Acknowledgement

This thesis marks the completion of my Master degree in Economics and Business at Erasmus University Rotterdam with the specialisations in Accounting & Finance and Urban, Port and Transport Economics.

I am truly grateful to my supervisor Dr. Erik Braun for his help and support over the years of my study. Without his help, I would not have been successful in completing this master thesis with two specialisations. I would also like to acknowledge Dr. Marc B.J. Schauten, who has helped me in completing my thesis; his valuable suggestions were very much appreciated.

I further wish to thank my family members who have greatly supported me during my study. Especially to my dear father, who cannot attend my graduation ceremony, but I know he is always in my heart and that he would be very happy to see me graduate.

Last but not least, I would like to thank my mother and my partner, their love and support mean a great deal to me. Thank you very much to all of you!

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Abstract

With the globalization and ICT development, the competition of regions and nations are gradually moving towards knowledge competition, therefore, the researches on knowledge economy have been increasingly popular in economic studies. Within the knowledge economy domain, one particular research challenge is how financial investments influence regional knowledge competitiveness. In our thesis, we will design a "regional knowledge economy competitiveness cyclical scheme" and further test which financial investments significantly affect regional competitiveness in the knowledge economy. We use data from 145 global regions, including North America, Europe and Asia-Pacific for our analysis. From that we find business firms' investments in R&D and innovation, government investment in higher education and private equity investment in knowledge-based industries are significant indicators that can promote regional knowledge competitiveness. North American regions are more competitive in the knowledge economy than European and Asian-Pacific regions. In order to increase European knowledge competitiveness, policy suggestions are provided for European policy makers at the end of this paper.

Keywords: Knowledge economy, regional competitiveness, financial investments, policy suggestions

Chapter 1. Introduction

1.1 Research background

The emergence of global knowledge economy means that globalization extends beyond markets for goods and finance into markets for technology, human capital and innovation. As a result, the competition of regions and nations are gradually moving towards knowledge competition and the researches on knowledge economy are increasingly becoming more popular.

Paul Romer (1986, 1990) was the first to illustrate "knowledge economy" in his new growth theory. He stressed that "knowledge" is a main driver of productivity and economic growth, departing from the traditional emphasis upon the accumulation of capital. OECD[1] (1996) advocated that comparing with natural resources, physical capital and low skill labour, "knowledge" has taken on a greater role of economic growth and all OECD economies are moving towards a knowledge-based economy. Harris (2001) and Karlsson *et al*. (2005) stressed that knowledge creation and distribution are the key drivers in the process of economic growth. Smith (2002) emphasized knowledge as an input factor has become more significant both in quantitative and qualitative terms. This reflected in growing levels of knowledge-based investments, for instance, R&D, software development, education, etc. Smith also claimed that knowledge is an important product as new forms of activities arises based on the trading of knowledge products. Thus, in order to increase competitive advantages, "knowledge" is the key power which should be seriously supported by business leaders and policy makers.

Porter (1990) discussed that regional "competitiveness" changes under the new environment of the global economy and advocate that knowledge is the force of these changes. Porter (2006) analyzed that globalization make the location seems less important because there are no location barriers to make knowledge investments. The paradox is the location still does matters. Many cities from historical view have economical advantages, but these advantages are not that natural anymore; the ability to source from anywhere is increasingly threatening local competition.

However, we face many challenges on how to measure knowledge economy. OECD (1996, pp31) explains two major challenges: "Inputs into knowledge creation are hard to map because there are no knowledge accounts analogous to the traditional national accounts". Also, "there are no stable formulae or 'recipes' for translating inputs into knowledge creation into outputs of knowledge". Knowledge is essentially unique, finding appropriate indicators to measure is challenging. OECD

[1] OECD: Organization for Economic Co-operation and Development

provided some indicators to measure knowledge economy. For instance, R&D, innovation and human resource are valid factors to measure knowledge input; GDP, unemployment rate can be used to measure knowledge output; the distribution of knowledge among universities or firms can be used to measure knowledge networks, etc. Anthony Arundel (2009) made further research on knowledge based economy indicators, by interviewing policy analysts and policy makers. He concluded that there are still some research 'gaps' of available indicators to meet both current and emerging policy needs. As the "knowledge economy" is a complicated topic, policy makers need more advanced research with better indicators to measure the economic impact of innovation in quantitative terms.

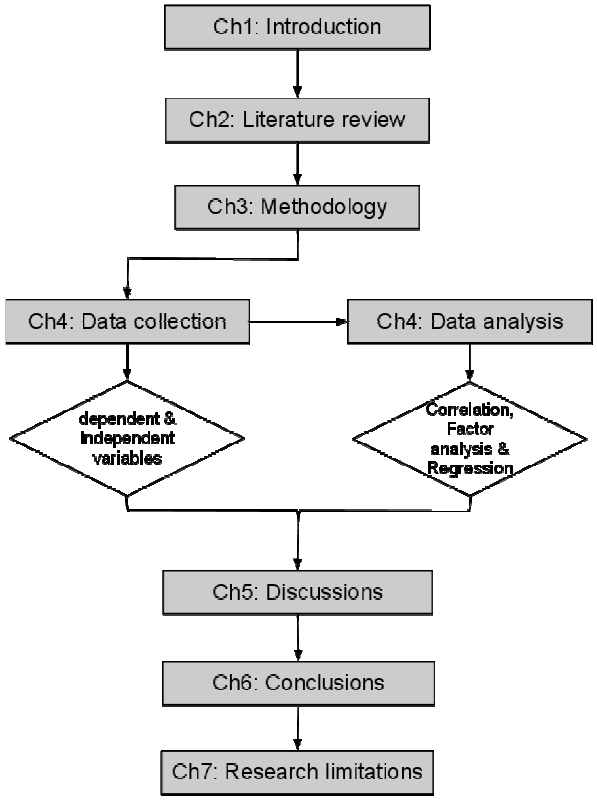
We believe financial investments play crucial roles in the increase of regional knowledge competitiveness. Hwang and Gerami (2006) found knowledge investments to have relationships with multifactor productivity and patent numbers. OECD (2005) emphasized that public and private expenditure on R&D and innovation can promote regional economic growth. Glaeser (2000) advocated that government investment in education will positively increase the human capital and economic growth. However, questions regarding the relation between financial investments and knowledge competitiveness are rarely discussed.

1.2 Research question

By reviewing previous literatures and empirical research papers, we identified the research gaps in the knowledge economy. There is no standardized model to measure the knowledge economy, especially till now there is not much research that discusses the influence of financial investments on knowledge competitiveness. Many classic researches have been discussing the knowledge economy on human capital, R&D and innovation and economic growth. In this thesis, we will therefore analyze the research question by building up a comprehensive framework that includes all elements on knowledge economy competitiveness and test the influence of financial investments on it.

Our research questions are:

Which financial investments significantly influence regional knowledge competitiveness? And what are the implications to policy makers?



1.3 Research structure

As the flowchart indicates, this thesis consists of seven parts. We will review literatures and discuss the research model in Chapter 2. In Chapter 3, we will discuss research methodology and formulate our hypotheses. In order to make analysis on knowledge competitiveness, we use World knowledge Competitiveness Index (WKCI) as our dependent variable[2].

Chapter 4 will be about data collection and data analysis. Because of data limitation, five financial investments indicators have been selected in our research, which are government investment in R&D and innovation, government investment in lower education, government investment in higher education, business firms' investments in R&D and innovation and private equity investment in knowledge-based industries. We will gradually add control variables from human capital, regional economic performance and dummy variables of locations to test if the effects of financial investments on regional knowledge competitiveness will be changed. SPSS 19.0 is used as our research tool. After our data analysis, we will make discussions on our findings in Chapter 5. In Chapter 6, we will make conclusion and policy suggestions for European policy makers. We also realize there are some research limitations of this thesis, therefore, we will discuss the limitations and give further research recommendations in Chapter 7.

[2] Research paper from Centre for International Competitiveness from Cardiff Business School in 2008

Chapter 2 Literature review

In this chapter, we will review key literatures regarding the knowledge economy and regional competitiveness. Based on the literature research, we will design a comprehensive scheme to describe knowledge economy competitiveness in a high level overview. Using the overview we will explain our research focus and discuss the research questions based on the scheme.

2.1 Knowledge economy

The concept of "knowledge economy" has been discussed by many scholars. Schumpeter (1911, pp56) was the first who emphasized the importance of knowledge in the economy by his reference to "new combinations of knowledge" at the heart of innovation and entrepreneurship. Drucker (1956,pp27) and Machlup (1962,pp41) introduced the term of "knowledge economy", claiming that "knowledge is becoming the one factor of production sidening both capital and labour." Since the 1980s, the concept of knowledge economy was accompanied by different terminologies, such as knowledge-based economy, information economy, new economy or learning economy. Among the different terms, they have common claim that knowledge creation and distribution are primary drivers in the process of economic growth, the distribution of income and the growing importance of knowledge-based networks among firms, governments and citizens (Harris 2001, Karlsson *et al.,* 2005). The research of Smith (2002) analyzed two reasons why the impacts of knowledge on economic processes increase over time. First of all, knowledge as an input factor becomes more and more significant in both quantitative and qualitative term. For instance, the knowledge based investments are gradually increasing in R&D, education or ICT development. Second, knowledge is also claimed as a product, knowledge-based companies are often established on the basis of new ideas, incorporating and applying new knowledge into products. For instance, many software companies have their own technologies or patents that are knowledge based.

ESRC[3] (2005) emphasized that economic success is increasingly based on the effective utilization of intangible assets such as knowledge, skills and innovative potential as key resources for competitive advantage. Thus, the term "knowledge economy" is typically used to describe this emerging economic structure. Huggins and Izushi, (2007) discussed the importance of the knowledge economy from two different levels. They stressed at its most fundamental level, the knowledge economy can be considered as the capacity and capability to create new ideas and creative thoughts, new processes and products to translate these into economic value and wealth. In higher level, the knowledge economy

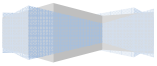
[3] Economic and Social Research Council: http://www.esrc.ac.uk/

can be defined as activities and resources centered on and geared towards innovation. With the development of global economy, regional competitiveness in the knowledge economy becomes more and more fierce. Knowledge is one of the key drivers to promote urban development and increase regional competitiveness.

2.2 Regional competitiveness in the knowledge economy

Porter (1990) discussed the regional competitiveness changes under the new environment of the global economy and emphasized that knowledge is the driven force of these changes. He claimed as results of globalization of markets, capital investments and company value chains, many countries have moved forcefully towards reducing budget deficits, strengthening financial institutions and streamlining regulations. To improve competitiveness is becoming increasingly essential to a country's prosperity. Porter analyzed "competitiveness" from both macro-level and micro-level. In the national level, competitiveness depends on the productivity with which a nation uses its labor force, financial capital and natural resources. At a micro-level, many companies renew their market focus, eliminate nonproductive activities, restructure their resources in order to speed up products and process efficiency. Rasper (2009) also discussed the importance of knowledge from firms' level (micro) and regional level (macro). He emphasized knowledge promotes economic growth in multi-levels, as knowledge does not diffuse instantaneously around the world but "agglomerates'. Regions act as collectors of knowledge externalities, containing traded and untraded firm with external circumstances that can alter firm performance, typically resulting from the collective action of other firms and institutions. With the right abilities, firms can complement their internal capabilities with external ones to integrate and utilize different types of knowledge. It is obvious that for a firm, being located in a region rich in knowledge resources is more favorable to perform than being located in a region that is less resourced in knowledge.

Braun (2008) discussed six fundamental developments that promote urban development and changing behavior of urban actors. The six trends include globalization, ICT revolution, media society, better transport connectivity, geo-political change and threat of terrorism. Under these trends, urban the knowledge economy has rapidly changed its structure. As the result of globalization and transport development, firms can easily obtain cheap raw materials and low-cost labor force around the world. Competition amongst firms is continuous and is becoming more fierce. Companies need to be more innovative and diverse in order to have strong competitive advantages. As the core elements of



innovation, knowledge refers to the cumulative stock of information and skills concerned with related new ideas with commercial values, new product development and new business models.

Huggins and Izushi (2007) emphasized regions are gradually viewed as economic units of analysis rather than nations as they have unequal distribution of wealth. Edomons (2000) discussed the regional competitiveness in the UK. He advocated there was a massive disparity between the proportions of knowledge based industries found in the different regions. London and South East of England are seen as the core economic drivers of the nation, they have higher competitive advantages over other regions, whereas Northern regions are less competitive. In China, similar inequality exists among regions. Regions in south coast, such as Shanghai, Hangzhou, Guangzhou and Hong Kong are seen as the strong drivers of Chinese economy as these regions are more advanced in manufacturing, trading and financial industries. However, the northwest regions such as Shanxi, Gansu and Qinghai are facing the negative effects of inequality like low income, low employment rate and low living quality. The unequal distributions in nations are mostly related to the different industries located and functions performed in these regions and differences in their supporting environments. The examples of supporting environments include universities, research institutes, business services providers and ICT infrastructure. Thus, it is interesting to use "region" as analysis unit to see whether the distribution of knowledge and capacity of the knowledge economy are unequal among global regions.

Another reason to analyze regional difference can be supported by the "location paradox" which is advocated by Michael Porter (2000, 2006). Porter[4] stressed that globalisation indeed make the location seems less important as there are no location barriers to make knowledge investment. However, the paradox is that the location still matters. For example, United States still is the most important country in the world; regions in the U.S. have tremendous specializations. There is no longer a competitive advantage if anything can be easily accessed from a distance. With less barriers and more mobility, the more decisive location becomes. As a result, the bottom half of U.S regions are facing more challenges. Many cities used to have a natural advantages, but do not have advantages anymore. The historic factors influencing location, such as proximity to inputs and markets, are being undercut, the ability to source from anywhere is increasingly becoming more important for local competition; in many respects, globalization is reinforcing localization, which means the most enduring competitive advantages in a global economy seem to be local.

[4] Michael Porter interview by senior writer Pete Engardio, which published in Bloomberg Businessweek magazine (2006)

The theoretical support of location competition lends considerable weight to use both data analysis and a policy approach at the regional, rather than the national level (Huggins and Izushi, 2002, 2007). As the integrated economic areas in the sub-national geographic units, location competition can be defined as regional competition. This level can bring us much closer in line with the nature of competition and the role of government in economic development activity. Thus, in our research, we will discuss the regional competitiveness rather than national competitiveness in the knowledge economy.

2.3 "knowledge" in economic theories

There are many economic literatures dealing with the knowledge economy and discussions regarding the relationship of knowledge with entrepreneurship, economic growth or firm's development. Four mainstream ideas exist that are fundamental in the knowledge economic theories.

2.3.1 Human Capital theory

Lewis (1954) begun the field of Economic Development and consequently came up the idea of human capital in his paper *Economic Development with Unlimited Supplies of Labor*. The term "human capital" was first discussed by Arthur Cecil Pigou[5], who emphasized that investment in human capital as well as investment in material capital. The best-known application of the term of "human capital" in economics is from Gary Becker. In 1964, he published his book entitled *Human Capital: A Theoretical and Empirical Analysis,* which became a standard reference for many years. In his view, human capital is a means of production, into which additional investment yields additional output. Human capital is substitutable, but not transferable like land, labor or fixed capital.

The definition of human capital that is widely adopted since recent years come from OECD (2001, pp 18), human capital is the "knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being". It is recognized as the foundation of the knowledge economy alters the principle of scarcity, which refers to the first-rate talent that can appropriate knowledge in ways that lead to competitive advantages. The innovative capacity depends on whether it attracts and retains the right people rather than the right technologies. The knowledge economy is marked by increasing labour market demand for more highly skilled workers. Some countries show that the more rapid the introduction of knowledge-intensive means of production, such as IT, bio-chemical, the greater demand for highly skilled workers. Besides, workers who use advanced

[5]Wikipedia: *Arthur Cecil Pigou*, http://en.wikipedia.org/wiki/Arthur_Cecil_Pigou

technologies are paid higher wages. Ceridian (2007) defined *Human Capital* is the stock of competences, knowledge and personality attributes embodied in the ability to perform labor so as to produce economic value. Human Capital is the attributes gained by a worker through education and experience.

2.3.2 Endogenous growth theory (new growth theory)

Endogenous growth theory (or new growth theory) was developed by Paul Romer (1983) and Lucas (1988) which was a natural starting point for gaining a better theoretical understanding of the emerging knowledge economy (Karlsson *et al*, 2005). The endogenous growth theory is a response to criticisms of neoclassical models of economic growth that assumed that technological change was exogenously determined. According to Romer (1983) and Lucas (1988), in neo-classical growth models, the long-term rate of growth is exogenously determinate by rather the savings rate or the rate of technical progress. However, these rates remain unexplained. Endogenous growth theory tries to overcome this shortcoming by building macroeconomic models out of microeconomic foundations. Individuals are assumed to maximize utility subject to budget constraints while companies maximize profits. Crucial importance is usually given to the production of new technologies and human capital. The engine for growth can be as simple as a constant return to scale production function or more complicated set ups with spillover effects (which are externalities of economic activity or processes those who are not directly involved in it), increasing numbers of products or increasing qualities. The main implication of recent growth theory is that policies which embrace openness, competition and innovation will promote economic growth. In contrast, policies which have the effects of restricting or slowing changes by protecting or favouring particular industries or firms are likely over time to slow growth to the disadvantage of the community.

According to Molaei (2010), the endogenous growth theory helps us make sense of the ongoing shift from a resource-based economy to a knowledge-based economy. It emphasizes the point that the economic processes which create and diffuse new knowledge are critical to shaping the growth of nations, communities and individual firms. Molaei (2010, pp1) further stressed the point of measuring knowledge that "the difficulty and uncertainty of being able to capture the value associated with knowledge is a real problem."

2.3.3 The knowledge-based theory of the firm

The further discussion on the knowledge economy is toward the knowledge-based view of the firm. The knowledge-based (KBV) of the firm is an extension of the resource-based view (RBV) of the firm (Grant, 1996a; Hoskisson et al., 1999; Sveiby, 2001; Bontis, 2002b). The RBV conceived the firm as an administrative organization and a collection of productive resources, both physical and human. According to Ariely (2003), the interpretation of knowledge as a resource establishes the theoretical connection between the RBV and the KBV. Hoskisson *et al.* (1999) claimed that the KBV of the firm considers that organizations are heterogeneous entities loaded with knowledge and knowledge resources are particularly important to ensure that competitive advantages are sustainable. Different from RBV of the firm, the knowledge-based view of the firm does not treat knowledge as a generic resource rather than having special properties, but distinguishes different types of knowledge-based capabilities (Kaplan and Schenkel, 2001).

2.3.4 The Knowledge Spillover Theory of Entrepreneurship

Acs and Audretsch (2005) discussed the Knowledge spillover theory of entrepreneurship. The basic argument is that knowledge created endogenously via R&D results in knowledge spillovers. Such spillovers give rise to opportunities to be identified and exploited by entrepreneurs. They explained that the incomplete knowledge generated in incumbent organizations generates an entrepreneurial opportunity, and entrepreneurial activity in turn provides the conduit facilitating the spillover and commercialization of that knowledge. By support by empirical research, they found that there is a strong relationship between knowledge spillovers and new venture creation.

2.4 The knowledge economy indicators

The four classic theories fit into the recent urgency to theorize and empirically test the hypothesis of the rise of the knowledge economy. In order to measure knowledge, many researches discussed the appropriate indicators of the knowledge economy. However, the clear indicators of regional competition in knowledge economic activity are limited by the numbers, types and quality. It is difficult to capture the economic value of knowledge by single input or output indicators of knowledge generation. And all indicators have advantages and disadvantages (Brinkley, 2006). OECD (1996, pp30-31) published the most recognized paper on the knowledge economy, it emphasized that the knowledge indicators cannot approximate the systematic comprehensiveness of traditional economic indicators because of four principle reasons:

- *Inputs into knowledge creation are hard to map because there are no knowledge accounts analogous to the traditional national accounts*
- *There are no stable formulae or "recipes" for translating inputs into knowledge creation into outputs of knowledge*
- *knowledge lacks a systematic price system that would serve as a basis for aggregating pieces of knowledge that are essentially unique*
- *New knowledge creation is not necessarily a net addition to the stock of knowledge, and obsolescence of units of the knowledge stock is not documented*

From the above statement we can formulate that traditional economic indicators are not appropriate for measuring the performance in a knowledge economy. To better understand the workings of the knowledge economy, new economic concepts and measurements are required which track phenomena beyond conventional market transactions. OECD (1996) suggested five perspectives to measure the knowledge economy, which are widely applied by many researches.

- Knowledge input: the indicators of knowledge input are shown on following table, includes R&D, innovation or human resources.

