a showcase for China's new economic policies. In contrast to traditional central authority policies, unified control over provincial revenue and spending was replaced with an arrangement that required the provincial government to remit to the central treasury fixed amounts of revenue according to annual targets specified for a five-year period starting from 1980, with any surplus above the targets left at the disposal of the provincial government. Second, the provincial government was given increased decision-making authority over a wade range of economic issues, including planning, investment, price control, economic regulations, foreign economic relations, and wage and labor (Eng, 1997). This arrangement of decentralisation and marketisation was obviously unprecedented at the time.

Upon receiving decision-making autonomy Guangdong province set about implementing a market economy, with the local government's priority being to use the 'market' to overcome deficiencies in capital, technology, and skilled workers through the attraction of FDI. Measures relating to extremely preferential taxation rates were initiated, with a tax rate of only 15% imposed for overseas investors compared to 33% for domestic enterprises (as well as a tax holiday during the first two years of business), a policy which remains in effect in 2007, along with a plethora of land-use policies were initiated. Land use policymaking was aided by differences between urban and rural land ownership rights. In rural areas, farmers own their land collectively, while in urban areas, the state owns the land, allowing local governments to change the ownership of the former into the latter at a very low cost, with the earning capacity of the land for farmers being very limited at that time. In the early 1980s, the fee for 30-year land use rights by foreign-funded enterprises was between US$0.4-0.8 million per hectare, and due to competition among city governments in many cases it was lower and even close to zero. By 2006, in some cities of the PRD the fee was still less than US$0.1 million per hectare (Xie, 2006).

Catalysed by these policies, FDI in PRD increased quickly and in 1980 Guangdong province received foreign capital of US$214.19 million. By 1990, this had reached US$2,023.47 million, rising to US$14574.66 million in 2000 and US$15,173.58 million in 2005. In 2001, the highest year so far, foreign investment in Guangdong province accounted for 31.7% of the national total.

Besides the capital and land, another factor requiring attention in PRD was the workforce and skills development, due to the historic lack of an industrial base and an associated well-trained pool of workers. Following reform and opening up, about 250 million of China's 400 million farmers departed from agricultural production and turned to opportunities elsewhere, a process which was extremely prevalent in PRD, whereby many foreign enterprises started to employ workers from the rural interior, in return for wages between two or three times their original farm income, While many of these workers had only received junior middle school education, after a short-term period of training they

Total value of foreign capital absorbed by Guangdong Province from 1979 **Figure 4**



Source: Guangdong Statistics Bureau, Guangdong Statistical Yearbook, Beijing: China Statistics Press, 2006.
Note: There is some difference in statistical accounting before and after 2002.

qualified are workers able to undertake manually and machine operating role in the labour-intensive industries, such as toy-making, garment processing, shoe-making, electronics assembly, that were the main feature of the first wave of FDI in PRD. Although one might assume that a result of this migration of labour from the rural to urban areas, such is the size of China's rural labor force the wages of farm workers has remain almost static, with the wage for rural workers in PRD increasing by only 68 Yuan between 1992 and 2004 (Qiao and Chen, 2003; Wu, 2005).

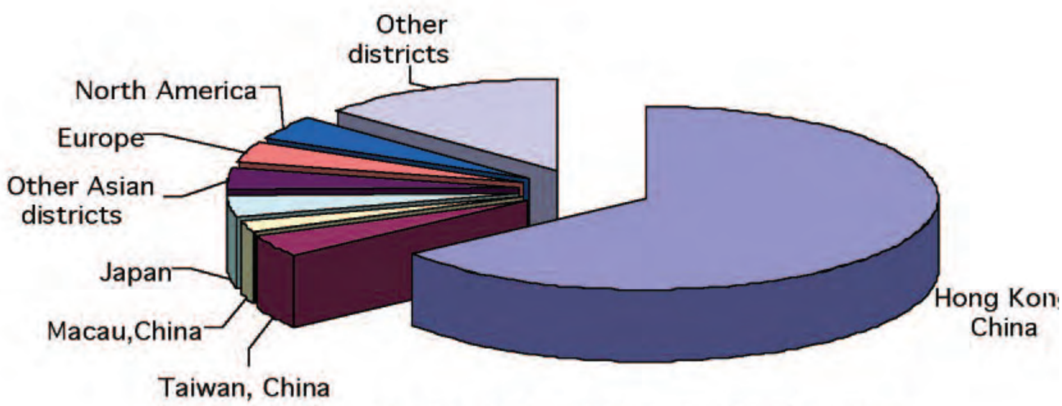
Alongside its special development status, the geographical proximity of PRD to Hong Kong has also been an important factor in the region's growth, as has been the network ties with Chinese emigrants around the world originating from the region. There are approximately 20 million Chinese emigrants living around the world, about 70% of whom have ancestral roots in Guangdong (Guan and Zhu, 1992). Furthermore, the dialect spoken by people in PRD is quite unique, and is very different from Chinese pronunciation in other regions (meaning Chinese people in other regions often have difficulty understanding this dialect). However, it is similar to that spoken in Hong Kong, which has promoted cultural ties between Hong Kong and PRD (Vogel, 1989; Shirk, 1994).