OECD manuals on knowledge indicators

Type of data	Title
R&D	Proposed Standard Practice for Surveys of Research and Experimental Development (*Frascati Manual* 1993)
R&D	Main Definitions and Conventions for the Measurement of Research and Experimental Development (R&D) (A Summary of the *Frascati Manual* 1993)
Technology balance of payments	Proposed Standard Method of Compiling and Interpreting Technology Balance of Payments Data (*TBP Manual* 1990)
Innovation	OECD Proposed Guidelines for Collecting and Interpreting Technological Innovation Data (*Oslo Manual* 1992)
Patents	Using Patent Data as Science and Technology Indicators (*Patent Manual* 1994)
Human resources	The Measurement of Human Resources Devoted to S&T (*Canberra Manual* 1995)

Source: THE KNOWLEDGE-BASED ECONOMY，OECD, 1996

- Knowledge stocks and flows: e.g. the embodied technology or R&D, etc
- Knowledge outputs: e.g. GDP, unemployment rate, productivity, etc
- knowledge networks: e.g. the distribution of knowledge among universities or firms, etc

- Knowledge and learning: e.g. human capital indicators, knowledge distribution power, institutional capabilities to transfer knowledge, etc.

Arundel (2009) made further research on knowledge based economy indicators. He claimed that there are four kinds of knowledge economy inputs, which are production and diffusion of information and communication technology (ICT), human resources, skills and creativity, Knowledge production & diffusion and Innovation, entrepreneurship and creative destruction. There are also two knowledge economy output indicators like economic performance and quality of life indicators. He interviewed 40 policy experts and decision makers across Europe with questions regarding the existing knowledge economy indicators and if they can sufficiently measure policy effects. The conclusion was that there were research 'gaps' in the ability of available indicators to meet both current and emerging policy needs. Policy analyst and policy makers need better indicators to measure the economic impact of innovation in quantitative terms. These types of indicators include human resources of specific industries (e.g. university researchers, high-tech industries); measurement of entrepreneurship and venture capital or measurement of innovation flows, etc. The research identified some missing indicators and also refined the methodology for constructing robust and credible composite indices.

2.5 Researches of investment in knowledge

By review the economic theories and knowledge measuring indicators, it is obvious that a large sum of investments are necessary to promote the development of the knowledge economy and increase regional knowledge competitiveness. We will further discuss more literatures about knowledge investments.

2.5.1 Human capital investments

Nelson and Phelps (1966) discussed the relationship of investment in human, technology diffusion and economic growth. Through conceptual models they concluded that the greater rate of return to education, the more technology progresses in the economy. They suggested society should build more human capital relative to tangible capital to promote the economy. However, the limitation of the research is that the conclusion was purely based on theoretical models without any support of real data statistics.

Blundell *et al.* (1999) tried to measure the human capital investment from non-technical point of view by the returns to education and training for the individual, the firm and the economy. From individual perspective, positive economic returns to education have been found various returns by the type and

level of qualification. For example, women in UK undertaking economics, accountancy or law subjects have significantly higher returns to their higher education than women undertaking other subjects. Undertaking a training also shown significant returns of the individual and the return were found to vary among the different sources and types of training courses. They elaborate that various types of human capital investment are complementary: early achievement and qualifications can determine future educational attainment; individuals with higher educational attainment will undertake more trainings on the job. From economy perspective, they emphasized the importance of human capital for national productivity growth is provided by growth regressions, where the education measures have been found to be significant explanatory variables. The research from Blundell *et al*. (1999) provided many valuable suggestions and indications for further knowledge investment studies. However, the limitation of the paper is the amount of concrete empirical work, caused by methodological difficulties and the lack of suitable data.

2.5.2 Investment in R&D and innovation

Hwang and Gerami (2006) made analysis of investment in knowledge inside OECD countries with more real data. He defined and calculated investment in knowledge as the sum of expenditure on R&D, on total innovation (public and private) and on software. They emphasized that measuring of investment in knowledge is characteristically complicated and lack of data. By evaluating output of different financial investment in knowledge of OECD countries during 1994-2002, they find the United States and Japan are moving more rapidly towards a knowledge-based economy than the EU. Since 1994, their investments in knowledge to GDP ratios have grown at a higher rate than that of the EU. In 2002, the United States invested 6.6% of GDP in knowledge, Japan 5.0% and European Union only an average of 3.8%. The variations in investments among EU countries differs; Scandinavian countries like Sweden and Finland invested more than 6%, while Portugal and Greece invested less than 2% of GDP in knowledge.

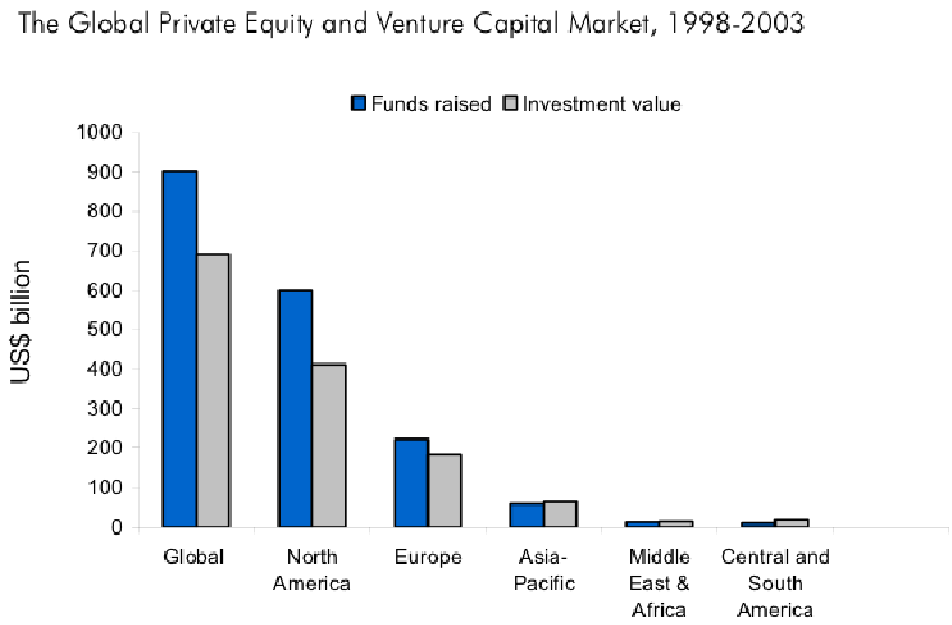
They suggested that when we consider investment, it should include ICT investment, R&D and higher education as different forms of "knowledge". The production of knowledge should respond to incentives. For instance, if there are high returns on ICT investment, R&D or innovation, the investment should also be increased. They also examined the influence of investment in knowledge in multifactor productivity growth and numbers of patent. The conclusion is that investment in knowledge can promote productivity growth.

The research from Hwang and Gerami provided us a good review of financial investment in the knowledge economy in global countries. However, most of their analysis is by data description; calculate increase rate or return on investment ratios. It is difficult for us to distinguish which financial investments have significant influence on the knowledge economy development.

2.5.3 The development of Private Equity investment

Another important investment in knowledge is from private equity sectors. We believe the entry of new knowledge-based entrepreneurs firms can contribute the regional economy prosperity. However, small start-up companies are facing difficulties of getting financed by banks because of their high uncertainty, information asymmetry and agency costs (Beck *et al.*, 2005). Private equity investors are specialized to overcome these problems. They provide support by start-up entrepreneurs staged financing, private contracting and active monitoring (Kaplan and Stromberg, 2001). Therefore, early stage and technology companies normally get more financial support from private equity sectors than banks.

In global countries, private equity investments are more common in the US than European and other countries. According to Gompers and Lerner (1999) venture funds picked up in the late 1970s and the early 1980s in the US. The US department of labour issued a clarification of the rule stating that diversification is an inalienable part of prudential investment behaviour. Therefore, in the next following eight years, the amount invested in new venture funds greatly increased from $481 million to nearly $5billion, almost half of them are pension fund. However, the PE industry in Europe has been developing in a slower rate. The evidence can be found through the global venture capital report from PricewaterhouseCoopers (2003, 2004).



Sources: PricewaterhouseCoopers (2003), PricewaterhouseCoopers (2004)

From the above graph, North America has the largest venture capital market. In 2001, it has almost 2/3 of the world total venture capital, which was five times larger than Western Europe. During the period 1998-2004 in global, venture capital investment has increased significantly. Apart from North America and Europe, the Asian market also has experience growth in funds and investments. PWC analyzed that the global venture capital development was driven by the Chinese economy, Japan's recovery and the India's software industry and resurgent growth in the Asian-Pacific countries such as Indonesia and Malaysia.

In response, the European Commission (2002) undertook explicit regulatory intervention to prohibit national legislation from preventing insurance companies and pension fund from investing in risk capital market. According to the report from EVCA (2006), at the end of 2006, many EU countries did not adopt any of the EC policies because of coordination problems and different degree of deregulation.

2.6 Research challenges on the influence of financial investments in knowledge competitiveness

From the previous literature reviews and empirical researches, we found many challenges when analyzing the role of financial investment in knowledge competitiveness.

First, there is no standard model to measure the knowledge economy and knowledge competitiveness.

From the literatures, it is clear that a large number of researches tried to analyze the knowledge economy from certain perspectives. But very little researches describe the knowledge economy in a comprehensive overview with consideration of all relevant elements. Therefore, we may have some findings that indicate certain relations in the knowledge economy from input to output, such as the positive relation between educational attainment and economic growth (Garba, 2002); the positive effects of human capital on the supply of entrepreneurial activity (Odekunle, 2001) or promotion on education will improve job status, job security and other benefits (Ayeni, 2003). But very little researches analyze the effects of input and output of the knowledge economy on regional knowledge competitiveness. For instance, what are the relations of financial investments with other knowledge input? Is the region with more financial investment become more competitive in a knowledge economy? We think in order to better answer these questions, it is important to design a research graph on the knowledge economy model before defining the specific research focus.

Second, there is not much research that discusses the influence of financial investments on knowledge competitiveness

Through literature review, we find knowledge investment researches mainly discussed the relation of public or private investments on human capital, R&D or economic growth. However, very few researches analyze how financial investments affect knowledge competitiveness and which one of them significantly promotes regional competitiveness. The previous researches explained that because of data limitation, the empirical researches are very difficult to conduct. As Arundel (2009) emphasized, there are seven data quality problems to collect the knowledge economy indicators, including accuracy, missing value, relevance, comparability, coherence, timeliness and availability. Therefore, we also will face these challenges because of the data collection difficulties on different financial investments.

Third, there are still some arguments on effective indicators to measure knowledge competitiveness.

When we discuss the influence of financial investments on knowledge competitiveness, we plan to test them with consideration of other elements. However, there are some arguments on how to define knowledge economy indicators. For instance, which indicator should we choose to measure regional economic performance? Since 1930s, the Gross Domestic Product (GDP) has been the standard economic indicator of many countries. GDP is a basic economic indicator and measures the level of total economic output relative the population of a country. However, GDP does not account for the social and environmental costs of production; it therefore is not a good measure of the level of over-all well being (OECD, 1996). Another indicator underlying the selection of high performing regions for

benchmarking is their relative GDP per capita, which is the indicator of the average standard of living of individual members of the population. An increase in GDP per capita represents national economic growth while a declining trend in GDP per capita indicates a sinking economy. However, GDP per capita as economic performance still has limitations. One of the problems is the inability to provide information about income distribution. Some income derived from the black market, or those which were not reported to the government were not taken into account (Madsen, 2006). Another problem is for countries with huge number of population, e.g. China and India, when we use GDP per capita to measure the wealth of the regions, these regions measures to be less wealthy than the regions in western countries. However, fast development of Asian regions does have influence on global knowledge economy structure. Therefore, the economic performance indicator should contain more economic measurement than only GDP and population; hence the introduction a new indicator "GUC[6]" later on this chapter.

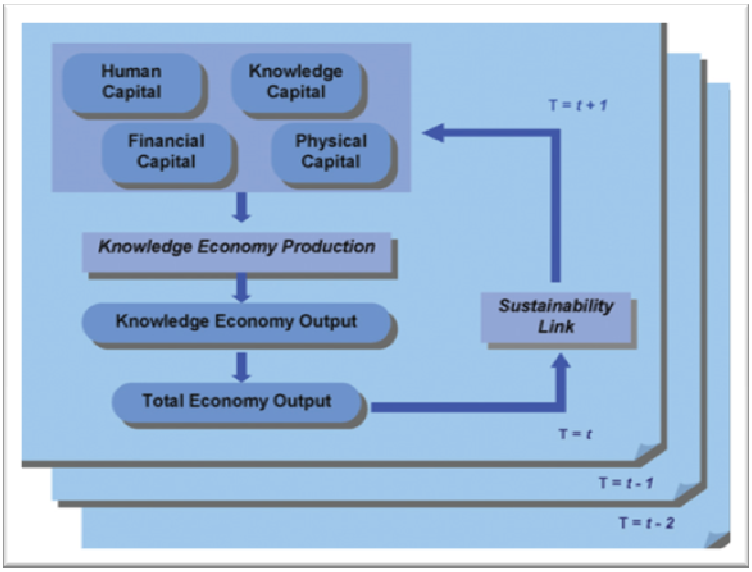
Another argument is how to define human capital indicators. Many researchers use investment in education to indicate human capital (Schultz, 1971; Psacharopoulos and Woodhall, 1997; Garba, 2002). We oppose this definition of investment in people to be of the same amount of human capital. Different from financial capital and physical capital, human capital is the stock of competences, knowledge and personality attributes embodied in the ability to perform labor so as to produce economic value. It is the attributes gained by a worker through education and experience (Arthur and Sheffrin, 2003). Thus, we argue that the numbers of skilled labors in certain knowledge-based industries are more appropriate to describe human capital. The investment in education as well as other financial investments in R&D or innovation should be measured separately. Klingbeil (2008) introduced the concept of Highly qualified personnel (HQP), which is a term that refers to people who have achieve certain specified level of educational qualification, e.g. on-the-job training and work and life experience that have a high level of human capital. We believe these HQP's occupied in many knowledge-intensive industries, such as IT, Bio-chemical, Mechanism or Electronic. The numbers of people that work in knowledge-based industries are more appropriate indicators as human capital.

[6] Originate from Global Urban Competitiveness Index

2.7 Researches on regional knowledge economy

2.7.1 Huggins and Izushi (2007) conceptual model

As it is a challenge to precisely define the knowledge economy, a design using a comprehensive model that describes the relevant components' relationship in the knowledge economy is necessary. Huggins and Izushi (2007) discussed how to measure regional knowledge economy within a model. They advocated the conceptual model is a multi-linked cycle which represents knowledge creation and utilization as well as capacity building. The following map shows their conceptual model:



This model is the result from two economic theories: human capital theory and endogenous models of economic growth. Human capital theory recognizes skills and expertise that promote the knowledge economy development. Endogenous economic growth theory advocates the accumulation of knowledge as a main source of long-term economic growth, and acknowledges the creation of knowledge by private-sector firms as an internal (endogenous) factor.

It is clear that there are four types of capital input in this model. According to Huggin and Izushi, human capital indicates the capacity of individuals in a region to create, understand and utilize the knowledge to create commercial values. It can be measured by managers, professionals and high-end technical workers as they are increasingly recognized as a source of innovation and a driver to stimulate investment and growth. The Knowledge capital refers to regions' resources or capacity to create new ideas. Financial Capital emphasizes the financial resources mobilized into new area of growth and knowledge through private equity investment. The physical capital refers to capital in the traditional

term of economic, e.g. the land, plants, equipment or buildings. According to the model, the four capital inputs lead to economy production, the production will become regional knowledge economy output, which will contribute the total economic output.

The model also includes a sustainably linkage between output to input. Huggin and Izushi defined this sustainability link as the education that individual are undertaking. Although strong regions are able to attract talent from other regions, in the long-term reinvestment in education will help to ensure regions' knowledge economy maintain sufficient flows of educated labor.

2.7.2 Arguments on the model from Huggins and Izushi (2007)

Huggin and Izushi's model contributes a good concept to map the regional knowledge economy. However, there are some critical arguments on their approach.

First, the financial capital in Huggin and Izushi's model is defined too narrow as it does not include other relevant financial investments.

From Huggin and Izushi's theory, they defined private Euqity (PE) as the only financial investment, which can enable a region to maximise the return on its R&D and innovation. However, PE is one kind of financial investments in the knowledge economy and the development on PE is not equal worldwide. The public and private investments (or public and private partnerships "PPP") still play important roles to support R&D and innovation, education and training or other economic activities in world regions. Therefore, we cannot ignore the government investments and business firms' investments on regional knowledge economy.

Second, "Knowledge capital" as one of the inputs of the knowledge economy is overlapping three other capitals.

As Huggin and Izushi (2007) claimed, the knowledge capital is the raw material of the knowledge economy, referring to regions' capacity for creating ideas. When we discuss about the regions' capacity, we think physical capital is a part of knowledge capital as the capacity and resource are relevant with regional physical resource. Huggin and Izushi's also claim that new ideas can be created by individuals, universities or other organizations. Thus, the indicators they choose to measure the knowledge capital include the numbers of registered patents, business or public investment in new product development. However, from these indicators we can tell human capital from universities or organizations and financial capital investment in knowledge are parts of knowledge capital. Actually, knowledge capital is a concept that is based on the mixture of human, financial and physical capital.

Thus, we argue it is not necessary to define four separate capital input of knowledge but use human capital, financial capital and physical capital instead.

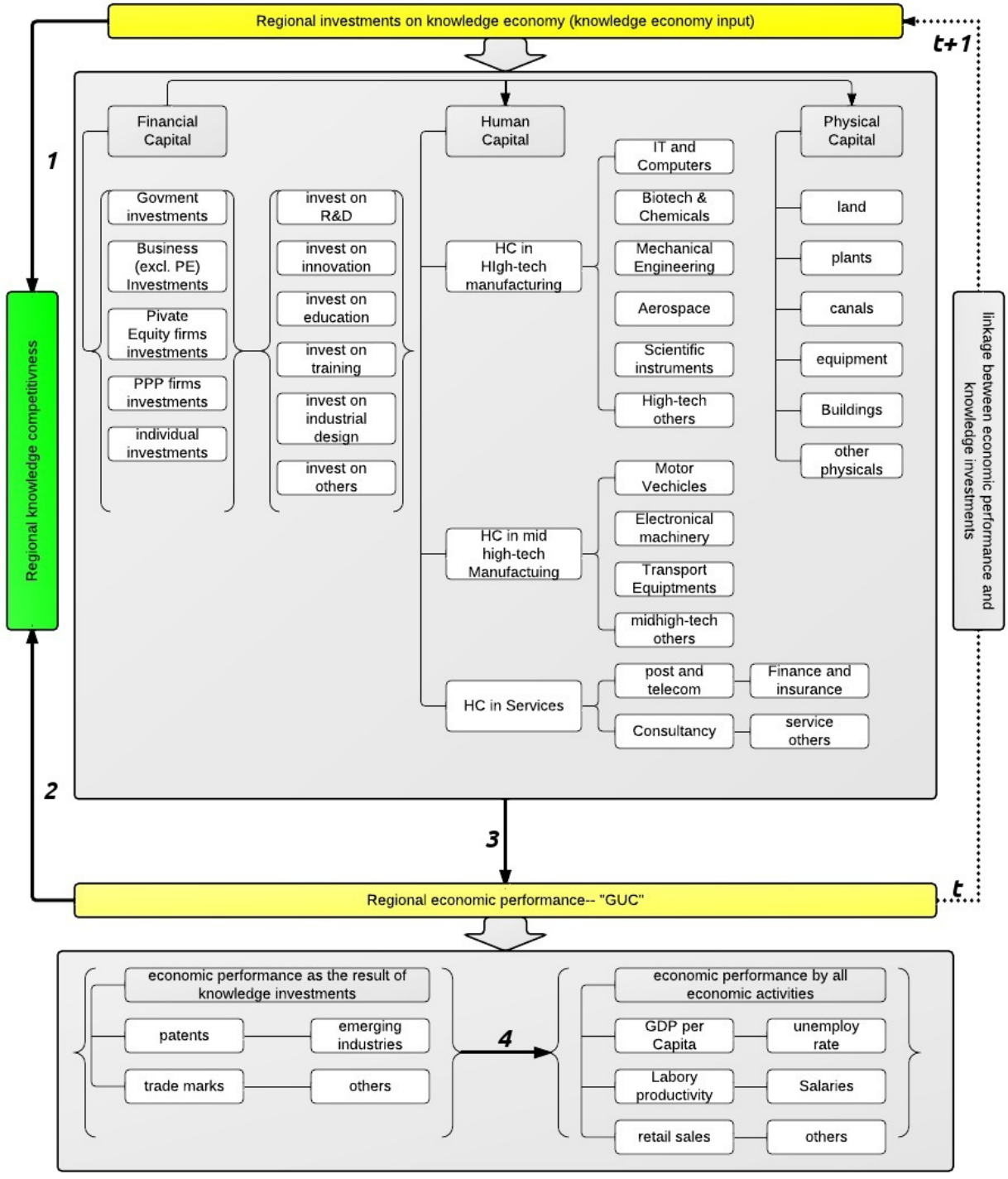
Third, the definition of "sustainability linkage" is not appropriate.

Huggin and Izushi advocated that knowledge economy is a multi-linked cycle model and there is a linkage between output to input. Education investment could be the element which supports this linkage, e.g. the public expenditure on education, internet and broadband access of citizens. However, the concept of sustainable development according to Brundtland (1987) is the development that meets the needs of the present without compromising the needs of future generations. HMSO (1994) claimed that most societies want to achieve economic development to secure higher standards of living, now and for future generations. They also seek to protect and enhance their environment, now and for their children. Sustainable development tries to reconcile these two objectives. Giddings *et al.* (2002) advocates that sustainable development is a multi-layered and multi-faced approach of three sectors: economy, society and environment. So when we consider the sustainable linkage for output to input, apart from education spending on human capital or provide financial capital on regional development, it is also important to make effort on negative externalities caused by economic development, such as CO2 emissions and global warming. For instance, regions can invest in renewable energy or recycling technologies in order to develop in a sustainable way. Therefore, we argue that education is too narrow to be defined as linkage between output and input of knowledge economy.

2.8 Regional knowledge competitiveness research model

2.8.1 Model description

Based on Huggin & Izushi's model and previous literatures, we design a "regional knowledge economy competitiveness cyclical scheme" as shown in the following graph.



The "regional knowledge economy competitiveness scheme" shows the regional knowledge competitiveness is influenced by two factors. One is regional investment in knowledge and another one is regions economic performance. Arrow 1 shows the relationship of the knowledge economy input with regional knowledge competitiveness; regions with more investment in knowledge can become more competitive in the knowledge economy. Arrow 2 indicates the relationship of knowledge output with regional knowledge competitiveness. We think regions with better economic performance will be more competitive in the knowledge economy. The two yellow bars are two main factors of regional knowledge competitiveness. The two grey blocks of each contains the influential factors.

There are three main capitals belonging to regional input of the knowledge economy, which are financial capital, human capital and physical capital; the financial capital actually can promote another two capitals' development. In financial capital, normally five main financial investment resources exist, e.g. government investment, business firms' investments (excluding the private equity firms) or private equity investment. The investments can be use on R&D, innovation, training or education. We define human capital by number of skilled labors in the high-technologies and medium high-tech industries. The physical capital includes lands, plants or equipments of regions.

All of the investments on knowledge will influence regional economic performance as arrow 3 indicates. In the economic performance block, part of the economic performance is knowledge output, which is the result of direct knowledge input, such as new registered patents, trademarks or emerging industries. The knowledge output with other economic activities together will influence total regional economic performance, as displayed using arrow 4. It is worth to mention that knowledge output in time "t" will affect knowledge input in time "t+1". Thus, it is interesting to have time series data on input and output elements to analyze their influence on knowledge competitiveness. However, due to lack of data we will only use cross-section data in our research.

2.8.2 Indicators in the research model

In order to support our research scheme, we make further researches regarding the knowledge economy components as we discussed in our model. Many research papers provide empirical findings and some of them gave research recommendations or conceptual ideas on the knowledge economy. See below for a mapping of previous research literatures:

Academic literatures on the knowledge economy indicators	
Researches	**Scholars**
Financial investment and the knowledge economy:	
• Invest in training appears to offer further benefits in terms of higher employment stability • Investment in education is important for national productivity growth	*Richard Blundell, Lorraine Dearden, Costas Meghir and Barbara Sianesi (1999)
• Investment in knowledge has relationship with multifactor productivity and patent numbers • Positive annual growth of knowledge investment has an impact on other knowledge economy's factors	*JunSeok Hwang, and Mohsen Gerami (2006), OECD (2005)
• A reliable supply of reasonably-priced finance is important for entrepreneurial activity and innovation • The supply of VC has been negatively affected by the credit crunch	*Martin Fransman (2008)
Human Capital and knowledge-based industries:	
• Human capital influence regional development	*Ullman (1958)
• Technology and Employment in the global knowledge Economy	*P. Sheehan, and G. Tegart (1998)
• Localize human capital and information in a cluster can result in knowledge spillovers	*Porter (1990)
• Knowledge jobs and knowledge workers	*Ian Brinkley (2006)
• Human Capital investment build the "Knowledge economy"	*T. J. Alexander(1997), OECD (1996)
• Human capital is responsible for labour productivity	*Robert (1991)
• Positive relation between educational attainment and economic growth	*Garba (2002)
• Human capital has positive effects on the supply of entrepreneurial activity and technological innovation	*Odekunle (2001)
• Knowledge intensive industries and The knowledge economy indicators	*OECD Science (2001), Iain McNicoll, Ursula Kelly, Richard Marsh
• Correlation human capital and regional economic growth	*Glaeser (2000)
Physical Capital and the knowledge economy	
• Discussion on human capital and physical capital	*Ann Markusen (2006)
• Higher worker skill levels enable higher returns to be extracted from investment in physical capital	*Enrique López-Bazo (2002)
Economic performance and the knowledge economy	
• knowledge is a main driver of productivity and economic growth	*Paul Romer (1986, 1990)
• knowledge creation and distribution are primary drivers in the process of economic growth	* Harris (2001)
• "knowledge" is greater important on economic growth	*OECD (1996)

• Investment in Knowledge and Knowledge expenditures	*OECD (2005) * *Details of these articles are in the reference list*

Regional knowledge competitiveness

In our research scheme, the research target (dependent variable) is regional knowledge competitiveness. The indicator we use is from World Knowledge Competitiveness Index (WKCI) made by centre for international competitiveness from Cardiff School of Management in 2008[7]. The report of WKCI measures the leading global regions' knowledge economy competitiveness. The WKCI is an overall benchmark of the knowledge capacity, capability and sustainability of each region. The competitiveness of a region will depend on its ability to anticipate and successfully adapt to social and economic challenges. Regions with higher scores indicate they are more competitive in the knowledge economy. Thus, it is interesting to analyze which factors have significant influence on regional knowledge competitiveness, especially the research gap of financial capital.

Financial Capital

As we mentioned earlier, there have not been many empirical researches covering the influence factor of different financial investments on knowledge competitiveness. One of the reasons is that financial investment data is hard to obtain as they are not publicly dispersed. Another reason is research topics of human capital, innovation and economic growth which are based on the classic knowledge economy theories are more popular for scholars. In order to be creative in our research, we will fill research gap to test which financial investment significantly influence regional knowledge competitiveness, and what implications it will mean for policy makers.

As our research scheme indicates, there are many financial capital resources, such as government investments, business firms' investments or private equity firms' investments. OECD (2005) discussed Investment in Knowledge (IK) in the knowledge economy conference in Paris. They stressed that knowledge expenditures directed towards activities with the aim of enhancing existing knowledge or acquiring new knowledge or diffusing knowledge. The knowledge investments are used for R&D, education, training, innovation and industrial design expenditure. We will discuss three main financial resources in this thesis, which are public financial investments, private financial investments (exclude PE firm) and private equity investments.

[7]Many scholars worldwide participated in this research, Dr. Huggin from University of Wales Institute, Dr. Izushi from Aston University and Dr. Luo from Shanghai Jiao Tong University.

In the public financial investments, governments normally make investment to support education, R&D and innovation. We think for a region, the more investments are put on the knowledge economy the more competitiveness it will be. In most countries in the world, government makes investments on residents' lower education from primary schools to high schools and some that invest in higher education, such as universities and research institutions. Olaniyan and Okemakinde (2008) in their empirical research found that investment in education has positive correlation with economic growth and regional development. Furthermore, governments also make investment in knowledge-intensive industries in order to support innovation and R&D. For instance, San Jose gains large support from government because of the IT cluster Silicon Valley which has greatly contributed the IT industry development and economic growth of the U.S.

Apart from government support, private investment in the knowledge economy is also vital. In order to increase competitive advantages, business firms put a large amount of funds on their R&D and innovation. For example, in 2010, Google spent approximately $476 million per quarter on R&D, specifically on their cloud infrastructure in order to be more competitive (Data Centre Knowledge, 2010); the amount is doubled compared with the previous quarterly spending. The investments from companies, especially from Multi-National Enterprise (MNEs) not only increase the firms' competitiveness, but also lead to regional knowledge upgrade and strengthen regional competitiveness.

Another resource of financing is private equity. According to European Commissions (2006), private equity is the provision of capital and management expertise to companies in order to create value and subsequently, with a clear view to an exit, generate capital gains after a medium to long holding period. Private Equity deals with the investments which are available for public participation. It includes Venture Capital, hedge funds, angel investor, LBO (leverage buyout funds) or Risk Capital. The definitions of all of these terms are getting more blurry. For instance, angel investors now compete with VCs on small, very early stage deals while some of the buyout and hedge funds are doing larger Venture Capital type deals. As private equity is used as the generic term to encompass all the sub-sets of financing stages, in our research, we will use private equity as general term to represent all sub-sets.

Human Capital indicators

In our research, human capital is measured by the numbers of employees per 1000 inhabitants of a region in the knowledge-based industries. OECD (2001) developed a set of indicators of 'high' and 'medium' technology manufacturing industries based on their relative R&D expenditures (or 'R&D

intensity'). This classification of 'high' and 'medium' technology manufacturing industries has tended to be used by the OECD and others as the cornerstone of definitions of knowledge-based industries.

OECD Classifications of Technology and Knowledge Intensive Industries

Manufacturing	SIC 1992	Services	SIC 1992
High Tech			
Pharmaceuticals	24.4	Post and Telecommunications	64.0
Office machinery and computers	30.0	Finance and Insurance	65.0,66.0,67.0
Aerospace	35.3	Business Activities (not including real estate)	71.0-74.0
Electronics-communications	32.0		
Scientific Instruments	33.0		
Medium High Tech			
Motor Vehicles	34.0		
Electrical Machinery	31.0		
Chemicals	24.0 (excluding 24.4)		
Other Transport Equipment	35.2, 35.4, 35.5		
Non-Electrical Machinery	29.0		

OECD Science (2001), Technology and Industry Scoreboard: Towards a Knowledge-Based Economy

The knowledge-based industries defined by OECD include high technology industries such as pharmaceuticals, aerospace or electronics-communications; and some medium high technology industries, e.g. motor vehicles, electrical machinery or chemicals. Services industries include post and telecommunication, finance or business activities. The indicators of human capital are the skilled labors in these industries.

Physical Capital indicators

In economics, physical capital refers to any manufactured asset that is applied in production, such as machinery, buildings or equipments. In economic theory, physical capital is one of the three primary factors of production. The two others are natural resources (including land), and the stock of competences embodied in the labour force. "Physical" is used to distinguish physical capital from human capital and financial capital (Samuelson and Nordhaus, 2004). Physical capital may also refer to

fixed capital or fixed assets. In our research scheme, the indicators of physical capital include land, plants, building, canals, equipments, etc.

Economic performance indicator

We use a new economic performance indicator "GUC" in this thesis. The full name of "GUC" is Global Urban Competitiveness Index, which is named by a research group with scholars from different countries in the world[8]. The research was led by Professor Pengfei Ni (Chinese Academy of Social Sciences) and Professor Peter Karl Kresl (Bucknell University, USA). The research sample consists of five hundred cities in 130 countries. The "GUC" contains collected data on 6 indices, which include scale of "green economic GDP", "green economic GDP per capita", "green economic GDP per square kilometer", "economic growth rate", "number of internationally recognized patent applications" and "multinational corporation index from the perspective of output". Each of these indicators has been put by different weight. The GUC index aims to give insights into the development and competitiveness of cities around the world. It is a new indicator which is published recently and has not been applied in any economic researches yet. In our research, we will try to use GUC as economic performance indicator in our analysis.

European Council (2000) designed the "Lisbon Agenda", which describes a long term development plan to increase European competitiveness. However, the strategy was evaluated to be a failure; the Lisbon Agenda has been revised twice. In order to increase European competitiveness and economic sustainable growth, European Commission (March, 2010) further revised the proposal and naming it the Europe 2020 Strategy. It is still too early to conclude if the new Strategy will be sufficient and effective to increase European competitiveness. But the researches on the influence of financial investments on knowledge competitiveness may provide helpful indications to policy makers.

Therefore, our research questions are:

Which financial investments have significant influence on the world regional knowledge competitiveness? And what are the implications to European policy makers?

[8] Pengfei Ni and Peter Karl Kresl (2010) published the book <<*The Global Urban Competitiveness Report 2010*>> to elaborate how GUC has been calculated with sophisticated methodology.

Chapter 3. Methodology

In this Chapter, we will introduce the methodology of our research, the data collection of dependent and independent variables, the definition of our hypotheses. In order to make out test step more clearly, a data test roadmap will be shown at the end of this chapter.

3.1 Data collection

Research data will be collected from many different resources. The dependent variable is the "World knowledge competitiveness index" (WKCI), which is used to make ranks of the knowledge competitiveness of global regions. The highest region is San Jose in US with the score 248.3 and the lowest region is Bangalore in India with the score 5.0. More description of WKCI will be discussed in Chapter 4.

We summarize the data source of independent variables into a table. In our research, the financial investment was measured by US dollars per capita of 2007. The human capital data was also collected from many resources. Human capital indicators are measured by the numbers of employment of knowledge-intensive industries per 1000 inhabitants in global regions around 2007.

In terms of the economic performance indicator, we try to compare GDP per capita and another data "GUC" (Global Urban Competitiveness Index) to test which one is more suitable to use as economic performance indicator. As we mentioned in the literature, the GUC is a comprehensive index that consists of different economic performance indicators, such as green economic GDP, green economic GDP per capita, economic growth rate, etc.

The index of "GUC" 2007 includes 500 global cities, ranking from high to low. The Top ranking city is New York, scores 1, and last ranking city is Harare in Zimbabwe scores 0. The highest Dutch city is Amsterdam ranks 35 with the score of 0.51, and lowest Dutch city is Utrecht ranks 166 with the score of 0.32. As the "GUC" is based on cities and other data source matches by regions, we placed the cities belonging to the regions together and calculated their average scores to represent the regional economic performance value.

Table of Data source:

Financial Capital	
Bureau of Economic Analysis	http://www.bea.doc.gov/
Canada's Venture Capital Association	http://www.cvca.ca/
Census of India	http://www.censusindia.net/
Department of Education	http://www.ed.gov/
Finish Venture Capital Association	http://www.fvca.fi/
Nation Science Foundation	http://www.nsf.gov/
National Center for Education Statistics	http://www.nces.ed.gov/
Statistics Canada	http://www.statcan.ca
Statistics Norway	http://www.ssb.no/
Shanghai Statistics	http://www.stats-sh.gov.cn/
US Bureau of Economic Analysis	http://www.census.gov/
OECD	http://www.oecd.org/std/ppp/
World Bank	http://www.worldbank.org/data/
Human Capital	
Australian Bureau of Statistics	http://www.abs.gov.au
Bureau of Labour Statistics	http://www.stats.bls.gov/
Bureau of Economic Analysis	http://www.bea.doc.gov/
Eurostat	http://europa.eu.it/comm/eurostat/
UK Office for National Statistics	http://www.statistics.gov.uk/
Statistics Canada	http://www.statcan.ca
Statistics Norway	http://www.ssb.no/
The Statistics Bureau of Japan	http://www.stat.go.jp
Indian Ministry of Statistics and Programme	http://mospi.nic.in/
OECD	http://www.oecd.org/std/ppp/
World Bank	http://www.worldbank.org/data/
Economic performance	
Australian Bureau of Statistics	http://www.abs.gov.au
Statistics Singapore	http://www.singstat.gov.sg/
Statistics Canada	http://www.statcan.ca

Statistics Norway	http://www.ssb.no/
Hong Kong Census and Statistics Department	http://www.info.gov.hk/censtatd/
OECD	http://www.oecd.org/std/ppp/
World Bank	http://www.worldbank.org/data/
Global Urban Competitiveness Index	http://www.docstoc.com/docs/33167238/Global-Urban-Competitiveness-Index-RankingsDOC

3.2 Hypotheses

There are 9 hypotheses in our research. Our research question is to test which financial investments significantly influence the regional knowledge competitiveness, and if the significance will be different with consideration of control variables.

3.2.1 Dependent variables

In our research, we will use index figures from Word Regional Knowledge Competitiveness (WKCI) as the dependent variable.

3.2.2 Independent variables and hypotheses

- **Financial investments**

We assume that financial investments have positive influence on the knowledge competitiveness. The regions with large financial investments in knowledge will be more competitive in the knowledge economy. There are five financial investments on knowledge which are government investment in R&D and innovation, government investment in lower (primary and secondary) and higher (university) education, business firms' investments in R&D and innovation and private equity investment in knowledge-based industries. We believe the more financial investments in regions' knowledge economy, the more competitive the regions in the knowledge economy will become. In the five financial capital categories, three of them are funded by government with the aim to promote lower education, higher education and R&D and innovation. Thus, we make the hypotheses as:

H1: Government investment in R&D and innovation can positively influence regional competitiveness in the knowledge economy

H2: Government investment in lower education can positively influence regional competitiveness in the knowledge economy

H3: Government investment in higher education can positively influence regional competitiveness in the knowledge economy

Apart from the public financing, there are also another two types of knowledge investments, which are business firms' investments and Private Equity (or Venture Capital) investment. Business firms' investments in the knowledge economy mainly focus on R&D and new product development. We believe the investments from organizations can positively influence regional knowledge economy development. For instance, investments from Google or Facebook on IT industries can promote the knowledge competitiveness in region of San Jose. Furthermore, a large number of venture capital can support more innovation and R&D while public financing cannot. We assume private equity investment in knowledge-based industries can significantly influence regional competitiveness in the knowledge economy. Therefore, the hypotheses of the two types of financial investments are:

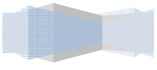
H4: Business firms' investments in R&D and innovation can positively influence regional knowledge competitiveness

H5: Private equity investment in knowledge-based industries can positively influence regional knowledge competitiveness

- **Control variable 1. Human capital**

As we mentioned in chapter 2, a large number of academic researches demonstrated that human capital plays a crucial role in the knowledge economy. Thus, we will add human capital as control variables into our research. However, there are some arguments on how to measure human capital. In order to make the definition of human capital distinguish from investment in education, we define human capital as the number of skilled labours in the knowledge based industries. Because of the limited amount of available data, four knowledge based industries have been collected. The qualified employees (per 1000 inhabitants) in each knowledge-intensive industry are used as human capital indicators. The four typical knowledge-intensive industries are IT and computer manufacturing, bio-chemicals, mechanical engineering and electronic-machinery industries. We think the significant effects of financial investments on WKCI will not be influenced by adding human capital indicators. Thus, we make hypothesis as:

H6. Adding the control variable of human capital will not affect the significance of financial investments influencing regional knowledge competitiveness.



- **Control variable 2. Regional economic performance**

Apart from the importance of financial investments and human capital, we believe that the economic performance of the regions will significantly influence their knowledge competitiveness. As we discussed in the previous literature, "GUC" is a very comprehensive indicator. It would be interesting to compare GDP per capita with GUC to see which one can better explain the relations of regional knowledge competitiveness and regional economic performance. We assume regions with better economic performance can have stronger knowledge competitiveness. The common understanding of this assumption is that regions with more wealth will be more competitive in the knowledge economy. Thus, our hypothesis is:

H7: Adding the control variable of regional economic performance indicator will not affect the significance of financial investments influencing regional knowledge competitiveness.

- **Control variable 3. Location: European, North American and Asian pacific regions**

We believe regions in North America are more competitive in the knowledge economy than European and Asian-Pacific regions. As dummy variables only consist of "0" and "1", we think to add location control variables will not influence the significance of financial investments on WKCI.