Between 1979 and 2005, Guangdong received US$162.85 billion in foreign investment of which US$105.42 billion US (65%) came from Hong Kong (Figure 5), and before 1990 the proportion was even higher, being between 80-90% (Huang, 1995). In the 1980s, as Hong Kong's local manufacturing costs increased, and its international competitiveness started to decline, the reforms in PRD represented an opportunity to reassert the competitiveness of Hong Kong's industrial capital. The model initially established was called *qiandian houchang* – meaning the 'store in the front' (Hong Kong) and 'factory in the backyard' (PRD) (Eng, 1997). This model made full use of Hong Kong's position as an international trade centre position, and the opportunity to investment in new manufacturing sites in the cost competitive PRD. While Hong Kong remained the shop window, production took place in PRD, with transport costs relatively low due to close proximity, with most of the PRD region being only one hour's driving time far from Hong Kong (Cheng, et al, 2004). In terms of the production process, after the raw materials arrive at Hong Kong Kwai Chung Harbour they are processed into components are on the assembly line in PRD within hours, with final products transport back to Hong Kong to be shipped around the world (Yu, 2005).

Although the dominance of Hong Kong investment has become more diluted in recent years, these links remain vital for the regional economy. Along with Hong Kong, Taiwan, Macao and overseas-based Chinese investors located in Southeast Asia account for 74% of foreign investment in PRD, with investment coming from North America, Europe, Japan, and other developed countries accounting for 12%. In general, PRD success in attracting FDI is clear, but is perhaps surprising given that other regions, such as YRD, had a far better industrial base and more developed sources of human capital already in place. However, it is also clear that the type of investment occurring was very much related to traditional industries, and mature – in some cases almost obsolete - technology (Zheng, 2006). This meant that the lack of indigenous base did not represent a major for this type of investment quickly embedding itself in the region. FDI, therefore, provide the means for the region to slowly absorb the range of knowledge – including management skills and general technical competencies – allowing it to shift towards more advanced form of economic development (Balasubramanyam, 1996). Overall, FDI in PRD has played a key role in facilitating the shift to a market economy, providing a model of modern industrial production organisation and management, and a bridge to the international market. Therefore, in the economic 'take-off' process in PRD, FDI provided a general framework for knowledge transfer, rather than a specific focus on technology transfer. It turned a planned economy into a market economy, a traditional economy into a modern economy, and a local economy into an international economy.

The knowledge transfer process has mainly been facilitated through middle-level managers and workers operating within the foreign-owned enterprises. In PRD, many Chinese middle-level managers working in foreign-owned enterprises for a number of years, mastering basic production management processes as well market information, eventually become entrepreneurs and start their own businesses, employing and skilling a new wave of workers, with the new business usually supplying it products to the foreign investors, which again receive cost advantages. As the products tend to remain intermediate inputs they do not

Total value of foreign capital absorbed by Guangdong Province by districts - source during 1979-2005 **Figure 5**



Source: Guangdong Statistics Bureau, Guangdong Statistical Yearbook, Beijing: China Statistics Press, 2006.