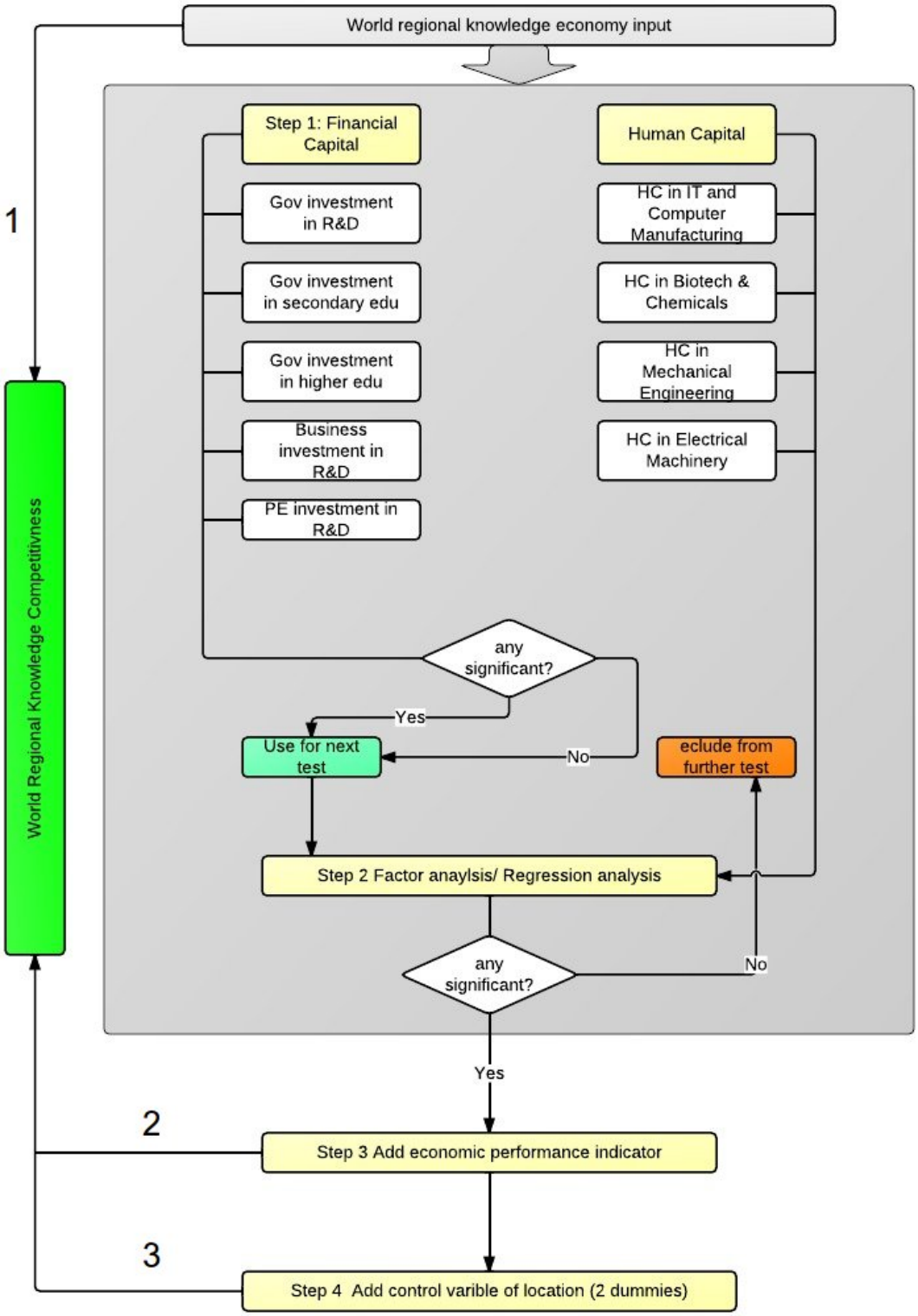
H8: Adding the control variable of location will not affect the significance of financial investments influencing regional knowledge competitiveness.

H9: Regions from North America are more competitive in the knowledge economy than regions from Europe and Asia-Pacific.

3.3 Research method

In order to have a comprehensive understanding of how financial investments influence regional knowledge competitiveness, we make a diagram to illustrate our research approaches.

Data analysis roadmap:



The above graph shows the test steps, arrow 1 from knowledge input to knowledge competitiveness means the relation between input elements with dependent variable. In step 1, we will test the relation of five financial capital indicators with WKCI. In order to further test if control variables have any influence on the significance of financial capital in WKCI, we will not exclude the insignificant financial indicators in early steps but keep the insignificant financial variables to the last step. In step 2, four human capital indicators will be added into our research. We will make correlation analysis to compare GDP per capita and GUC to test which one is more suitable to put into our research model. After selecting the appropriate economic performance indicator, we will make factor analysis and regression analysis. The insignificant human capital indicators in step 2 will be excluded from further test steps.

In step 3, we will add control variable of economic performance indicator into our research. Arrow 2 indicates the relationship of economic performance with knowledge competitiveness. Our aim is to exam if the control variable from output has any influence on the (in) significance of financial variables.

In step 4, the last control variable will be added into our research model. In order to test if regions from North American, European and Asian have any significant difference on knowledge competitiveness, we will add two dummy variables (representing the three regions respectively) into the regression. It is also interesting to test if dummy variables have any influence on the (in) significance financial variables. Arrow 3 shows the relationship of all independent variables with dependent variable.

When we do the data analysis, we try to exclude the insignificant variables (GUC) in step 3 and then continue to make analysis to step 4. However, we find as part of our research graph, the economic performance indicator is an important component that has certain influence on the financial variables' significance. Therefore, eventually we did not exclude GUC from our regression. More details of data analysis approach of this research will be discussed in next chapter.

3.4 Research tool

In order to test the relationship between independent variables with knowledge competitiveness, we will use the statistics program SPSS 19.0. We will put key analysis results in the data analysis part to discuss our findings; other relevant SPSS output will be attached as supplement in the appendix. In chapter 4, we will make data analysis to test our hypotheses.

Chapter 4. Data analysis

In this chapter, we first discuss data transformation and data description. After that, we will make four steps to test our hypotheses.

4.1 Data transformation

The dependent variable is from World Knowledge Competitiveness Index (WKCI). In the independent variables, we have financial investments, measured by US dollar per capita; human capital indicators measured by the numbers of skilled labours per 1000 inhabitant of a region; GDP per capital measured by the US dollar per capita. In order to make the data we collected to be more comparable, we make a data transformation on independent variables with exception of "GUC". As "GUC" is an index, all figures are in ratio format (between 0 and 1), therefore in our research, we use the original figures of "GUC".

The equation table explain our research model and the meaning of coefficient after data transformation.

*In the original regression, the equation is:

$Y = a + bX$

Meaning: A unit increase in X is associated with an average of b units increase in Y.

After data transformation by natural logarithm, the equation is:

$Y = a + bLn(X)$

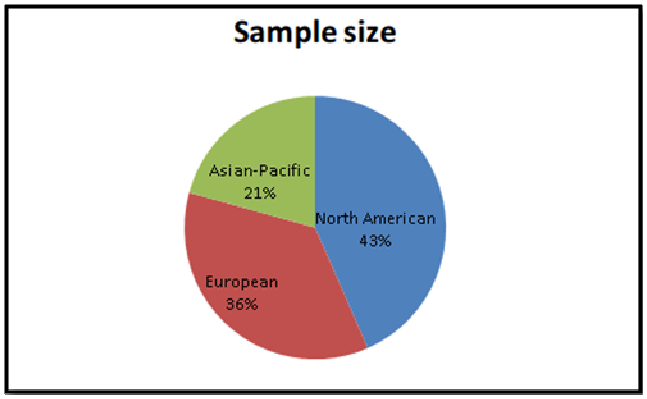
Meaning: A 1% increase in X is associated with an average b/100 units increase in Y.

**Wikipedia statistics/ data transformation*

4.2 Data description

4.2.1 Sample size

From the 145 global regions, 63 regions are from North America, 52 regions from Europe and 30 regions are from Asia-Pacific. The pie chart below shows the sample size and the ratio of the three regions.



From the sample size pie chart, the ratio of North American regions 43%, European regions 36% and Asian-Pacific results to 21%. The data we collected are based on the available data of each region and of each dependent variable. We found the U.S. has more transparent information sharing resources, thus more data was available than other world regions. Data collection in European regions is becoming a bit difficult. Data in Asian countries is only available in some developed cities; Middle East data is most hard to collect.

4.2.2 Dependent variable

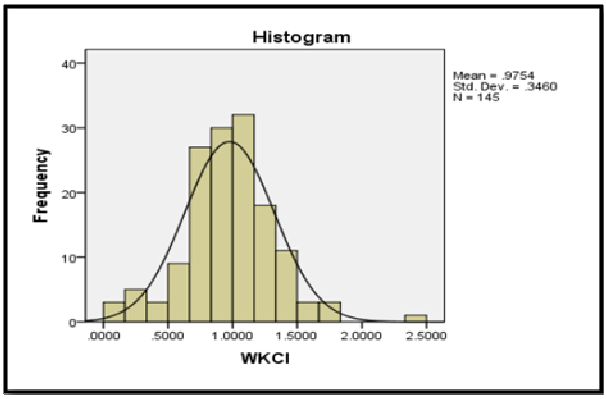
In order to interpret the coefficients in our regression easier, we use the original World Knowledge Competitiveness Index (WKCI) and divide it by 100. As WKCI is an index data, dividing it by 100 will not change the relative difference between variables. Also, the relationships between independent variables with dependent variable will not be influenced.

Statistics

WKCI

N	Valid	145
	Missing	0
Mean		.975386
Std. Deviation		.3459910
Minimum		.0498
Maximum		2.4827

The above statistic table shows us the data description of WKCI. The maximum figure is 2.4827 and the minimum is 0.0498. See below for a graph describing the data distribution of dependent variable.



The histogram illustrates that the dependent variable is not perfect but close to normal distribution. The graph shows most of WKCI indicators distribution is between 0.5 and 1.5 while few of them locate on two sides of the tail.

4.2.3 Independent variables

As mentioned before, there are many independent variables with different measurement units. Making a data transformation is needed before analysis. We make nature logarithm transformation on the independent variables, the result is shown below.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Gov_RD	145	-.6400	7.3400	4.637379	1.2434060
Gov_Lowedu	145	4.4600	7.8200	6.854759	.6074458
Gov_Highedu	145	3.2400	6.9000	5.764621	.7717576
Business_RD	145	1.5400	7.4200	5.934276	1.0941878
PE	143	-.2000	7.2200	3.834755	1.3712043
HC_IT	139	-1.0100	4.6400	1.497554	1.1021362
HC_Bio	143	-.4000	3.6500	1.789650	.8355410
HC_Mech	143	.0400	4.6900	2.942308	.8909543
HC_Elec	142	-.7900	3.5900	1.923732	.9130773
GDP_pp	145	8.7300	11.0400	10.380069	.4328435
GUC	112	.1983	1.0000	.429606	.1397857
Valid N (listwise)	105				

After data transformation, the sample size of most of the variables is close to 145. The highest mean is GDP per capital (10.3) and the lowest mean is GUC (0.4). The highest standard deviation is private equity (1.37) and the lowest is GUC (0.14). From the data distribution, it is interesting to see that government investment in R&D, Business investment in R&D and private equity investment have the largest standard deviation. This could because the financial investments in knowledge are distributed unevenly globally. North American might have invested more on R&D and innovation in comparison with Europe and Asia.

4.3 Data analysis

Step1. Financial Capital with knowledge competitiveness

There are five types of financial capital indicators in our data, which are government investment in R&D and innovation (Gov_RD), government investments in lower education (Gov_lowedu), government investments in higher education (Gov_highedu), Business firms' investments in R&D and innovation (Business_RD), and private equity investment in knowledge-based industries.

Step1.1 Correlation analysis

The results of the correlations analysis on these five financial variables are displayed on following table.

Correlations

		WKCI	Gov_RD	Gov_Lowedu	Gov_Highedu	Business_RD	PE
WKCI	Pearson Correlation	1	.363**	.663**	.547**	.849**	.769**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	145	145	145	145	145	143
Gov_RD	Pearson Correlation	.363**	1	.335**	.467**	.381**	.281**
	Sig. (2-tailed)	.000		.000	.000	.000	.001
	N	145	145	145	145	145	143
Gov_Lowedu	Pearson Correlation	.663**	.335**	1	.782**	.682**	.768**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	145	145	145	145	145	143
Gov_Highedu	Pearson Correlation	.547**	.467**	.782**	1	.505**	.598**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	145	145	145	145	145	143
Business_RD	Pearson Correlation	.849**	.381**	.682**	.505**	1	.674**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	145	145	145	145	145	143
PE	Pearson Correlation	.769**	.281**	.768**	.598**	.674**	1
	Sig. (2-tailed)	.000	.001	.000	.000	.000	
	N	143	143	143	143	143	143

**. Correlation is significant at the 0.01 level (2-tailed).

From the table above, the correlation coefficient (co) between business investments on R&D and innovation with WKCI is 0.849, which means this indicator is highly correlated with regional knowledge competitiveness. We can find similar situation on government investment in lower education (co=0.663), government investment in higher education (co=0.547) and private equity investment in knowledge-based industries (co=0.769), are all highly correlated with knowledge competitiveness. However, in the coefficient table where the values highlighted within the rectangle, the result states that government investment in lower education has strong correlation with 3 variables: Gov_highedu (co=0.782), Buisness_RD (co=0.682) and PE (co=0.768). If we put lower education investment together with other variables into our model, it will cause collinearly problem in our regression. We think investment in lower education also have certain effects on regional knowledge competitiveness, we make another two regression models. The first regression model includes five independent variables. In

the second regression, we will use four independent variables excluding the government investment in lower education.

Step1.2 Regression analysis

Equation 1:

$Y = \alpha_o + \beta_1 Ln(X1) + \beta_2 Ln(X2) + \beta_3 Ln(X3) + \beta_4 Ln(X4) + \beta_5 Ln(X5) + \varepsilon$

Y= World Regional Knowledge Competitiveness Index

a_o=constant

Xi=Independent variables

β_1= coefficient of government investment in R&D and innovation

β_2= coefficient of government investment in lower education

β_3= coefficient of government investment in higher education

β_4= coefficient of business firms' investments in R&D and innovation

β_5= coefficient of private equity investment in knowledge-based industries

ε= Error term

Regression 1: Put five independent variables into the model

The model summary table shows R Square is 0.804, which indicates that 80.4% of the variance in the model can be explained with the created regression. The ANOVA table tests the acceptability of the model from a statistical perspective. The significance value of the F statistic is less than 0.05, which means that the variation explained by the model is not due to chance. See below for the summary generated using SPSS.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.896[a]	.804	.796	.1567249

a. Predictors: (Constant), PE, Gov_RD, Gov_Highedu, Business_RD, Gov_Lowedu

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.773	5	2.755	112.147	.000[a]
	Residual	3.365	137	.025		
	Total	17.138	142			

a. Predictors: (Constant), PE, Gov_RD, Gov_Highedu, Business_RD, Gov_Lowedu
b. Dependent Variable: WKCI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.198	.199		-.994	.322
	Gov_RD	.005	.013	.018	.391	.697
	Gov_Lowedu	-.118	.050	-.206	-2.374	.019
	Gov_Highedu	.061	.032	.134	1.891	.061
	Business_RD	.203	.018	.635	11.273	.000
	PE	.105	.016	.414	6.637	.000

a. Dependent Variable: WKCI

As the coefficient shows us investment in lower education has significant influence on regional knowledge competitiveness (P=0.019<0.05). However, the coefficient of government investment in lower education is -0.118. It indicates that invest in lower education will negatively influence the regional knowledge competitiveness. We believe regions investing on lower education will become less competitive does not make any sense. With the consideration of the results from the correlation table, we think putting the five indicators into one equation may misinterpret the relationship between independent and dependent variable. In regression 2, we will exclude the Gov_loweredu from our model.

Equation 2:

$Y= \alpha_o + \beta_1 Ln(X1)+\beta_2 Ln(X2)+\beta_3 Ln(X3)+\beta_4 Ln(X4)+\varepsilon$

Y= World Regional Knowledge Competitiveness Index

a_o=constant

Xi=Independent variables

β_1= coefficient of government investment in R&D and innovation

β_2= coefficient of government investment in higher education

β_3= coefficient of business firms' investments in R&D and innovation

β_4= coefficient of private equity investment in knowledge-based industries

ε= Error term

Regression 2: Put four independent variables into the model

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.892[a]	.796	.790	.1593369

a. Predictors: (Constant), PE, Gov_RD, Gov_Highedu, Business_RD

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.635	4	3.409	134.262	.000[a]
	Residual	3.504	138	.025		
	Total	17.138	142			

a. Predictors: (Constant), PE, Gov_RD, Gov_Highedu, Business_RD
b. Dependent Variable: WKCI

The model summary table in regression 2 shows R Square is 0.796, which indicates that 79.6% of the variance in the model can be explained with the created regression, which is slightly less than in regression one. The ANOVA table tests the acceptability of the model from a statistical perspective. The sum of squares indicates that most of variation of WKCI is explained by the model (13.635). The significance value of the F statistic is less than 0.05, which means that the variation explained by the model is not due to chance.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.588	.114		-5.154	.000
	Gov_RD	.011	.013	.037	.829	.409
	Gov_Highedu	.009	.024	.021	.385	.701
	Business_RD	.189	.017	.592	10.922	.000
	PE	.088	.014	.348	6.131	.000

a. Dependent Variable: WKCI

In the coefficients table, we find business investments on R&D and innovation, private equity firms investments on knowledge based industries are significant indicators (P=0.00<0.05). However, the government investment in R&D and higher education do not significantly influence our dependent variable (P>0.05). Of the two significant indicators, business investment has the largest coefficient 0.189, which means 1% increase of business R&D investment of a region, the knowledge competitiveness of this region will increase 0.189 units. The coefficient of private equity investment is 0.088, which means 1% increase of PE investment of a region, the knowledge competitiveness of this region will increase 0.088 units.

It is disappointed that both government investment in R&D or high education did not significantly influence regional knowledge competitiveness. We also make another regression analysis by include government investment in lower education but exclude the higher education investment (appendix 1.1). Besides, we try to use Partial Least Square (PLS) analysis to test all five financial capital indicators to see what are the difference results can be found (appendix 1.2).

The results from different analysis methods show that business firms' investments in R&D and private equity investment can significant influence WKCI while government investment does not.

Conclusion of step1:

- If we only test five financial capital variables without considering any control variables, business firms' investments in R&D and private equity investment in knowledge-based industries can have significant influence on regional knowledge competitiveness.
- Government investment in R&D and innovation, government investment in lower education and government investment in higher education do not show significant effects to influence regional knowledge competitiveness.

However, it is too early to conclude only two financial capital indicators are significant. It is possible when we take the control variables into account that the (in)significant indicators will be different. In order to make our analysis more precise, we will not exclude the insignificant indicators based on the results by the step 1. In the next step, we will add control variables of human capital to make further analysis.

Step2. Add control variable of Human Capital

As literature discussed, human capital is a significant factor to promote the knowledge economy and economic growth. We select human capital indicators from four industries, which measured by skilled labour per 1000 inhabitants in 2007. The four industries are IT and computers manufacturing (HC_IT), Bio-chemicals industries (HC_Bio), Mechanical engineering (HC_Mech) and Electronic machinery (HC_Elec).

Step2.1 Correlation analysis

The correlation analysis on the four human capital indicators and five financial capital indicators results in the following table:

Correlations

		WKCI	Gov_RD	Gov_Lowedu	Gov_Highedu	Business_RD	PE	HC_IT	HC_Bio	HC_Mech	HC_Elec
WKCI	Pearson Correlation	1	.363**	.663**	.547**	.849**	.769**	.385**	.250**	.244**	.310**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000	.003	.003	.000
	N	145	145	145	145	145	143	139	143	143	142
Gov_RD	Pearson Correlation	.363**	1	.335**	.467**	.381**	.281**	-.094	-.106	-.253**	-.231**
	Sig. (2-tailed)	.000		.000	.000	.000	.001	.273	.209	.002	.006
	N	145	145	145	145	145	143	139	143	143	142
Gov_Lowedu	Pearson Correlation	.663**	.335**	1	.782**	.682**	.768**	-.203*	.160	.211*	.083
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.017	.056	.012	.329
	N	145	145	145	145	145	143	139	143	143	142
Gov_Highedu	Pearson Correlation	.547**	.467**	.782**	1	.505**	.598**	-.227**	.065	.062	-.119
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.007	.442	.460	.157
	N	145	145	145	145	145	143	139	143	143	142
Business_RD	Pearson Correlation	.849**	.381**	.682**	.505**	1	.674**	.320**	.303**	.360**	.364**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000	.000	.000	.000
	N	145	145	145	145	145	143	139	143	143	142
PE	Pearson Correlation	.769**	.281**	.768**	.598**	.674**	1	.075	.166*	.186*	.222**
	Sig. (2-tailed)	.000	.001	.000	.000	.000		.381	.049	.027	.008
	N	143	143	143	143	143	143	138	141	141	140
HC_IT	Pearson Correlation	.385**	-.094	-.203*	-.227**	.320**	.075	1	.264**	.179*	.533**
	Sig. (2-tailed)	.000	.273	.017	.007	.000	.381		.002	.035	.000
	N	139	139	139	139	139	138	139	139	139	138
HC_Bio	Pearson Correlation	.250**	-.106	.160	.065	.303**	.166*	.264**	1	.502**	.516**
	Sig. (2-tailed)	.003	.209	.056	.442	.000	.049	.002		.000	.000
	N	143	143	143	143	143	141	139	143	143	142
HC_Mech	Pearson Correlation	.244**	-.253**	.211*	.062	.360**	.186*	.179*	.502**	1	.646**
	Sig. (2-tailed)	.003	.002	.012	.460	.000	.027	.035	.000		.000
	N	143	143	143	143	143	141	139	143	143	142
HC_Elec	Pearson Correlation	.310**	-.231**	.083	-.119	.364**	.222**	.533**	.516**	.646**	1
	Sig. (2-tailed)	.000	.006	.329	.157	.000	.008	.000	.000	.000	
	N	142	142	142	142	142	140	138	142	142	142

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The above table shows us all human capital variables are not highly correlated with each other. The human capital in electronic engineering industries is slightly higher correlated than in IT and computer manufacturing[9], bio-chemical and mechanical engineering industries. But in general, the correlation coefficients among all human capital variables are acceptable. No high correlation between human capital indicators and financial capital indicators are found. This indicates that adding human capital indicators as control variables of financial capital will not cause colinearity in our regression.