increase the propensity of these new firms to utilise more advanced technology, with learning processes for these firms tending to relate to internationalization, rather technological upgrading (Chen et al, 2005). However, this situation is gradually changing, with local enterprises beginning to become less dependent on foreign-owned enterprises as a new cluster of large and medium-size local domestic enterprises grown in the PRD. Rather than the previous focus on 'imitated innovation', the firms are establishing 'self-initiated innovation' that can compete with the foreign investors. For example, the capacity of self-initiated innovation among firms such as Huawei, ZTE, and TCL has improved markedly in recent years. As China's largest telecommunications equipment firm, Huawei was founded in the PRD city of Shenzhen in 1988, and despite its short history is now applying for more than 1,000 patent registrations annually. By 2007 Huawei had applied for more than 22,000 patents and from 2000 it has recruited 1,000-2,000 IT graduates annually from China's leading universities. Annual investment in R&D is more than 10% of sales, and it has set-up R&D facilities in India, the United States, Sweden, Russia, as well as Beijing, Shanghai and Nanjing. It is claimed at 48% of the firm's 62,000 employees are engaged in R&D. In 2006, sales revenues reached US$31.24 billion, 65% of which came from overseas markets, ranking first and second globally for sales in its product range.

Huawei is not an isolated case, and a new group of local enterprises have grown up initially learning from foreign investors, and subsequently competing with them. This more recent development of local high-technology enterprises has played a positive role in improving the knowledge and technology structure of the PRD region. These companies not only attract a large number of technical personnel from China, but also promote the government's public investment in R&D and related services. As a result, a number of innovative technology platforms have been established, which in turn further attract investment from foreign-owned high-technology enterprises, promote their R&D activities, and improve their export product base. In 2000, high-technology products in PRD accounted for 25% of the exports of foreign-owned enterprises, by 2005 this had increased 43%, which highlights the gradual shift from a labour-intensive and primary processing region to one that is beginning to develop a growing and complementary knowledge-based sector. It also highlights the change in PRD's economic growth path from a dependency on investment-driven economic growth to one that is beginning to encompass technical innovation (Tan, 2005). PRD is in the process of moving from receiving and absorbing of strategic management knowledge to creating its own technological knowledge for innovation.

4. The Yangtze River Delta: City-Network Driven Model

4.1 Regional Socio-Economic Characteristics

YRD is China's strongest economic region. In 2006, it accounted for 22.2% of China's total GDP, with only 2.2% of the land mass and 10.8% of the total population. Its GDP per capita is twice the national average, and in 2006 reached US$6,004, which based on purchasing power parity equates to US$ 22,304. At the core of the region is Shanghai, which has a GDP per capita of US$27,016. About one-half of China's most developed counties are with YRD, which is also China's most urbanised. The region consists of 80 cities, small and large, which constitute a hierarchy structure conducive to industrial development and knowledge diffusion. YRD has a strong industrial foundation, and is the birthplace of China's modern industry, which began to take shape in Shanghai, Wuxi and Suzhou in the early 20th century. Before reform and opening-up, the state-owned enterprises in YRD were the largest, with industrial output for Shanghai alone accounting for 12.5% of national output in 1980. At the same time, the collective enterprises in the region - at that time called 'township enterprises' – were the most advanced in China, especially in Jiangsu province, with the volume and output value of township enterprises accounting for almost half of the nationwide total (Luo and Zeng, 2001). Therefore, it is important to account for YRD's industrial foundation when analysing the rapid economic take-off which occurred following reform.

YRD is China's most advanced science, technology, and education. Historically, it is a region that always attached a great importance to education, and has among the highest levels of education attainment in China (Table 3). In more historic times, a large number of famous scientists and academics originated from the region, while more recently the number of R&D personnel and scientists and engineers per 1,000 residents in YRD is almost twice the national average, and is higher than the other two regions (Table 4). In 2005, the total R&D expenditures reached US$30.55 billion, accounting for 26% of the national total (Table 10).

YRD has traditionally been one of China's most open regions, and after the Opium War Shanghai, as part of the first batch of modern Chinese cities, was forced to open its gates and began the process of modernisation, developing significant links with the capitalist production mode. By the 1930s, Shanghai had become the centre of China's national industries, with the largest light industrial base. It developed as an important international financial and trade centre in Far East. Post 1978, and its openness has continued to develop, which has been enhanced by the massive development of the Pudong area of Shanghai as a new financial centre.

Comparison of R&D Expenditure across the Three Regions (2005) — **Table 10**

Regions	Amount US$ billion	Proportion of the national total %	Per capita US$s
BGRs	43.58	34.02	190
PRD	12.75	9.95	138
YRD	33.55	26.18	237
Other 22 provinces	38.23	29.85	45
National total	**128.11**	**100.00**	**99**

Source: (1)China S&T Statistics, http://www.sts.org.cn/sjkl/kjtjdt/data2006/;
(2) National Bureau of Statistics of China, China Statistical Yearbook, Beijing: China Statistics Press, 2006

4.2 Analysis of the Regional Economic Growth Model

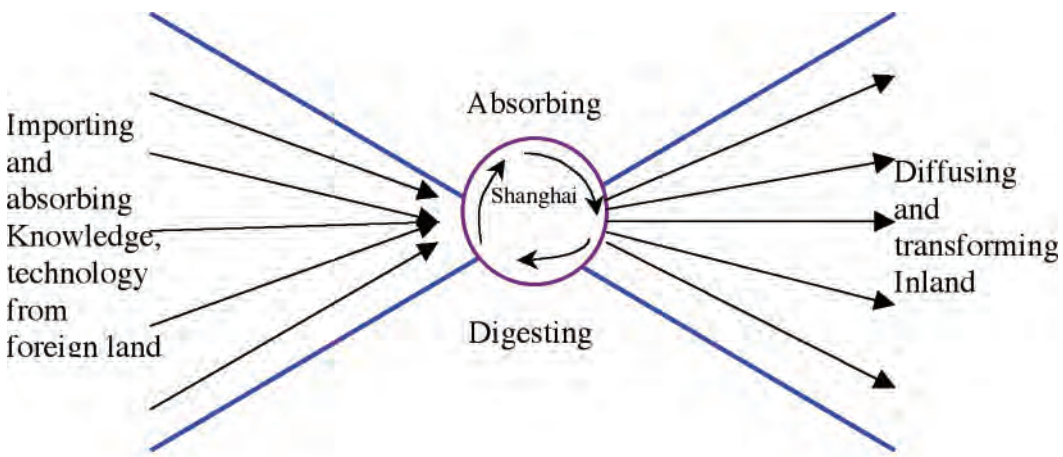
As already indicated, compared to PRD and BGR, YRD has superiority in terms of the industrialisation, urbanisation and a historically rooted form of openness. Therefore, while YRD formally opened to the outside world, following the 1978 reforms, one stage later than PRD, the economic development of the region was rapidly activated by the relaxation of the planned economy and the introduction of market mechanisms. While PRD's economy has mainly depended on FDI-driven forces and BGR's on government-driven forces, YRD display a different form of economic driver based on the development of a city-network driven model whereby new knowledge and technology becomes first diffused from the core city of Shanghai to more peripheral cities and then across the region's industrial and business base a whole. PRD's system of cities, with a range of small, medium and large cities, can be conceptualised as a pyramid, with Shanghai as the core city and its apex. The diffusion effect through this pyramid displays two forms: neighbor diffusion and rank diffusion (Hagerstrand, 1969). Neighbor diffusion mainly manifests itself through Shanghai's industrial linkage with adjacent cities in southern Jiangsu and northern Zhejiang, where there a strong degree of economic connectedness. Rank diffusion mainly manifests itself through advanced technolgical transfer with larger cities such as Nanjing, Suzhou, Wuxi, and Hangzhou, on through to the medium and smaller cities.

Shanghai's technological foundation and human resource capability – particularly at management level – results in a higher regional technology absorption effect than other regions. One output of this is that it is able to cooperate and collaborate more easily with other technological players, such as multinationals, on the global stage. After infusing this technology, Shanghai is able to diffuse and transfer it throughout the region as a whole via the city-network pyramid. Furthermore, Shanghai plays a similar role at the national level, acting as the convergent pivot technologically connecting China with the global economy (Figure 6). From this perspective, in newly developing nations, relatively well-developed core cities play an extremely important leadership role at the economic take-off stage. At a regional level, the rapid development of YRD is closely related to the economic and technological function of Shanghai.