[9] In further discussions, we will refer this indicator by using "human capital in IT".

Step 2.2 Regression analysis

We first test which human capital indicator(s) should be added with financial investment indicators into one regression model.

Step 2.2.1 Regression analysis 1

We put all independent variables into one regression model.

The equation of the regression 1 is:

$Y=\alpha_o+\beta_1 Ln(X1)+\beta_2 Ln(X2)+\beta_3 Ln(X3)+\beta_4 Ln(X4)+\beta_5 Ln(X5)+\beta_6 Ln(X6)+\beta_7 Ln(X7)+\beta_8 Ln(X8)+ \beta_9 Ln(X9)+\varepsilon$

Y= World Regional Knowledge Competitiveness Index

a_o=constant

Xi=independent variables

β_1= coefficient of government investment in R&D and innovation

β_2= coefficient of government investment in lower education

β_3= coefficient of government investment in higher education

β_4= coefficient of business firms' investments in R&D and innovation

β_5= coefficient of private equity investment in knowledge-based industries

β_6= coefficient of human capital in IT and computer manufacturing industries

β_7= coefficient of human capital in Bio-chemicals industries

β_8= coefficient of human capital in Mechanical engineering industries

β_9= coefficient of human capital in Electronic machinery industries

ε= Error term

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.913[a]	.834	.822	.1369109

a. Predictors: (Constant), HC_Elec, PE, Gov_RD, HC_Bio, HC_IT, HC_Mech, Gov_Highedu, Business_RD, Gov_Lowedu

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.973	9	1.330	70.973	.000[a]
	Residual	2.381	127	.019		
	Total	14.354	136			

a. Predictors: (Constant), HC_Elec, PE, Gov_RD, HC_Bio, HC_IT, HC_Mech, Gov_Highedu, Business_RD, Gov_Lowedu

b. Dependent Variable: WKCI

R Square of this model is 0.834, means 83.4% of the variance in the model can be explained with the created regression. ANOVA test illustrates that our regression model is significant (p=0.00<0.05).

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.036	.220		-4.699	.000
	Gov_RD	.010	.013	.039	.804	.423
	Gov_Lowedu	.005	.048	.008	.102	.919
	Gov_Highedu	.069	.029	.152	2.360	.020
	Business_RD	.184	.020	.505	8.971	.000
	PE	.082	.015	.318	5.609	.000
	HC_IT	.067	.015	.226	4.598	.000
	HC_Bio	-.006	.017	-.015	-.357	.722
	HC_Mech	-.001	.020	-.001	-.027	.979
	HC_Elec	.012	.022	.032	.554	.580

a. Dependent Variable: WKCI

The above table shows four independent variables significant influence WKCI. Same results as in step1, business firms' investments in R&D, private equity investment are significant indicators (P=0.00<0.05). Among the four human capital variables, only human capital in IT industries is significant (P=0.00<0.05). In this step, "government investments in higher education" becomes a significant indicator while it was insignificant in step1.

In order to find why human capital in IT industries is the only significant indicator among the four human capital variables, we will make a separate regression only using human capital indicators.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.412[a]	.169	.144	.3001510

a. Predictors: (Constant), HC_Elec, HC_Bio, HC_IT, HC_Mech

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.717	.100		7.203	.000
	HC_IT	.119	.028	.404	4.244	.000
	HC_Bio	.050	.037	.128	1.371	.173
	HC_Mech	.035	.040	.088	.862	.390
	HC_Elec	-.051	.045	-.133	-1.124	.263

a. Dependent Variable: WKCI

The above table shows human capital in IT industries significantly influence WKCI while other indicators do not. The coefficient of human capital in IT is 0.119, which shows positive relation between human capital in IT industries with regional knowledge competitiveness. We will exclude another three human capital indicators from further researches. Thus, we make the final regression in step 2.

Step2.2.2 Regression analysis 2

The equation of regression 2 is:

$Y= \alpha_o + \beta_1 Ln(X1) + \beta_2 Ln(X2) + \beta_3 Ln(X3) + \beta_4 Ln(X4) + \beta_5 Ln(X5) + \beta_6 Ln(X6) + \varepsilon$

Y= World Regional Knowledge Competitiveness Index

a_o=constant

Xi=independent variables

β_1= coefficient of government investment in R&D and innovation

β_2= coefficient of government investment in lower education

β_3= coefficient of government investment in higher education

β_4= coefficient of business firms' investments in R&D and innovation

β_5= coefficient of private equity investment in knowledge-based industries

β_6=coefficient of human capital in IT and computer manufacturing industries

ε= Error term

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.913[a]	.834	.826	.1350599

a. Predictors: (Constant), HC_IT, PE, Gov_RD, Gov_Highedu, Business_RD, Gov_Lowedu

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.974	6	1.996	109.409	.000[a]
	Residual	2.390	131	.018		
	Total	14.364	137			

a. Predictors: (Constant), HC_IT, PE, Gov_RD, Gov_Highedu, Business_RD, Gov_Lowedu
b. Dependent Variable: WKCI

This regression model includes six indicators, five of them are financial capital variables and the other one is human capital in IT. R Square of this model is 0.834, means 83.4% of the variance in the model can be explained with the created regression. F test in ANOVA illustrates that the model is significant (p=0.00<0.05).

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.001	.211		-4.736	.000
	Gov_RD	.009	.011	.035	.818	.415
	Gov_Lowedu	.004	.047	.007	.089	.929
	Gov_Highedu	.065	.028	.142	2.312	.022
	Business_RD	.184	.019	.506	9.594	.000
	PE	.084	.014	.325	6.001	.000
	HC_IT	.070	.013	.237	5.395	.000

a. Dependent Variable: WKCI

The significant indicators of financial investments are different from our test in step 1. From the "Coefficients" table, it is obvious that human capital in IT ($p=0.00<0.05$), business investments in R&D ($p=0.00<0.05$), private equity investments in knowledge-based industries ($p=0.00<0.05$) and government investment in higher education ($p=0.02<0.05$) are all significant independent variables. From the positive coefficients, we find all significant indicators positively influence the knowledge competitiveness. Especially, government investment in higher education was not a significant indicator when we only test financial capital variables in step1. However, we find different conclusion when we take into account of control variable of human capital in IT. The reason could be investment in higher education interacts with human capital in high-technology industries like IT. With more investments by government in higher education, more human capital in knowledge-based industries will emerge.

Apart from above test, we also try to make factor analysis on nine independent variables (see appendix 2.1). We find five financial investment indicators belong to factor 1, human capital in IT belongs to factor 3 and other three human capital indicators belong to factor 2. Thought our test, factor 1 and human capital in IT industries significantly influence WKCI (see appendix 2.2), which further illustrate that we can keep all financial investment indicators and human capital in IT industries into next step.

Conclusion of Step2

- When we add control variable of four human capital indicators with five financial capital variables into one model, we find government investment in higher education become significant while it was an insignificant indicator in step1.
- Among four human capital variables, only human capital in IT shows significant influence on dependent variable WKCI.
- The significant influence of business firms' investments in R&D and private equity investment in knowledge-based industries do no change with the consideration of control variables of all human capital indicators or only human capital in IT industries.

Step3. Add control variable of regional economic performance indicator

In this step, we will add another control variable of regional economic performance indicator into our model. We start with a correlation analysis on all indicators. In order to determine if GDP per capital or GUC is more suitable to use as regional economic performance indicator, a correlation analysis will be made by all indicators into one table.

Step 3.1 Correlation analysis

Correlations

		WKCI	Gov_RD	Gov_Lowedu	Gov_Highedu	Business_RD	PE	HC_IT	GUC	GDP_pp
WKCI	Pearson Correlation	1	.363**	.663**	.547**	.849**	.769**	.385**	.442**	.694**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000	.000	.000
Gov_RD	Pearson Correlation	.363**	1	.335**	.467**	.381**	.281**	-.094	.335**	.487**
	Sig. (2-tailed)	.000		.000	.000	.000	.001	.273	.000	.000
Gov_Lowedu	Pearson Correlation	.663**	.335**	1	.782**	.682**	.768**	-.203*	.414**	.822**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.017	.000	.000
Gov_Highedu	Pearson Correlation	.547**	.467**	.782**	1	.505**	.598**	-.227**	.371**	.743**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.007	.000	.000
Business_RD	Pearson Correlation	.849**	.381**	.682**	.505**	1	.674**	.320**	.391**	.692**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000	.000	.000
PE	Pearson Correlation	.769**	.281**	.768**	.598**	.674**	1	.075	.485**	.767**
	Sig. (2-tailed)	.000	.001	.000	.000	.000		.381	.000	.000
HC_IT	Pearson Correlation	.385**	-.094	-.203*	-.227**	.320**	.075	1	.062	-.160
	Sig. (2-tailed)	.000	.273	.017	.007	.000	.381		.528	.059
GUC	Pearson Correlation	.442**	.335**	.414**	.371**	.391**	.485**	.062	1	.500**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.528		.000
GDP_pp	Pearson Correlation	.694**	.487**	.822**	.743**	.692**	.767**	-.160	.500**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.059	.000	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

From the correlation table above, we can find that GDP per capita is significantly correlated with WKCI with coefficient of 0.694. However, GDP is also highly correlated with government investment in lower education (co=0.822), government investment in higher education (co=0.743), business R&D investment (co=0.692) and private equity investment (co=0.767). If we put GDP into our regression model, there will be a collinear problem, which could lead to misinterpretation of the test results. The GUC is displaying less correlation with all other independent variables even if the correlation of GUC with WKCI is a bit lower than GDP per capita, which is 0.442. To further approximate an accurate analysis, the control variable we add should not be highly correlated with financial capital variables. Thus, after comparing GDP per capita and GUC, we decided to use GUC as economic performance indicator to make further analysis.

Step3.2 Factor analysis

In step 3, the independent variables include five indicators of financial capital, one indicator of human capital (human capital in IT) and one indicator of economic performance (GUC). In order to test if any independent variables belong to one factor, we make factor analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.420	48.856	48.856	3.420	48.856	48.856
2	1.305	18.644	67.500	1.305	18.644	67.500
3	.855	12.208	79.708			
4	.662	9.458	89.166			
5	.360	5.150	94.316			
6	.271	3.870	98.186			
7	.127	1.814	100.000			

Extraction Method: Principal Component Analysis.

The "Total Variance Explained" table shows us two factors that can designated as components' eigenvalues greater than 1 be extracted. The "cumulative %" indicates three factors explain nearly 67.50% of the variability in the original seven variables.

Component Matrix[a]

	Component	
	1	2
Gov_RD	.566	-.149
Gov_Lowedu	.894	-.200
Gov_Highedu	.837	-.326
Business_RD	.738	.427
PE	.816	.180
HC_IT	-.092	.925
GUC	.618	.258

Extraction Method: Principal Component Analysis.

a. 2 components extracted.

From the compoment matrix, we can tell two factors can be extracted. The coefficients indicate that most of the variables belong to factor 1 but human capital in IT belongs to factor 2. From the compoment Matrix, we can conclude the two factor as:

Factor 1: Financial Capital

-Government investments on R&D and innovation (0.566)

-Government investments on lower education (0.894)

-Government investments on higher education (0.837)

-Business investments on R&D and innovation (0.738)

-Private equity investments on R&D, innovation and management (0.816)

-Economic performance indicator GUC (0.618)

Factor 2: Human capital in IT industries

-Human Capital in IT and computer manufacturing industries (0.925)

We think to divide all independent variables into these two factors are theoritical problematic. In our research scheme, the five financial capial variables are input elements while economic performance is output element. Thus, it does not make sense to put input and output elements into one factor. In order to analyze which financial capital have significant influence on WKCI, we will put all independent variables into a regression model.

Step3.3 Regression analysis

Step3.3.1 Regression analysis 1

We first make regression analysis with all independent variables, the equation of regression 1 is:

$Y= \alpha_o+ \beta_1 Ln(X1)+\beta_2 Ln(X2)+\beta_3 Ln(X3)+\beta_4 Ln(X4)+ \beta_5 Ln(X5)+ \beta_6 Ln(X6)+ \beta_7(X7)+\varepsilon$

Y= World Regional Knowledge Competitiveness Index

a_o=constant

Xi=independent variables

β_1= coefficient of government investment in R&D and innovation

β_2= coefficient of government investment in lower education

β_3= coefficient of government investment in higher education

β_4= coefficient of business firms' investments in R&D and innovation

β_5= coefficient of private equity investment in knowledge-based industries

β_6=coefficient of human capital in IT and computer manufacturing industries

β7=coefficient of GUC

ε= Error term

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.921[a]	.849	.838	.1319574

a. Predictors: (Constant), GUC, HC_IT, Gov_RD, PE, Business_RD, Gov_Highedu, Gov_Lowedu

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.605	7	1.372	78.803	.000[a]
	Residual	1.706	98	.017		
	Total	11.312	105			

a. Predictors: (Constant), GUC, HC_IT, Gov_RD, PE, Business_RD, Gov_Highedu, Gov_Lowedu
b. Dependent Variable: WKCI

The "Model Summary" shows us R square 84.9%. It means the independent variables in our model can explain 84.9% of dependent variable. The F-test in the ANOVA is significant, providing strong evidence against the null hypothesis in the linear regression model.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.953	.222		-4.290	.000
	Gov_RD	.001	.014	.005	.097	.923
	Gov_Lowedu	-.040	.052	-.068	-.764	.447
	Gov_Highedu	.115	.034	.255	3.415	.001
	Business_RD	.183	.021	.503	8.607	.000
	PE	.074	.015	.310	4.841	.000
	HC_IT	.081	.014	.274	5.707	.000
	GUC	.035	.111	.015	.319	.750

a. Dependent Variable: WKCI

The "Coefficients" table illustrates government investment in higher education, business firms' investment in R&D and private equity investment in knowledge-based industries are still significant ($P<0.05$). The indicator of human capital in IT industries is also significant. However, different from our expectation, the economic performance indicator "GUC" is an insignificant variable, the P value of GUC is 0.750, which is much higher than 0.05. It is possible that we put too many independent variables into one model; especially the indicator of government investment in lower education; which is highly correlated with other independent variables. Thus, we excluded government investment in lower education from the regression model (for result, see appendix 3.1) and the result shows that there are still four significant indicators, while the GUC remains an insignificant indicator.

Step3.3.2 Regression analysis 2

As we analyze from previous steps, government investment in R&D and lower education have not been significant indicators. Thus, we excluded them from the regression model and tested it further again.

Equation of regression 2:

$Y= \alpha_o+ \beta_1 Ln(X1)+\beta_2 Ln(X2)+\beta_3 Ln(X3)+\beta_4 Ln(X4)+ \beta_5(X5)+\varepsilon$

Y= World Regional Knowledge Competitiveness Index

a_o=constant

Xi=independent variables

β_1= coefficient of government investment in higher education

β_2= coefficient of business firms' investments in R&D and innovation

β_3= coefficient of private equity investment in knowledge-based industries

β_4=coefficient of human capital in IT and computer manufacturing industries

β_5=coefficient of GUC

ε= Error term

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.921[a]	.848	.841	.1310485

a. Predictors: (Constant), GUC, HC_IT, Gov_Highedu, Business_RD, PE

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.594	5	1.919	111.733	.000[a]
	Residual	1.717	100	.017		
	Total	11.312	105			

a. Predictors: (Constant), GUC, HC_IT, Gov_Highedu, Business_RD, PE
b. Dependent Variable: WKCI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.093	.129		-8.463	.000
	Gov_Highedu	.101	.024	.223	4.199	.000
	Business_RD	.179	.019	.489	9.258	.000
	PE	.069	.013	.287	5.115	.000
	HC_IT	.085	.013	.286	6.386	.000
	GUC	.036	.106	.015	.340	.734

a. Dependent Variable: WKCI

The above results show that three financial capital indicators and human capital in IT have significant influence on regional knowledge competitiveness. However, as economic performance indicator, "GUC" still does not show any significant influence on WKCI. The possible explanation is that as an index indicator, GUC is too comprehensive as it composes out of different indexes, making it difficult to precisely describe the regional economic performance. For the completeness of the analysis, we also put GDP per capital into the regression model (please see appendix 3.2) but it also did not show any significant effects either, while the other four independent variables were unchanged in their significance.

From our analysis, we find regional economic performance cannot explain regional knowledge competitiveness. It may because financial capital and human capital indicators show more significant influence on WKCI in our research. It is also possible that a more appropriate indicator to reflect regional economic performance need to be developed.

Conclusion of Step 3:

- GDP per capita is highly correlated with other independent variables while GUC has less correlation with other independent variables.
- GUC did not show any significant influence on knowledge economy competitiveness (same results by testing GDP per capita).

- Three financial capital indicators are still significant with consideration of control variable of economic performance. Adding economic performance indicator in to the research model will not change the significant effects of financial capital variables on WKCI.
- The significant independent financial investment indicators till step 3 are government investment in higher education, business firms' investments in R&D, private equity investment in knowledge-based industries and human capital in IT industries. The insignificant financial capital variables till step 3 are government investment in R&D and government investment in lower education.

In the next step, we will add the last control variables of location into regression to test if the knowledge competitiveness can be influenced by the regional differences. As mentioned before, we collected data from three big world regions: North American, European and Asia-Pacific. We will add two dummies variables into step 4 in order to compare knowledge competitiveness in different world regions.

Step 4. Add control variable of location

Step 4.1 Add dummy variables into regression model to compare North American, European and Asian-Pacific regions

From the analysis of step 3, we the economic performance indicator GUC does not show any significant influence on dependent variable. In order to test if control variables of location can influence the significance of financial capital variables, we will maintain all financial capital indicators for further tests, with exception of the GUC.

Step 4.1.1 Regression analysis 1:

The equation of regression analysis 1 in step 4 is:

$Y= \alpha_o+ \beta_1 Ln(X1)+\beta_2 Ln(X2)+\beta_3 Ln(X3)+\beta_4 Ln(X4)+ \beta_5 Ln(X5)+ \beta_6 Ln(X6)+ \beta_7(X7)+ \beta_8(X8)+ \varepsilon$

Y= World Regional Knowledge Competitiveness Index

a_o=constant

Xi=independent variables

β_1=coefficient of government investment in R&D and innovation

β_2=coefficient of government investment in lower education

β_3=coefficient of government investment in higher education

β_4=coefficient of business firms' investments in R&D and innovation

β_5=coefficient of private equity investment in knowledge-based industries
β_6=coefficient of human capital in IT and computer manufacturing industries
β_7=coefficient of dummy of North American regions
β_8=coefficient of dummy variable of European regions
ε= Error term

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.919[a]	.844	.834	.1319256

a. Predictors: (Constant), Dummy_EU, Gov_Lowedu, HC_IT, Gov_RD, Business_RD, PE, Gov_Highedu, Dummy_North American

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.119	8	1.515	87.039	.000[a]
	Residual	2.245	129	.017		
	Total	14.364	137			

a. Predictors: (Constant), Dummy_EU, Gov_Lowedu, HC_IT, Gov_RD, Business_RD, PE, Gov_Highedu, Dummy_North American
b. Dependent Variable: WKCI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.907	.215		-4.222	.000
	Gov_RD	-.004	.012	-.015	-.327	.744
	Gov_Lowedu	.039	.049	.061	.793	.429
	Gov_Highedu	.025	.031	.054	.796	.428
	Business_RD	.172	.020	.474	8.411	.000
	PE	.088	.014	.342	6.263	.000
	HC_IT	.075	.013	.256	5.873	.000
	Dummy_North American	.055	.047	.084	1.155	.250
	Dummy_EU	-.047	.041	-.071	-1.160	.248

a. Dependent Variable: WKCI

From the above "Coefficients" table, independent variables in regression model can explain 84.4% of dependent variable. The indicators of business investment in R&D, private equity investment in knowledge-based industries and human capital of IT industries significantly influence regional knowledge competitiveness as their P value are lower than 0.05. Different from step 3, the government investment in higher education becomes an insignificant indicator (P=0.428>0.05). Also, the two dummies variables of North American and European regions are both insignificant indicators (P>0.05), which means knowledge competitiveness of these two regions do not significantly influence by the location.