Looking more closely at this form of regional knowledge diffusion in YRD, it is clear that both firms and universities play important roles within the city-network framework. In terms of diffusion across firms, technology diffuses from overseas enterprises to domestic enterprises, as well as from state-owned enterprises to newer enterprises in the region. One reason why technology and knowledge is better diffused from overseas firms to domestic firms in YRD than in PRD is the higher absorptive capacity of YRD's domestic enterprises, and stronger capability to engage in technology transfer. Also, the proportion of FDI from Europe, North America is more than double in YRD compared to PRD, which, as we have seen, mainly stems from other emerging Asian industrialized. This has led to the development of far more joint ventures and collaborative agreements between foreign investors and domestic firms in YRD than PRD. FDI from the west has tended to be significantly more advanced than other foreign investors in relation to technology and integrated management, and the diffusion effects of technology and synthesised knowledge are more apparent, taking a vital role in improving the technological and industrial structure of the region (Gan, 2003). Between 1978 and 2005, 57% of FDI in Shanghai was in the form of joint and cooperative ventures, compared with only 19% in Guangdong. The ventures facilitate domestic firms in accessing technical and management training, advanced equipment support, and technical guidance and so on. For instance, in the automobile industry, Shanghai has entered joint venture or cooperation agreements with Volkswagen, GE, Daewoo and Ssangyong, with the government playing a role in guiding the framework of these agreements, such as the setting of quality standards across industries, especially the automotive and transport sectors. Government's setting of standards is intended to promote transparency across the parties involved in joint ventures, promoting further bilateral cooperation and technology transfer.

Diffusion from state-owned enterprises to other firms in region mainly occurs through the introduction of technical workers and new industrial facilities. China's state-owned enterprises still possess the highest quantity and best quality specialised technological human resources, with Shanghai's state-owned enterprises being China's strongest. Therefore,

The Diffusion Function of Shanghai **Figure 6**



many technological problems arising in private enterprises and collectively operated enterprises throughout YRD can potentially be solved by specialised talent residing in Shanghai's state-owned enterprises. As early as the 1980s when Jiangsu and Zhejiang's township enterprises and private enterprises lacked technical talents, they invited engineers from Shanghai to help them solve technological problems largely in their spare time, a phenomenon which became known as the 'weekend engineer' and became more formalised in the 1990s (Rui, 2006). Similarly, at a firm level, state-owned enterprises in Shanghai have a long tradition of supplier relationships with collectively-operated and private enterprises in Jiangsu, Zhejiang and the Shanghai suburban districts, usually producing spare parts and other upstream and downstream products. Through these links, state-owned enterprises have introduced quality standards and provided technical training to their workers. Although these links cannot be said to have diffused core technologies from Shanghai across the region, they have acted as an important diffuser of knowledge stimulating the initial growth of private enterprises located in the region's smaller and more medium-sized cities.

Technological diffusion from universities to firms is also more apparent in YRD than PRD or BGR. While the number of universities in the core city Shanghai is slightly smaller than that of Beijing, their ability to undertake technological commercialization is much stronger than the universities in Beijing. An important difference is that the main research funds for Beijing's universities are sourced from national and local government, while Shanghai's universities obtain much of their funds from the private sector, particularly through the provision of technology services and contract research. The more developed industrial base in YRD has heightened demand for these services and research, and universities in Shanghai have taken a strong initiative in meeting this demand, with R&D projects funded to ensure they are close to market demand. Such university-enterprise cooperation is a very important lever in promoting knowledge and technology diffusion from universities to enterprises. In summary, the spatial technology diffusion effect in YRD over the 30 years is more marked than it is PRD and BGR. Within this process, the city-network configuration and urban structure of YRD plays an important and advantageous role in facilitating technology diffusion.

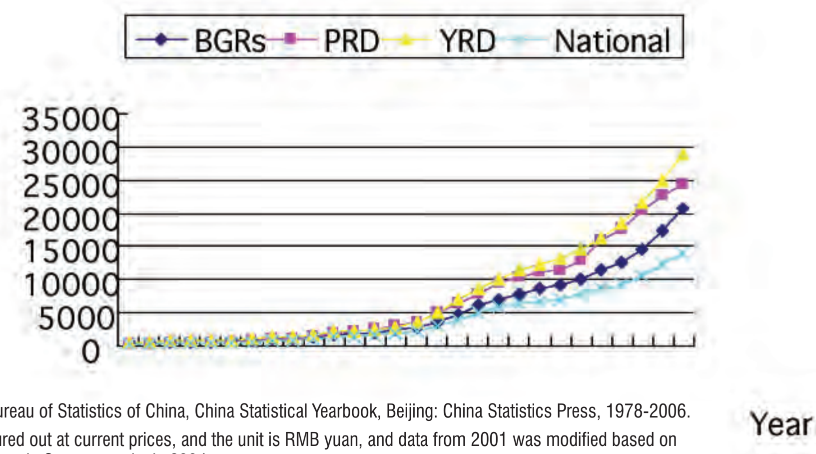
5. A Comparison of Regional Growth and Diffusion

5.1 Growth

Although all three regions have achieved very high levels of growth since 1978, such growth and development has not been uniform, with PRD experiencing the most rapid economic development and BGR the least. Between 1978 and 2005 the compound annual GDP growth rates of BGR, PRD and YRD are 14.9%, 16.8% and 15.4% (at current prices) respectively. When comparing the two Delta regions, we find that although GDP per capita of the YRD is higher in absolute value, the PRD's performance is higher due to its low starting base (Figure 7).