The new results indicate that after exclusion of the GUC from our model and by adding the location control variables, the significance of government investment in higher education has become insignificant. Does GUC influence the significance of "Gov_Highedu", or is it because of the many financial capital indicators in one model that is resulting in a collinear problem in the model?

In order to clarify the answer, the GUC has been added back to the model for another regression.

Step 4.1.2 Regression analysis 2:

The equation of regression analysis 2 in step 4 is:

$Y= \alpha_o + \beta_1 Ln(X1) + \beta_2 Ln(X2) + \beta_3 Ln(X3) + \beta_4 Ln(X4) + \beta_5 Ln(X5) + \beta_6 Ln(X6) + \beta_7 (X7) + \beta_8 (X8) + \beta_9 (X9) + \varepsilon$

Y= World Regional Knowledge Competitiveness Index

a_o=constant

Xi=independent variables

β_1=coefficient of government investment in R&D and innovation

β_2=coefficient of government investment in lower education

β_3=coefficient of government investment in higher education

β_4=coefficient of business firms' investments in R&D and innovation

β_5=coefficient of private equity investment in knowledge-based industries

β_6=coefficient of human capital in IT and computer manufacturing industries

β_7=coefficient of dummy of North American regions

β_8=coefficient of dummy variable of European regions

β_9=coefficient of GUC

ε= Error term

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.928[a]	.861	.848	.1277895

a. Predictors: (Constant), GUC, Dummy_EU, HC_IT, Gov_Lowedu, Gov_RD, Business_RD, PE, Dummy_North American, Gov_Highedu

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.744	9	1.083	66.299	.000[a]
	Residual	1.568	96	.016		
	Total	11.312	105			

a. Predictors: (Constant), GUC, Dummy_EU, HC_IT, Gov_Lowedu, Gov_RD, Business_RD, PE, Dummy_North American, Gov_Highedu
b. Dependent Variable: WKCI

The "Model Summary" shows us R square 86.1%. It means the independent variables can explain 86.1% of dependent variable. The F-test in the ANOVA is significant, providing strong evidence against the null hypothesis in the linear regression model.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.868	.221		-3.934	.000
	Gov_RD	-.015	.015	-.054	-1.042	.300
	Gov_Lowedu	.000	.054	.001	.009	.993
	Gov_Highedu	.069	.036	.153	1.910	.059
	Business_RD	.173	.022	.475	7.874	.000
	PE	.077	.016	.320	4.925	.000
	HC_IT	.089	.014	.298	6.298	.000
	Dummy_North American	.064	.049	.097	1.298	.197
	Dummy_EU	-.049	.043	-.073	-1.138	.258
	GUC	.062	.109	.026	.571	.569

a. Dependent Variable: WKCI

From the above test with the "GUC" as economic performance indicator, we find three same significant indicators as step 4.1.1. The P value of government investment in higher education is 0.059, very close to 0.05. The reason for this can be explained by our research scheme. In our research graph, economic performance is considered as the output of the knowledge economy input, which is one of the components to influence knowledge competitiveness. When we make a model to predict the regional knowledge competitiveness, even if GUC is an insignificant indicator, it may influence other independent variables' significance.

We also find government investment in R&D and lower education as insignificant indicators by different way of testing. Thus, from step 1 to step 4, we can conclude that among five financial capital indicators, government investment in R&D and lower education do not significantly influence regional knowledge competitiveness. As a result, we will exclude them from our research model. In further discussion, we will only deal with three financial capital variables out of the original five indicators.

Step 4.1.3 Regression analysis 3 - Comparing North American and Asian-Pacific regions[10]

The model without two financial capital indicators:

$Y= \alpha_o+ \beta_1 Ln(X1)+\beta_2 Ln(X2)+\beta_3 Ln(X3)+\beta_4 Ln(X4)+ \beta_5 Ln(X5)+ \beta_6 Ln(X6)+ \beta_7(X7)+\varepsilon$

Y= World Regional Knowledge Competitiveness Index

a_o=constant

Xi=independent variables

β_1= coefficient of government investment in higher education

β_2= coefficient of business firms' investments in R&D and innovation

β_3= coefficient of private equity investment in knowledge-based industries

[10] Before applying two dummies in the model, we analyzed each of them first, by putting only one dummy variable into the regression to test North American regions vs Non-American regions, European vs non-European regions and Asian-Pacific vs non-Asian-Pacific regions (for results, see appendix 4.2). Comparing with non-North American regions, regions in North American are more competitiveness in knowledge economy; Comparing with non-European regions, European regions are less competitive in knowledge economy. Asian-Pacific regions do not play significant role to influence world knowledge economy comparing with non-Asian regions.

β_4= coefficient of human capital in IT and computer manufacturing industries
β_5= coefficient of dummy of North American regions
β_6= coefficient of dummy variable of Asian-Pacific regions
β_7= coefficient of GUC
ε= Error term

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.927[a]	.860	.850	.1271962

a. Predictors: (Constant), GUC, Dummy_EU, HC_IT, Business_RD, Gov_Highedu, PE, Dummy_North American

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.726	7	1.389	85.881	.000[a]
	Residual	1.586	98	.016		
	Total	11.312	105			

a. Predictors: (Constant), GUC, Dummy_EU, HC_IT, Business_RD, Gov_Highedu, PE, Dummy_North American
b. Dependent Variable: WKCI

The "Model Summary" shows us R square 86.0%. It means the independent variables can explain 86.0% of dependent variable. The F-test in the ANOVA is significant, providing strong evidence against the null hypothesis in the linear regression model.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.930	.144		-6.482	.000
	Gov_Highedu	.065	.028	.145	2.378	.019
	Business_RD	.169	.019	.464	8.712	.000
	PE	.080	.015	.334	5.506	.000
	HC_IT	.088	.013	.297	6.720	.000
	GUC	.028	.103	.012	.275	.784
	Dummy_North American	.096	.034	.146	2.811	.006
	Dummy_Asia-Pacific	.049	.041	.058	1.192	.236

a. Dependent Variable: WKCI

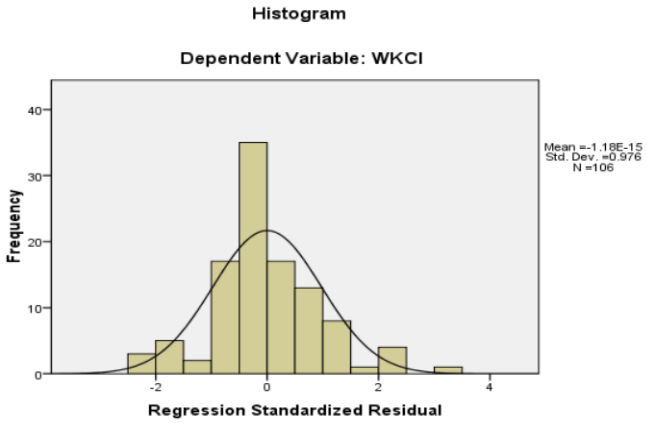
Among these three indicators, business firms' investments in R&D and innovation has the largest coefficient 0.169, which means with 1% increase of business investment in knowledge, the regional knowledge competitiveness will increase 0.169 units. The coefficients of private equity firm investments on knowledge is 0.080 while human capital in IT is 0.88, which both show the positive relation between independent variables with WKCI. The coefficient of North American is 0.096, which indicates regions in North American are significantly more competitive in the knowledge economy (P=0.006<0.05). Asian regions knowledge competitiveness is not influenced by its location (P=0.236>0.05). A reason could be that the sample size of Asian regions is relatively small which in terms has the same effect in its influence.

After excluding government investment in R&D and government investment in lower education, we can find government investment in higher education becomes significant (p=0.019<0.05). The other three indicators as in regression 4.1.2 are significant. We believe even if GUC is insignificant in previous research, it can influence the significance of financial capital indicators in our research. In order to prove that the significance of government in higher education is not due to the exclusions of the two financial capital indicators (especially government investment in lower education is highly correlated with other independent variables), we excluded GUC as well as government investment in R&D and government investment in lower education (please see results in appendix 4.1). The results indicate without GUC, government investment in higher education becomes an insignificant indicator, which further illustrates our research scheme is designed logically as it takes into account of relevant input and output elements which influence the regional knowledge competitiveness. If we only take out part of the elements to make analysis, the results would be misinterpreted.

Put coefficients into the equation:

Y=-0.930+0.65Ln(Gov_Highedu)+0.169Ln(Business_RD)+0.080Ln(PE)+0.88Ln(HC_IT)+0.028GUC +0.096DumNA+0.049DumAsian+ε

The histogram of the model shows us that the regression standardized residual is close to normal distribution, which indicates the validity of our mode.



Step4.1.4 Comparing European and Asian-Pacific regions

By using dummy variable of Asian-Pacific regions as base line, we can also compare European regions with Asian-Pacific regions. As test results of other independent variables are the same as step 4.1.3, we will only discuss the results of dummies.

	Coefficient	Sig
Dummy_European	**-0.096**	**0.006**
Dummy_Asian-Pacific	**-0.047**	**0.309**

The table above illustrates European regions are less competitive in the knowledge economy (P=0.006<0.05, co=-0.096). This means that on average regions from Europe rank lower on WKCI. Asian regions knowledge competitiveness is not influenced by its location (P=0.309>0.05).

Conclusion of step 4.1

- If we put five financial capital indicators with human capital in IT industry and two dummies variables into one model (excluding the GUC), the government investment in higher education becomes insignificant.
- If we add GUC back to the model, the government investment in higher education will become a significant indicator to predict knowledge competitiveness, which indicates as the knowledge economy output, even if GUC is an insignificant indicator, it still has certain value to predict other input variables.
- Government investment in R&D and government investment in lower education are insignificant indicators to predict regional knowledge competitiveness. The results are not influenced by adding any control variables.
- In the final model, government investment in higher education, business investment in R&D, private equity investment in knowledge-based industries and human capital in IT industry are significant indicators to influence regional knowledge competitiveness.
- Regions from North America are more competitive in the knowledge economy while regions from Europe are less.
- Asian regions knowledge competitiveness is not influenced by its location.

Step 4.2 Further discussions on control variable of location

Through our analysis from step 1 to 4.1, it is clear that business investment in R&D, private equity investment in knowledge-based industries significantly influence regional knowledge competitiveness. Regions with more investment in R&D by business firms or venture capital companies will be more competitive in the knowledge economy. However, government investment in higher education did not show significant influence when we only test five financial capital indicators. The significance of this indicator is found by adding control variable of human capital in IT or GUC. Thus, it is interesting to test if we exclude government investment in higher education from our final research model, what will be the results.

Step 4.2.1 Compare North American regions and Asian-Pacific regions

The equation with 2 dummy variables:

$Y= \alpha_0+ \beta_1 Ln(X1) + \beta_2 Ln(X2)+ \beta_3 Ln(X3)+ \beta_4 X4+ \beta_5 X5+\beta_6 X6+\varepsilon$

Y= World Regional Knowledge Competitiveness Index

α_0=constant

X=independent variables

β_1=coefficient of human capital in IT

β_2= coefficient of business firms' investments in R&D and innovation

β_3=coefficient of private equity investment in knowledge-based industries

β_4=coefficient of economic performance indicator

β_5=coefficient of dummy variable North American regions

β_6= coefficient of dummy variable Asian-Pacific regions

ε= Error term

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.923[a]	.852	.843	.1301520

a. Predictors: (Constant), Dummy_EU, GUC, HC_IT, Business_RD, PE, Dummy_North American
b. Dependent Variable: WKCI

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.635	6	1.606	94.795	.000[a]
	Residual	1.677	99	.017		
	Total	11.312	105			

a. Predictors: (Constant), Dummy_EU, GUC, HC_IT, Business_RD, PE, Dummy_North American
b. Dependent Variable: WKCI

The "Model Summary" shows us R square 85.2%. It means the independent variables can explain 85.2% of dependent variable. The F-test in the ANOVA is significant, providing strong evidence against the null hypothesis in the linear regression model.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.659	.089		-7.388	.000
	HC_IT	.080	.013	.270	6.177	.000
	Business_RD	.179	.019	.489	9.176	.000
	PE	.091	.014	.380	6.445	.000
	GUC	.044	.105	.019	.423	.673
	Dummy_North American	.135	.030	.206	4.465	.000
	Dummy_Asia-Pacific	.041	.042	.049	.977	.331

a. Dependent Variable: WKCI

Not surprisingly, the coefficients table illustrates human capital in IT, business firms' investments in R&D and innovation and private equity investment in knowledge-based industries are all significant indicators (P=0.00<0.05). Among these three indicators, business firms' investments in R&D and innovation has the largest coefficient 0.179, which means with 1% increase of business investment in knowledge, the regional knowledge competitiveness will increase 0.179 units. The coefficients of private equity firm investments on knowledge is 0.091 while human capital in IT is 0.80, which all shows the positive relation between independent variables and WKCI .

It is clear that the dummy variable of North American regions is significant (p=0.27<0.05) while dummy variable of European is insignificant. The coefficient of dummy in North American is positive, which indicates the regions from North America are more competitive. The results from dummies show that when we take into account the influence of two financial capital indicators (without government investment in higher education) as well as human capital in IT on world regional knowledge competitiveness, North American regions are more competitive in knowledge economy. Asian regions knowledge competitiveness however, is not influenced by its location.

Put coefficients in the equation:

Y=-0.659+0.08Ln(HC_IT)+0.179Ln(Business_RD)+0.091Ln(PE)+0.044Economic+0.135DumNA +0.41DumAsia+ε

Step4.2.2 Regression analysis 2: Comparing European and Asian regions

	Coefficient	Sig
Dummy_European	**-0.135**	**0.000**
Dummy_Asian-Pacific	**-0.095**	**0.027**

When we compare European regions with Asian-Pacific, both of them are significant (P<0.05). However, the coefficients of these regions are both negative, dummy in European is "-0.135" while the dummy variable in Asian is "-0.095". The results illustrate that both European and Asian-Pacific regions are less competitive in the knowledge economy. The knowledge competitiveness of Asian regions is marginally higher than European regions. We think the samples of our data collection maybe one of the reasons to explain the results. As we mentioned at the beginning of this chapter, the sample size of Asian-Pacific regions are relatively small compared with North American and European regions. Under good circumstances, data can be collected in many Asian-Pacific developed regions and especially the big cities: Hong Kong, Shanghai or Singapore. However, many medium-sized or less developed cities does not have public data source. As result, when we compare regions in Asia and Europe, European regions are less competitive as the sample data of Europe contains metropolitan cities like London to east European cities like Warsaw. But it is could be also a signal that on global level, Asian-Pacific regions are gradually increasing their competitiveness, and their potential knowledge competitiveness may even become higher than European regions. Therefore, it is important for European policy makers to realize the competition and design effective strategies to increase European knowledge competitiveness.

Conclusion of step 4.2

- If we exclude government investment in higher education from our research model, business firms' investments in R&D and private equity investment in knowledge-based industries, human capital in IT industries are still significant indicators.
- Regions in North American are more competitive in the knowledge economy while regions in Europe and Asia are less. Asian regions rated slightly higher than Europe.

4.3 Hypotheses Testing:

To conclude our findings, we first review our hypotheses, and then summarize our findings into one table.

Review our hypotheses in chapter 3:

- H1:Government investment in R&D and innovation can positively influence regional competitiveness in the knowledge economy
- H2:Government investment in secondary education can positively influence regional competitiveness in the knowledge economy
- H3:Government investment in higher education can positively influence regional competitiveness in the knowledge economy
- H4:Business firms' investments in R&D and innovation can positively influence regional knowledge competitiveness
- H5:Private equity investment in knowledge-based industries can positively influence regional knowledge competitiveness
- H6:Adding the control variable of human capital will not affect the significance of financial investments influencing world regional knowledge competitiveness.
- H7:Adding the control variable of regional economic performance indicator will not affect the significance of financial investments influencing world regional knowledge competitiveness.
- H8:Adding the control variable of location will not affect the significance of financial investments influencing world regional knowledge competitiveness.
- H9:The North American regions are more competitive in the knowledge economy than European and Asian-Pacific regions.

Hypotheses	H1	H2	H3	H4	H5	H6	H7	H8	H9
Accept				√	√			√	√
Reject	√	√				√	√		
Accept with condition(s)			√						

From the above table we can see four hypotheses are accepted while four of them are rejected. Government investment in higher education was not a significant indicator by only analyzing financial investment indicators. But it show significant influence on WKCI when control variables are put into the model, thus we put H3 in a separate column. This finding further illustrates the importance to analyze financial investments in a comprehensive knowledge economy research scheme rather than only focus on the relationship of financial capital with knowledge competitiveness.

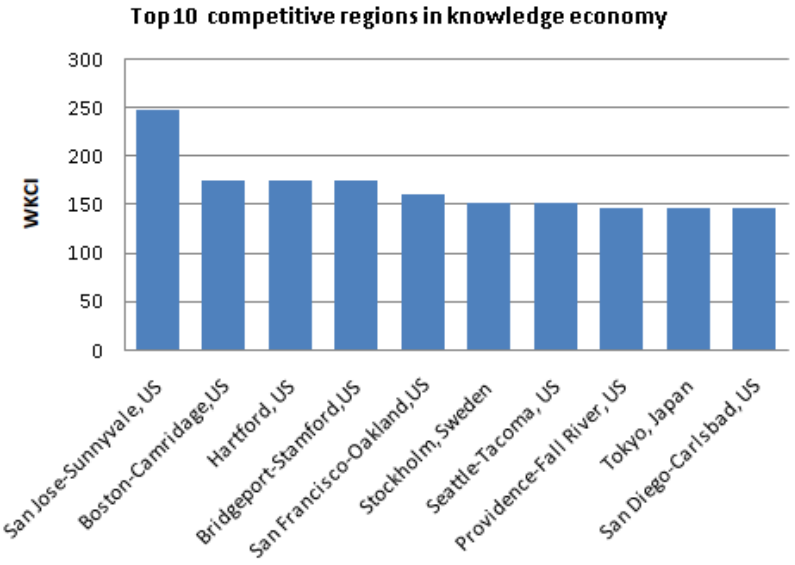
Chapter 5. Discussions and Recommendations

In this chapter, we will make discussions on regional competitiveness in the knowledge economy and the significant financial investments that influence the regional knowledge competitiveness. We will also provide recommendations on how to increase European knowledge competitiveness for policy makers.

5.1 Discussion on World regional knowledge competitiveness

Through our data analysis, three financial capital variables were found that can significantly influence regional knowledge competitiveness. These are government investment in higher education, business firms' investments in R&D and private equity investment in knowledge-based industries. When we consider the location control variables, North American regions are more competitive in the knowledge economy while European regions are less competitive. Before continuing with the discussion, a brief analyze on knowledge competitiveness scores will be presented first.

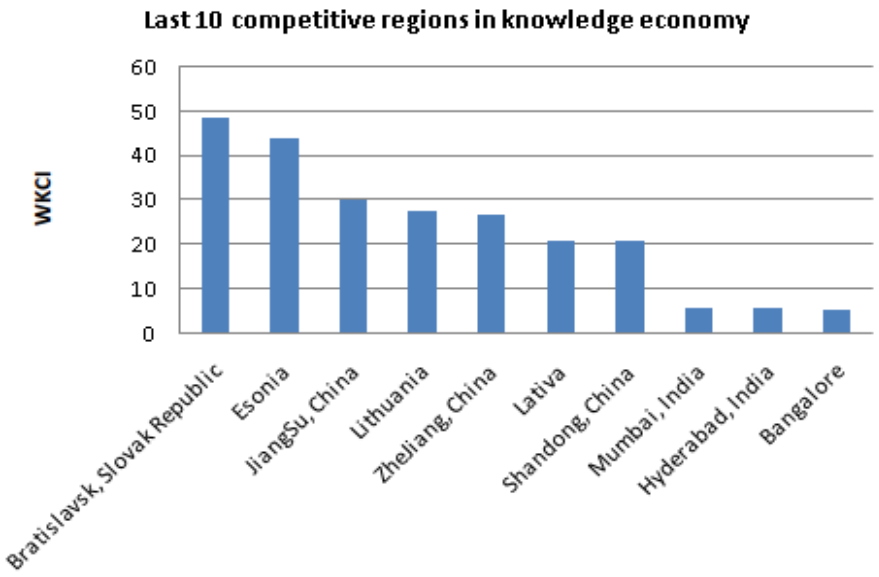
The following graph shows the top 10 competitive regions in the knowledge economy (the graph was made by the original WKCI index figure without divisions by 100).



From the figure above, eight regions originate from the US and only two from non-US. The most competitive region of 2008 is San Jose (248.3) due to its large amount of investment in knowledge-intensive business development, especially in the fields of high-technology engineering, IT and computer manufacturing industries. The second competitive region is Boston (175.3), which thrives on high level of intellectual and financial capital. Boston also has eight research universities including

Harvard and Massachusetts Institute of Technology. A great numbers of international students go to Boston to study and continue to work there, which largely promote Boston knowledge competitiveness. Hartford (175.1) region ranks the third as it boosts by strong results for both R&D spending and private equity investment. Region of Bridgeport (174.7) ranks fourth, it lies demographically next to Hartford. It is competitive in the knowledge economy due to large investments in R&D and innovation. The fifth region is San Francisco (160.8).

Stockholm (151.8) is the only European region among the top 10, ranking 6th. By increase of business R&D spending, biotechnology and chemical sector, a strong employment regulations and higher education spending, Stockholm shows strong knowledge competitiveness in the world. Tokyo (147.0) is the only Asian region in top 10 because of the abundant of high-technology R&D and business innovation spending by both public and private sectors.



The lower rank is taken by India, China and East-European regions. The lowest three are Bangalore (5.0), Hyderabad (5.3) and Mumbai (5.5). The Chinese regions with fairly low score are Shandong (20.6), Zhejiang (26.5) and JiangSu (30.2). Among all Chinese regions, Shanghai has the highest score (79.4) ranking 110 out of 145. The development of Shanghai surpasses Berlin and British Columbia; it has been seen as the fastest growing region in recent years. Two other Chinese fast growing regions are Hong Kong (72.6) and Beijing (48.9); both are strong climbers in the knowledge economy ranking.

5.2 Discussion on financial investments in the knowledge competitiveness

Through our analysis, we identified three significant indicators: business firms' investments in R&D and innovation, private equity investment in knowledge-based industries and government investment in higher education (with consideration of control variables). We found North American regions are more competitive in the knowledge economy than European and Asian regions. Without the influence of government investment in higher education, regions from North America will rank even higher on WKCI. Our research results provide some indications to world regional policy makers on the importance of sufficient financial investments on knowledge competitiveness. We will analyze our finding from three perspectives.

5.2.1 The importance of business firms' investments in R&D and innovation

In order to make a region become more competitive in knowledge, regional and national managers need to realize that business firms' investments in R&D and innovation plays a crucial role, especially Multinational enterprises (MNEs), which are the major business investors to support R&D and innovation in new technologies. Therefore, attracting more MNEs R&D and innovation centres into a region can effectively promote the regional knowledge competitiveness.

The most knowledge competitive region in the world is San Jose because it is the location of Silicon Valley. Silicon Valley has been the world centre for venture capital markets, technology investment, and innovation for the last 15 years. Silicon Valley accumulates the largest technology expertise in the world, boasting more than 6,600 technology companies employing more than 254,000 people (Orange, 2010). The success story of Silicon Valley of conducting deals and supporting entrepreneurial capitalism has been widely adopted around the world.

Because of globalization and development of ICT, many firms can locate the research centres out off their home countries, and set knowledge centres in other lower cost countries or regions, such as China and India. As a result, the world knowledge structure is gradually changing. The UNCTAD (2005) shows that the world leading R&D spenders are increasingly offshoring and outsourcing their innovation activities to Asia, especially to China and India. Economic Intelligence Unit Survey found that by 2006, China has become the third most important location for overseas R&D affiliates, after the U.S and the UK, followed by India (6^{th}) and Singapore (9^{th}). The survey also revealed that more than half of the responding firms have at least one R&D facility in China, India or Singapore. For MNEs, the main reason for outsourcing R&D and innovation to Asia is because of the cheaper cost in skilled knowledge

workers. For instance, the cost of employing a chip design engineer in Asia is typically between 10 to 20 percent of the cost in Silicon Valley (Dieter, 2005). As result of the large number of MNEs R&D and innovation investment in Asian regions, the Asian knowledge economy has been booming. Therefore, the regional and national policy makers in Asian countries are attracting more MNEs to locate R&D centres into their regions by cost advantages. Also lower entry barrier and tax deduction from knowledge-based firms are in order to encourage investments of MNEs in the regions.

The western countries policy makers need to realize that with more MNEs outsourcing their R&D centres into cheaper labour cost countries, the competitiveness of these regions will steadily grow. From MNEs perspective, lower labour cost can lead to higher turnover. From regional manager perspective, attracting more MNEs investment in R&D and innovation is crucial for the regional knowledge competitiveness. Therefore, it is important for European policy makers to design efficient policies to balance the different requirements from firms and regions.

5.2.2 Discussion on Private Equity [11]sectors

Another important financial capital resource to increase regional knowledge competitiveness is the investment from Private Equity (PE). From our research, we find regions with more PE investment in R&D will become more competitive in the knowledge economy.

The first reason is PE can support entrepreneurial talents by turning ideas and basic science into products and services. Start-up entrepreneurs or knowledge-based Small and Medium Enterprises (SMEs) do not have the financial support or sufficient cash flow as MNEs do. PE can greatly promote their development and growth. The private equity industry represents a transmission channel of privately available capital into sectors of the economy that have no access to the public capital markets.

Secondly, PE can increase regional employment rate and also attract higher level managers. Financial Times (2005) made a survey interviewing 160 European executive directors about their preference of profession selection. They found that 70% of finance directors and 80% of chief executives were interested in positions in private equity. This finding indicates the job creation by PE not only attracts high skilled labours, but also attracts higher level managers. According to EVCA research, between 2000 and 2004 European private equity and venture capital financed companies created 1 million new jobs,

[11] As we discussed in literature review, we use private equity as general term to represent venture capital, LBO, Angle Capital and Risk Capital.

which translates to a compound annual growth rate of 5.4% per year, it clearly illustrates the importance of private equity firms on regional development.

Furthermore, private equity contributes to economic growth through the introduction of new products and processes on the market, and the development of an improved absorptive capacity of the knowledge generated by private and public research institutions (Herrmann and Liebig, 2004). According to Deutsche Bundesbank estimates, venture capital needs to be considered as an additional "link" explaining variations in economic performances. Therefore, the innovative policy instruments that would stimulate the participation of private venture capital funds available in the market are needed.

According to the European Commission (2006), the global private equity industry is still heavily concentrated in the US and the UK. The US market is the most mature and developed and accounts for approximately 75% of the funds raised in the period 1983-2005 (approx €990bn). In Europe, the proportion of buy-out funds raised has continued to increase in many years reaching over 80% of total funds raised in 2005. However, as the "bubble" of 2000 and financial crisis in 2008, private equity managers in Europe have found it difficult to raise funds as a result of historic underperformance. However, recent substantial exits of European private equity backed by companies like CSR, Skype, and Q-cells offer some optimism. Our research and these examples indicate that private equity is an important driver for innovation and regional economic growth; therefore it needs support from policy makers.

5.2.3 Importance of government investment in higher education

We also find government investment in higher education to be a significant indicator. Our findings shows if the regions want to increase their knowledge competitiveness, government should make more investment in higher education.

The significance of this indicator was found by the influence of control variable of human capital in IT industries and economic performance indicator. This finding illustrates that many knowledge economy components are interrelated. For instance, better education can train more high skilled labors, such as human capital in knowledge-based industries. Good educational levels help employability and progress in increasing the employment rate and promote economic growth.

Besides, we find in the model without government investment in higher education (step 4.2), US regions will become even more competitive than Europe and Asia. A possible explanation is that more

stimulation by private investors (e.g. sponsorship from business firms and individuals) exists in the US, while European regions relies more on government funds. Private investments in higher education have not been included in our model because of data limitations. It is our prediction that this indicator may influence US knowledge competitiveness.

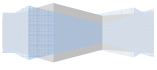
In order to increase European competitiveness in the knowledge economy, more government investment in higher education should be made. According to European Commission statistics, less than 33% of the population with age 25-34 in Europe has a university degree compared to 40% in the US and over 50% in Japan. In ShangHaiJiaoTong world University index, only Oxford and Cambridge, the two European universities are ranked in the top world 20. Under these circumstances, European policy makers need to realize the importance of investing in higher education. Without sufficient highly educated human capital, it will be difficult for European regions to increase competitiveness through R&D and innovation in high-tech industries.

5.3 Discussion on insignificant indicators in our analysis

In our research, government investment in R&D and government investment in lower education did not show any significant influence on world regional knowledge competitiveness. A possible explanation is that compared with the three other financial capital variables, these two indicators are relatively weak. It may also because of our research data limitation. In general, the regions in our analysis are relatively developed compare with global average level (as in more developed regions, more public data sources are available), thus the investments in lower education in these regions may not have significant power to influence their knowledge competitiveness. Another explanation is to investment in lower education will take a longer time for regions to improve their knowledge competitiveness. Therefore, a longer time lag may exist between government investments in lower education with regional knowledge competitiveness.

However, we cannot ignore the influence of public expenditure on R&D and government investment in lower education on regional knowledge competitiveness. For example, European commission 2020 strategies stressed that 3% of the EU's GDP should be invested in R&D in order to increase European competitiveness, which used to be lower than 2%. It demonstrates that EU policy makers are taken the knowledge influence of public investment into account.

Besides, investment in lower education can also provide good education foundation for higher education. Birdsall (2002) suggested public resources for education in developing countries should be



reallocated from higher to lower levels because government spending on education should be directed to those levels where the gap between social and private returns is the highest. This is the case for many developing countries. In developed countries, lower education is beneficial for low skilled labour to look for jobs and reduce poverty.

Chapter 6. Conclusion and policy recommendation

This chapter consists of two parts. We will first conclude our research question. After that, recommendation will be given to European policy makers to help them with their aim to increase European knowledge competitiveness.

6.1 Research conclusion

This thesis aims to fill the research gaps in the knowledge economy studies. Our research is to test which financial investments significant influence regional knowledge competitiveness. We first design a "regional knowledge economy competitiveness cyclical scheme" which consists of all input and output factors, after that we test which financial investments have significant influence on the world regional knowledge competitiveness. The dependent variable for our research originated from World Regional Knowledge Competitiveness Index (WKCI).

From our data analysis, we find three financial capital variables that can positively influence regional knowledge competitiveness. Business firms' investments in R&D and innovation, private equity investment in knowledge-based industries displayed positive influence on all test steps. However, government investment in higher education did not show significance when tested with five financial capital indicators without control variables. They show significant influence on WKCI when control variables of human capital in IT and GUC are considered.

We also discuss the importance of these financial investments. Business firms' investments, especially Multinational enterprises (MNEs), are the major business investors to support R&D and innovation in new technologies. Asian regions are growing fast in their competitiveness because of large numbers of MNEs outsourcing their R&D centres in these regions. Private equity investment can support entrepreneurial talents by turning ideas and basic science into products and services; increase regional employment rate and contributes to regional economic growth. Government investment in education can cultivate more highly educated human capital.

By comparing three world regions with consideration of three significant financial investments, we found North American regions to be more competitive in the knowledge economy while Europe regions are relatively less competitive. Asian regions knowledge competitiveness is not influenced by its location. Besides, if we compare three regions but exclude government investment in higher education, North American regions will be the most competitive, Asian regions will be second and European last (this result may because of the data limitation as we explained in step 4.2.2). The findings also indicate

government investment in higher education will actually bring European and Asian regions closer to the competiveness of North American regions. In order to increase European knowledge competiveness more investment should be made on higher education. It is worth mentioning that many Asian regions are developing very fast (e.g. China and India) because of the abundant investments from both public and private on knowledge and a large numbers of high-tech outsourcing R&D centres from MNEs. Therefore, Asian regions still have large growth capability in the future compared with the US and European regions.

6.2 Policy recommendations to European policy makers

6.2.1 Review of European policy

With the aim to make Europe more competitive, European Council (2000) in Lisbon designed the "Lisbon Strategy" also known as the "Lisbon Agenda". It describes a long term development plan for the economy of the European Union between 2000 and 2010. The goal was to make EU to be "the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion[12]". The main topics in Lisbon Strategy were economic, social and environmental renewal and sustainability. However, the strategy was not successful; by the end of 2010 most of planned goals were not achieved. Till now, the European strategy has been revised twice. In 2004, Wim Kok made a mid-term review on Lisbon Agenda and stressed that the strategy has failed to act with sufficient urgency. The disappointed result is due to an overloaded agenda, poor coordination and conflicting priorities. Based on this report, European Commission released a new proposal in February 2005 to refocus the Lisbon Agenda. In 2009, Spain's Prime Minister José Luis Rodríguez Zapatero pointed out that the non-binding character of the Lisbon Strategy contributed to the failure, and this lesson needed to be taken into account by the new Europe 2020 strategy (DW-World.De, 2010). In March 2010 the European Commission launched the proposal for the Europe 2020 Strategy. The new strategy's goal is to stimulate a smart, sustainable and inclusive growth, which is mutually reinforcing the economic, social and territorial cohesion. There are five EU key targets: promote innovation, face climate change, increase employment rate, encourage education and poverty reduction.

[12] The quotations of Lisbon Agenda is from European Commission website, please see details in reference list

It is still too early to conclude if the European 2020 Strategy will be sufficient and effective to increase European competitiveness. In order to provide helpful indications to European policy makers, we would like to make some suggestions based on our findings.

6.2.2 Policy recommendations

6.2.2.1 Develop European own specialism

European faces challenges from the US and Asia. It is urgent for Europe to develop own specialism to promote its knowledge competitiveness. According to Financial Times (2005), the US accounts for 74 % of top 300 IT companies and 46 % of top 300 firms ranked by R&D spending. The EU's world share of exports of high-tech products is lower than US; the share of high-tech manufacturing in total value added and numbers employed in high-tech manufacturing are also lower than US. However, as Europe has large coal, oil and natural gas reserves, European Union should further develop its specialization in energy and chemical industries. The six oil producers in the European Union include UK (the largest), Denmark, Germany, Italy, Romania and the Netherlands. We suggest governments to promote the cooperation and joint R&D and innovation among big energy firms of these countries, with the aim to develop world leading technology in oil and chemical industries. European Union can make incentives and apply subsidies to encourage energy firms to make research on sustainable energy.

6.2.2.2 Invest in European higher education

As few of the world top leading universities are from Europe, many young scientists leave Europe after graduating and continue further studies in the US. Therefore, Europe needs to dramatically improve its attractiveness to global researchers. In order to increase attractiveness, European countries need to increase funding on universities and research institutions in order to improve their research environment. It is important for policy makers to realize that cutting higher education funds is a short term vision for budget saving. However, in a long-term, it will lead regions or nations to lose their knowledge competitiveness because they are less attractive. Besides, European countries need to reduce the administrative obstacles to facilitate the entry of researchers and their families from outside the EU through simplified, fast-track resident permit and visa procedures.

Another suggestion to European regions is to promote interaction between universities, scientists and researchers and build joint-research institutes. For example, Tinbergen Institute (TI) is the world leading research graduates institutes which combines the best of three Dutch universities, Erasmus University Rotterdam, University of Amsterdam and VU University Amsterdam. TI attracts many

internationals to study and research in The Netherlands. We suggest forming more institutes like TI out of top universities from different European countries. By combination of research advantages from different universities and attractiveness of different cultures, Europe may attract more talent scholars.

6.2.2.3 Promote private equity investment

From our research, we find by comparing the US, the private equity is not heavily promoted in Europe. It represents a small share of total business investment in knowledge economy. In terms of % in GDP in 2008, the US was 0.05% while only 0.02% in Europe (EVCA).

Private equity investment depends much on regulatory and fiscal conditions created by government. PE can contribute to national economic prosperity when there is sufficient stock of private capital in the hands of ambitious and experienced business people, who are creative innovators and seeking financial support in their young companies. In the US, many private equity investors deal with individual entrepreneurs, in Europe however, investors turn to institutions. Because, Europe lacks the creative, highly ambitious and quick growth high-tech young companies together with the limited funds available for PE investment. Therefore, the politicians and government should make efficient policies in promoting the development of private equity in Europe.

One suggestion is to create an investment environment for private equity finance, by lowering the entry and exit barriers for private equity firms. Policy makers can improve the tax laws by reducing investment company tax and by allowing private equity and venture capital firms to exit without being taxed. European countries can also learn from each other by creating an optimal conditions at regional or national level that facilitate private equity financing development. Politicians within European Union should consider the solutions that could improve the situation for EU private equity managers to find more opportunities to sell their products in other European countries. Therefore, a common understanding of private placement constitutes, how to qualify the treatment and what the potential risks are, that need to be regulated by European policy makers.

Chapter 7. Research limitation and further research recommendations

7.1 Research limitations

In this research, we designed a "regional knowledge economy competitiveness cyclical scheme" and examined which financial investments significant influence knowledge competitiveness. The research approach has been undertaken with much attention on concreteness. But there are still limitations of this paper. Within this chapter, the limitations will be highlighted with a short description.

As the limitation of data resources and data availability, we only selected cross section data. We realize that it may take some time to increase the regional knowledge competitiveness after having invested in the knowledge economy. The time lag can be tested if we have time series data. However, as WKCI and GUC are both recent topics of research, the research data is limited for the period 2007-2008. Besides, we only choose five different types of financial investments in the knowledge economy and limited numbers of human capital and economic performance indicators. However, we realize that the indicators can be more than we select. As our research scheme shows, a large number of indicators exist in financial capital, human capital and regional economic performance. Theoretically, all these indicators can be examined into the research model, but due to data source limitation, only parts of the indicators were used within the tests.

Secondly, as mentioned earlier, there not many research papers written using the "GUC" as it is a topic introduced in the recent years. Due to the limited research available on this topic, our research finding will share similar limitations. Thus, we cannot simply conclude that economic performance does not influence regional knowledge competitiveness only by the insignificance of GUC. We think this finding may be different when other economic performance indicators are used.

Third limitation is the duration of research time. Due to this limitation no structured interviews has been done as part of the information gathering of this research. Input from actors within the field of the knowledge economy, e.g. regional economic development managers or European knowledge competitive policy makers would have been quite valuable. The suggestions and discussions of this paper are mainly based on data analysis results, academic literatures, media interview reports and academic scholars' suggestions. Thus, research findings can be perceived as limited because of the limitation in information collection and knowledge acquisition by the author. The "Knowledge economy" is a complicated and comprehensive study, we believe that research continuation done by specialized scholars would definitely result in a more valuable and interesting findings.

7.2 Further research suggestions

We hope the findings in this paper will be used by future researches to test the influence of financial capital on regional knowledge competitiveness. As there is no standardized model on knowledge economy measurement, we hope our "regional knowledge economy competitiveness cyclical scheme" can contribute on further knowledge economy studies.

We suggest further studies to work on the knowledge competitiveness model; testing the model by using more financial capital indicators and collecting more relevant economic indicators for further analysis. As mentioned, data does not always tell us a full story, we believe a research with depth, should be a combination of data analysis and interviews e.g. with policy makers and business leaders.

Bibliography

Academic literatures

Aernoudt, R (1999): *European policy towards venture capital: myth or reality?* Venture Capital, 1(1), 47-58.

Acs, Z. J. and Audretsch, D. B. (2005): *Entrepreneurship, Innovation and Technological Change*, Foundations and Trends in Entrepreneurship, Now Publishing.

Alexander Popov and Peter Roosenboom (2008): *On the Real Effects of Private Equity Investment: Evidence from New Business Creation*, European Central Bank and RSM, JEL classification: G24, L26, M13

Alexander Popov and Peter Roosenboom (2009): *Does private equity investment spur innovation? Evidence from Europe*, European Central Bank working papers series, NO 1063/June 2009

Anthony Arundel (2009): *knowledge economy indicators*, Policy Relevance of the Knowledge Economy Indicators Project, MERIT

Alexander T.J. (1997): *Human capital investment: building the "knowledge economy"*, POLICY OPTIONS

Ann Markusen (2006): *Human versus physical capital: Government's role in regional development*, University of Minnesota

Ariely, G. (2003): *Knowledge Management As A Methodology Towards Intellectual Capital*, Presented at the 3rd European Knowledge Management Summer School, Spain, 7 - 12 September, San Sebastian.

Ayeni, O. (2003): *Relationship Between Training and Employment of Technical College Graduates in Oyo* State between 1998 and 2001, Ph.D Thesis.

Beck, T., A. Demirgüç-Kunt, and V. Maksimovic (2005): *Financial and legal constraints to growth: does firm size matter?* Journal of Finance, 60(1), 137-177.

Bontis, N. (2002b): *Managing Organizational Knowledge by Diagnosing Intellectual Capital*, In Choo and Bontis (Eds.) The Strategic Management of Intellectual Capital and Organizational Knowledge, New York: Oxford University Press, 621-642.

Brundtland Report (1987): *Development and International Economic Co-operation: Environment Report of the World Commission on Environment and Development*, General Aseembly, United Nations

Cathie Madsen, (2006): *NationMaster: The Importance Of GDP Per Capita,*

Drucker, P. (1959): *Landmarks of tomorrow: a report on the new post-modern world*, New York: Harper.