The growth difference across the three regions may partly result from the transfer effects of internal and external knowledge and technology. PRD is the most market-oriented region among the three, and the market plays a critical role in resource allocation. Although its knowledge and technology levels are lower than the other regions, its internal diffusion effect is apparent. As for BGR, during its restructuring and reform it has not moved as swiftly towards a market-oriented system as the two Deltas due to the historical issues mapped out in this study and the continuing momentum of a planned economy approach. In the region, enterprises lack vitality and technology commercialisation is difficult relative to the two other regions. While there is significant research undertaken by universities and scientific institutes, it is not often oriented towards market demand, resulting in a supply of knowledge disconnected from demand. As a result, commercialisation activity has tended to be towards the development of spin-off enterprises, rather than other forms of knowledge transfer, restricting diffusion across the region as whole. Furthermore, many of the spin-off firms established by universities and scientific institutes do not operate according to market forces, and are highly dependent on state support and the government as their chief customer (Kroll and Liefner, 2007).

The growth of three regions during 1978-2005 **Figure 7**



Source: National Bureau of Statistics of China, China Statistical Yearbook, Beijing: China Statistics Press, 1978-2006.
State: GDP is figured out at current prices, and the unit is RMB yuan, and data from 2001 was modified based on China Economic Census results in 2004.

5.2 The Spatial Diffusion of the Three Regions

The spatial diffusion of knowledge and technology within regions can drive their economic development and, particularly in the case of Chinese regions, this diffusion occurs through a pattern where knowledge emanates in the core cities and diffuses through to the periphery. In order to measure differences across our three regions, we use the following formula:

$$F = \frac{C_{T_0} / R_{T_0}}{C_{T_1} / R_{T_1}}$$

Here F denotes the degree of centralisation of the core city, C_{T_0} and C_{T_1} the GDP per capita in 1978) and 2005, respectively, of the core city, R_{T_0} and R_{T_1} the GDP per capita in 1978 and 2005, respectively, of the region in which the core city is located.

Correspondingly, the numerator part denotes the degree of centralisation the core city relative to the region in 1978, and the denominator part denotes the degree of centralisation in 2005. If the value of F is bigger than one, it means the disparity between core city and periphery during the period has shrunk; the bigger the value is the more disparity has shrunk. In contrast, if the value of F is less than one it means the disparity between the core city and the periphery has widened; the less the value is the more the disparity has widened. If the value of the two components of F rises, agglomeration processes have occurred in the region. In other words, the core city has attracted resources from the rest of the region. If the value of the two components of F decreases, diffusion effects can be said to have occurred across the region. In other words, the core city mainly distributes resources to the region and drives the economic development of the region as a whole.

We use formula (1) to compute the variations in the degree of centralization (F) of BGR, PRD and YRD, with the respective results being 1.19, 2.31 and 1.36. It is clear that between 1978 and 2005, the rate of centralisation in BGR is less than in the other two regions. The degree of centralisation of the core city, Beijing, in BGR actually decreases slightly from 2.59 in 1978 to 2.17 in 2005. Meanwhile, the degree of centralisation of the core city Shanghai in YRD decreases sharply from 4.11 in 1978 to 1.78 in 2005, with the degree of centralisation of the core city Guangzhou in PRD decreasing from 2.46 in 1978 to 1.81 in 2005.

The decrease in centralisation reflects the diffusion effect from the core city, with a strengthening of each of the regions as a whole. In the three regions, the YRD has the highest diffusion and BGR the least. One possible explanation is the size of the region. However, other research has found that many of the areas in close proximity to Beijing are among the region's poorest, with these areas termed the 'Poverty Belt', which account for almost 4,000 villages and 27 million people when the neighbouring areas around the region's other core city of Tianjing are included (Fan, 2005; Wei, 2005). This poverty belt is acknowledged by the government as restricting the diffusion of knowledge and technology innovation in the region, and compares unfavourably to YRD, whereby knowledge created in Shanghai appears to diffuse to many neighbouring counties, which are among China's most prosperous.

5.3 The General Difference in Growth and Diffusion across the Three Regions

It is very interesting to note the differences across the three regions, which can be analysed further by the use of the Structure Conduct Performance (SCP) framework. Although the SCP framework is generally a model to understand the links between firms and their markets (Stigler, 1968), it can also be utilised to frame the links between regions and their development. In effect, we argue that different socio-economic structures have led to different economic paths, resulting in different levels of performance. These differences are summarised in Table 11.

Evolutionary Comparison of the Three Regions — **Table 11**

Features	The BGRs: Government-driven model	The PRD: FDI-driven model	The YRD: City network-driven model
Historic base (structure)	Good economic foundation. Richest resources for science & technology and education, Strong influence of the government.	Poor economic foundation. Poor resources for science & technology and education.	Stongest economic foundation. Urbanised economy. Rich in resources for science & technology and education.
Mechanisms (conduct)	Central and local government resource input for R&D, education and other related fields. Universities and research institutes engaged in setting up spin-off enterprises to commercialise their technology. Large number of government funded development zones.	The most rapidly developed market economy. First region carrying out opening-up policies in China. Intensive FDI introduced through favourable policies. Most technology and human resources introduced from outside the region., Highly developed export market.	Linkage across the region's cities is strong. The flow of factors of production is highly active across the region; Introduction of high quality FDI from developed countries. Significant cooperation between local companies and foreign investors.
Performance	Above the national average, but not very efficient. Connections across the enterprise sector relatively weak. Spatial diffusion of knowledge not very efficient.	Most efficient and rapid economic growth; but a dependency on external sources of knowledge may affect continuity of economic growth.	Efficient, technology and knowledge diffusion both across both enterprises and cities. High quality and sustainable growth.

6. Conclusion

In China, BGRs, PRD and YRD are the three leading economic regions, each with their own particular growth model resulting from their social and economic conditions. BGR continues to show government-driven characteristics even though the market economy has been in place for more than a decade. Both state and local government have allocated large human and financial resources to education and technology, and the setting up of spin-off enterprises to commercialise technology and the establishment of high-tech development zones within the region. PRD shows FDI-driven characteristics, especially overseas Chinese-owned FDI. In this region technologies come from overseas within an export oriented market. YRD shows city network-driven characteristics, with the core city Shanghai diffusing its knowledge and technologies to medium and smaller cities.

Between 1978 and 2005, all the three regions performed above the national average. PRD grew the fastest, and BGR the slowest. These differences in growth rate can be linked to the institutional vitality originating in each of the regions. While PRD has no advantages in terms of human resources and technology, it has been adept in taking advantage of external technology and resources, and more recently transforming this technology and knowledge to meet its needs. The growth of BGR has been hindered by the lack of a match between the supply and demand of technology, even though the government has allocated significant resources for innovation. YRD has the most evolved economic and technological base, allowing it to absorb advanced technology from developed countries, and establish cooperation between local enterprises and foreign capital, which reinforces the development of the region. As for spatial diffusion, effects are most pronounced in YRD, with the core city Shanghai strongly driving the development of peripheral cities, contrary to the restricted diffusion apparent in BGR.

In general, each of the three regions has its own characteristics. Will they converge in the future? We consider this doubtful. The continuance of marked differences in the economic and social conditions, and technological bases, mean that while they may all continue to grow, they will do so through different ways and means. A convergence in these models will be somewhat dependent on the extent to which central and regional policymakers seek to, and are able to effectively, transfer policy lessons from one region to another. For example, policies aimed at increased marketisation in BGR, or policies focused on indigenous innovation in PRD.

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INVESTOR IN PEOPLE

Western Avenue
Cardiff
CF5 2SG
tel: +44 (0)29 2041 6070
fax: +44 (0)29 2041 6286
email: uwicinfo@uwic.ac.uk
uwic.ac.uk

Rhodfa'r Gorllewin
Caerdydd
CF5 2SG
ffôn: +44 (0)29 2041 6070
ffacs: +44 (0)29 2041 6286
ebost: uwicinfo@uwic.ac.uk
uwic.ac.uk