Enrique López-Bazo and Rosina Moreno (2002): *Does human capital stimulate investment in physical capital? Evidence from a cost system framework,* AQR Research Group-IREA, Universitat de Barcelona

Eric Braun (2008): *City Marketing: towards an integrated approach*, PHD thesis of ERIM, Erasmus University Rotterdam

Ernst, Dieter (2005): *Complexity and internationalization of innovation: why is chip design moving to Asia?*, International Journal of Innovation Management, 9(1): 47-73

Gilson, R. J (2003): *Engineering a venture capital market: lessons from the American experience*, Stanford Law Review, 55(4), 1067-1103.

Garba (2002): *Human Capital Formation, Utilization and the Development of Nigeria*.,Selected Papers for the 2002 Annual Conference of the Nigeria Economic Society. (NES). Ibadan. Polygraphics Ventures Ltd.

Gary S. Becker (1964, 1993): *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*, Chicago, University of Chicago Press.

Giddings, B., Hopwood, B. and O'Brien, G. (2002): *Environment, Economy and Society: fitting them together into sustainable developmen*t, Sustainable Development, 10 (4), pp. 187-196.

Glaeser, E. L. (2000): *The new economics of urban and regional growth*, In The Oxford handbook of economic geography, ed Gordon, C., Meric, G., Feldman, M, 83-98, Oxford: Oxford University Press.

Gompers, P., and J. Lerner (1999): *The Venture Capital Cycle*, Cambridge, Mass.: MIT Press, 1999.

Grant, R. (1996a): *Towards a knowledge-based view of the firm.* Strategic Management Journal, 17, 109-122.

Harris, R.G. (2001): *The knowledge-based economy: intellectual origins and new economic perspectives*, International Journal of Management Reviews, 3(1), pp. 21-40.

HMSO (1994): *Environment Bill*, HMSO, London, ISBN: 0108701050

Hoskisson, R. E., Hitt, M. A., Wan, W. P., & Yiu D. (1999): *Theory and Research in Strategic Management: Swings of a Pendulum*, Journal of Management, 25(3): 417-45.

Iain McNicoll et. al (2002): Defining and identifying the knowledge economyin Scotland: A regional perspectiveon a global phenomenon, University of Strathclyde Publishing

Ian Brinkley (2006): Defining the knowledge economy, The Work Foundation, 2006

Jacobs, J. (1961): *The Death and Life of Great American Cities*, New York: Random House.

Jacobs, J. (1969): *The Economies of Cities*, New York: Random House.

JunSeok Hwang, and Mohsen Gerami (2006): *Analysis of Investment in Knowledge inside OECD Countries*, International Journal of Human and Social Sciences 1:2 2006

Kaplan, S. and A. Schenkel (2001): *Knowledge-based theories of the firm in strategic management: a review and Extension*, MIT Sloan Working Paper 4216-01.

Kaplan, S. and P. Stromberg (2001): *Venture capitalists as principals: contracting, screening, and monitoring*, American Economic Review, 91(2), 426-430.

Karlsson, C., B. Johansson and R.R. Stough (2005): *Entrepreneurship and dynamics in the knowledge economy*, New York: Routledge.

H. Herrmann, T. Liebig (2004): *Studies of the Economic Research*, Deutsche Bundesbank, No18/2004

Hoskisson, R., Hitt, M., Wan, W. and Yiu, D. (1999). *Theory and research in strategic management: Swings of a pendulum*, Journal of Management, 25 (3), 417-456.

Lucas, R. (1988): *On the Mechanics of Economic Development*, Journal of Monetary Economics, 22: 3-42.

Machlup, F. (1962) *The production and distribution of knowledge in the United States*. Princeton: University Press.

Marjo Haataja; Jussi Okkonen (2004): *Competitiveness of Knowledge Intensive Services*, FRONTIERS OF E-BUSINESS RESEARCH

Martin Fransman (2008): *Finance and Innovation*, Institute for Japanese-European Technology Studies University of Edinburgh

Melanie Klingbeil (2008): *Measuring Human Capital in the Knowledge Economy*, Centre for Policy Research in Science and Technology, SFU

Mohammad Ali Molaei (2010): *A New Measurable Definition of Knowledge in New Growth Theory*, World Academy of Science, Engineering and Technology 66 2010

Nancy Birdsall (2002): *Public Spending on Higher Education in Developing Countries: Too Much or Too Little?*, Economics of Education Review, Vol. 15, No. 4, pp. 407~119

Nelson, R.R., and E. Phelps, (1966): *Investment in humans, technology diffusion and economic growth*, American Economic Review 56, No.2 (May):69-75.

Odekunle S. O. (2001): *Training and Skill Development as Determinant of Workers' Productivity in the Oyo State Public Service.* Unpublished Ph.D Thesis, University of Ibadan.

Olaniyan. D.A and Okemakinde. T (2008): *Human Capital Theory: Implications for Educational Development*, European Journal of Scientific Research, ISSN 1450-216X Vol.24 No.2 (2008), pp.157-162

Organization for Economic Co-operation and Development (1994): *Competitiveness Helping Business to Win,* Cm 2563, Published June 1994 by Stationery Office Books

Organization for Economic Co-operation and Development (1995): *Manual on the measurement of human resources devoted to S&T "Canberra manual"*. Paris: OECD.

Organization for Economic Co-operation and Development (1996): *The knowledge-based economy*, GENERAL DISTRIBUTION, OCDE/GD (96) 102, Paris

Organization for Economic Co-operation and Development (2001): *The well-being of nations: the role of human and social capital*. Paris: OECD.

Otto Raspe (2009): *The Regional Knowledge Economy; a Multilevel Perspective on Firm Performance and Localized Knowledge Externalities*, GeoMedia (Faculty of Geosciences, Utrecht University), Utrecht University

Paul. M. Romer (1983): *Dynamic Competitive Equilibria with Externalities, Increasing Re-turns and Unbounded Growth*, Ph.D, dissertation, University of Chicago

Paul. M. Romer (1986): *Increasing Returns and Long-run Growth*, Journal of Political Economy,Vol. 94(5):1002-1037.

Paul. M. Romer (1987): *Crazy explanations of the productivity slowdown*, NBER Macroeconomics Annual, 2:163-202.

Paul. M. Romer (1990): *Endogenous technical change*, Journal of Political Economy, 98(5): S71- S102.

Paul A. Samuelson and William D. Nordhaus (2004): *Economics*, 18th ed., Glossary of Terms Factors of production

Pengfei Ni and Peter Karl Kresl (2010): *The Global Urban Competitiveness Report 2010,* Edward Elgar Publishing

Porter, M. E. (1990): *The Competitive Advantage of Nations*, New York: Free Press.

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

PricewaterhouseCoopers (2002): *Global Private Equity 2002,* http://PwC-Global-Private-Equity-2002.pdf

PricewaterhouseCoopers (2003): *Global Private Equity 2003,* http://PwC-Global-Private-Equity-2003.pdf

PricewaterhouseCoopers (2004): *Global Private Equity 2004,* http://PwC-Global-Private-Equity-2004.pdf

Psacharopoulos, G and Woodhall, M. (1997): *Education for Development: An Analysis of Investment Choice*, New York Oxford University Press.

Rob van Tulder, Jakob H. Rasmussen, Fabienne Fortanier, Sascha Haselmayer, Sandra Genee (2007): *PRIVATE SECTOR R&D: GLOBAL VIEW*, EU SIXTH FRAMEWORK [Regions of Knowledge 2]

Richard Blundell, Lorraine Dearden, Costas Meghir and Barbara Sianesi (1999): *Human Capital Investment: The Returns from Education and Training to the Individual, the Firm and the Economy*, Fiscal Studies (1999) vol. 20, no. 1, pp. 1–23

Richard Florida, Charlotta Mellander, and Kevin Stolarick (2007): *Inside the black box of regional development-Human capital, the creative class and tolerance*, CESIS Electronic Working Paper Series, Paper No. 88

Richard R. Nelson and Edmund S. Phelps (1966): *Investment in humans, Technological diffusion and economic growth*, The American Economic Review, Vol. 56, No. 1/2 (Mar. 1, 1966), pp. 69-75

Robert B. (1991): *Economic Growth in a Cross Section of Countries*. Quarterly Journal of Economic 106 (2) p.407-414.

Robert Huggins and Hiro Izushi (2002): *World Knowledge Competitiveness Index 2002: Benchmarking the Globe's High Performing Regions.* Cardiff: Robert Huggins Associates.

Robert Huggins and Hiro Izushi, and Will Davies (2005): *World Knowledge Competitiveness Index 2005*. Pontypridd: Robert Huggins Associates.

Robert Huggins and Hiro Izushi (2007): The *Knowledge Competitive of regional economies: conceptualization and measurement*, Bank of Valletta Review, No. 35, Spring 2007.

Robert Huggins and Hiro Izushi, and Will Davies, Luo Shougui (2008): *World Knowledge Competitiveness Index 2008,* Centre for International Competitiveness

Schumpeter, J (1911): *The Theory of Economic Development*, Oxford: Oxford University Press.

Slavo Radosevic (2007): *Knowledge based economy indicators and their relevance and application to the SEE countries*, University College London

Solow, R. (1956): *A Contribution to the Theory of Economic Growth*, Quarterly Journal of Economics, 70: 65-94

Smith, K. (2002): *What is the knowledge economy? Knowledge intensity and distributed knowledge bases. Maastricht: United Nations University*, Institute for New Technologies, Discussion Paper Series.

Sullivan Arthur and Steven M. Sheffrin (2003): *Economics: Principles in action*, New Jersey: Pearson Prentice Hall.

Sveiby, K. (2001): *A knowledge-based theory of the firm to guide in strategy formulation*, Journal of Intellectual Capital, 2 (4), 334-358.

Tim Jenkinson (2008): *The development and performance of European private equity*, Saïd Business School, Oxford University and CEPR

Timothy Edmonds (2000): *Regional Competitiveness & the Role of the Knowledge Economy*, Economic Policy & Statistic Section, Research Paper 00/73, 27 July 2000

Thomas Andersson and Glenda Napier (2007): *The Role of Venture Capital, Global Trends and Issues from a Nordic Perspective*, IKED, Malmö, September 2007

Ullman, E. L. (1958): *Regional development and the geography of concentration*, Papers and proceedings of the Regional Science Association, 4:179-98.

UNCTAD (2005), *UNCTAS Survey on the Internationalization of R&D*, Occasional Note, UNCTAD/WEB/ITE/IIA/2005/12, 12 December

UNCTAD (2007), *Knowledge, Technological Leaning and Innovation for Development*, The Least Development Countries Report, United Nations, NewYork.

Timothy Edmonds (2000): *Regional Competitiveness & the Role of the Knowledge Economy*, Research Paper 00/73, Economic Policy & Statistics Section, House of Commons Library.

W.A.Lewis (1954): *Economic Development with Unlimited Supplies of Labour,* University of Manchester

World Bank (1993): *Review of Public Expenditure ODI*, London.

Zoltan J. Acs, David B. Audretsch, Pontus Braunerhjelm and Bo Carlsson (2005): *The Knowledge Spillover Theory of Entrepreneurship*, Institute for Development Strategies, The Ameritech Foundation, December 2005

Media Source:

Bloomburg Businessweek online Extra (2006): *Q&A with Michael Porter*, the Harvard professor and popular author explains the "location paradox" and talks about the competitive challenges facing the U.S.

http://www.businessweek.com/magazine/content/06_34/b3998460.htm

Cathie Madsen (2006): *The importance of GDP per Capita*, Nation Master online magazine, Dec, 2006 http://www.nationmaster.com/article/The-Importance-of-GDP-Per-Capita

Christina Pomoni (2010): *The Difference Between The Knowledge Economy And The Traditional Economy*, Bukisa online source: http://www.bukisa.com/articles/356578_what-is-the-difference-between-the-knowledge-economy-and-the-traditional-economy

Data Centre Knowledge online news (2010): *Google Boosts Data Center Spending*: http://www.datacenterknowledge.com/archives/2010/07/19/google-boosts-data-center-spending/

Deutsche Bundesbank: http://www.bundesbank.de/statistik/statistik.en.php

DW-World.De European Union 08.01.2010: *Spain calls for binding EU economic goals - and penalties* http://www.dw-world.de/dw/article/0,,5098907,00.html?maca=en-current_affairs_europe-105-rdf

Economic Intelligence Unit: http://www.eiu.com/public/

European Commission: http://ec.europa.eu/index_en.htm

European Union Law :http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52005DC0024:EN:NOT

European 2020 Strategy: http://portal.cor.europa.eu/europe2020/Profiles/Pages/welcome.aspx

EVCA: http://www.evca.eu/publicandregulatoryaffairs/default.aspx?id=164

Financial Times: http://www.ft.com/home/europe

Organe (2010): *Road Map to Silicon Valley*:http://roadmaptosiliconvalley.org/venture-capital/history/

Presidency conclusions Lisbon European Council 23 and 24 March 2000: http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/00100-r1.en0.htm

Sweden admits Lisbon Agenda 'failure' (2009) by EurActiv with Reuters: http://www.euractiv.com/en/priorities/sweden-admits-lisbon-agenda-failure/article-182797

Wikipedia Statistics: http://en.wikipedia.org/wiki/Data_transformation_%28statistics%29

Appendix

Step 1

1.1 Research results in financial capital: use government investments on lower education into the model instead of investments on higher education

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.894[a]	.799	.793	.1581805

a. Predictors: (Constant), Gov_Lowedu, Gov_RD, Business_RD, PE

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.685	4	3.421	136.739	.000[a]
	Residual	3.453	138	.025		
	Total	17.138	142			

a. Predictors: (Constant), Gov_Lowedu, Gov_RD, Business_RD, PE
b. Dependent Variable: WKCI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.297	.194		-1.531	.128
	Gov_RD	.015	.012	.052	1.254	.212
	Business_RD	.199	.018	.622	11.020	.000
	PE	.104	.016	.409	6.502	.000
	Gov_Lowedu	-.055	.037	-.095	-1.475	.143

a. Dependent Variable: WKCI

1.2 Partial Least Square regression on how financial capital indicators influence WKCI

Proportion of Variance Explained

Latent Factors	Statistics				
	X Variance	Cumulative X Variance	Y Variance	Cumulative Y Variance (R-square)	Adjusted R-square
1	.653	.653	.690	.690	.688
2	.123	.776	.096	.786	.783
3	.131	.907	.010	.796	.792
4	.034	.942	.008	.804	.798
5	.058	1.000	2.564E-5	.804	.796

Parameters

Independent Variables	Depende...
	WKCI
(Constant)	-.198
Gov_RD	.005
Gov_Lowedu	-.118
Gov_Highedu	.061
Business_RD	.203
PE	.105

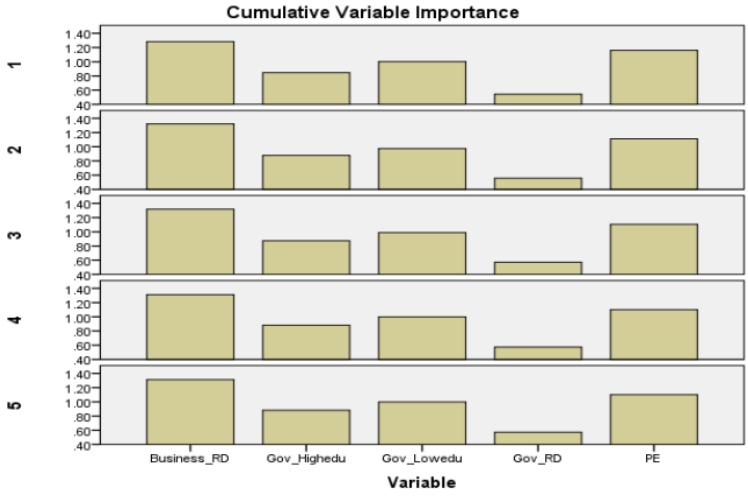
Variable Importance in the Projection

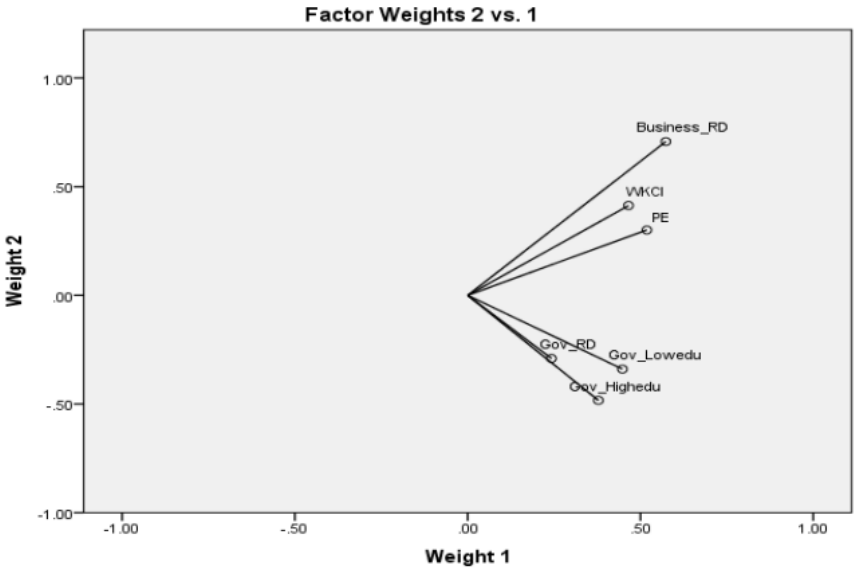
Variables	Latent Factors				
	1	2	3	4	5
Gov_RD	.542	.556	.572	.573	.573
Gov_Lowedu	1.001	.975	.988	.998	.998
Gov_Highedu	.846	.878	.873	.882	.882
Business_RD	1.282	1.322	1.318	1.312	1.312
PE	1.159	1.112	1.105	1.100	1.100

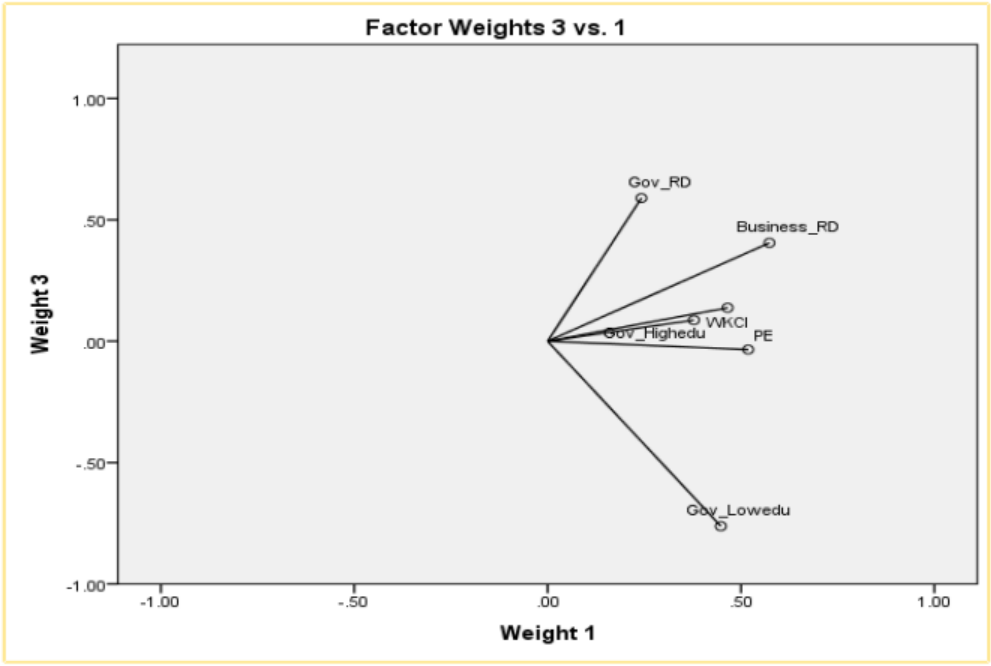
Cumulative Variable Importance

Weights

Variables	Latent Factors				
	1	2	3	4	5
Gov_RD	.242	-.291	.590	-.278	.193
Gov_Lowedu	.448	-.339	-.762	-.795	-.225
Gov_Highedu	.378	-.484	.087	.706	-.204
Business_RD	.573	.707	.405	.119	-.490
PE	.518	.301	-.034	.217	.798
WKCI	.465	.413	.138	.210	.009




Factor Weights 2 vs. 1
Weight 2
Weight 1
1.00
.50
.00
-.50
-1.00
-1.00
-.50
.00
.50
1.00
Business_RD
WKCI
PE
Gov_RD
Gov_Lowedu
Gov_Highedu


Factor Weights 3 vs. 1
Weight 3
Weight 1
1.00
.50
.00
-.50
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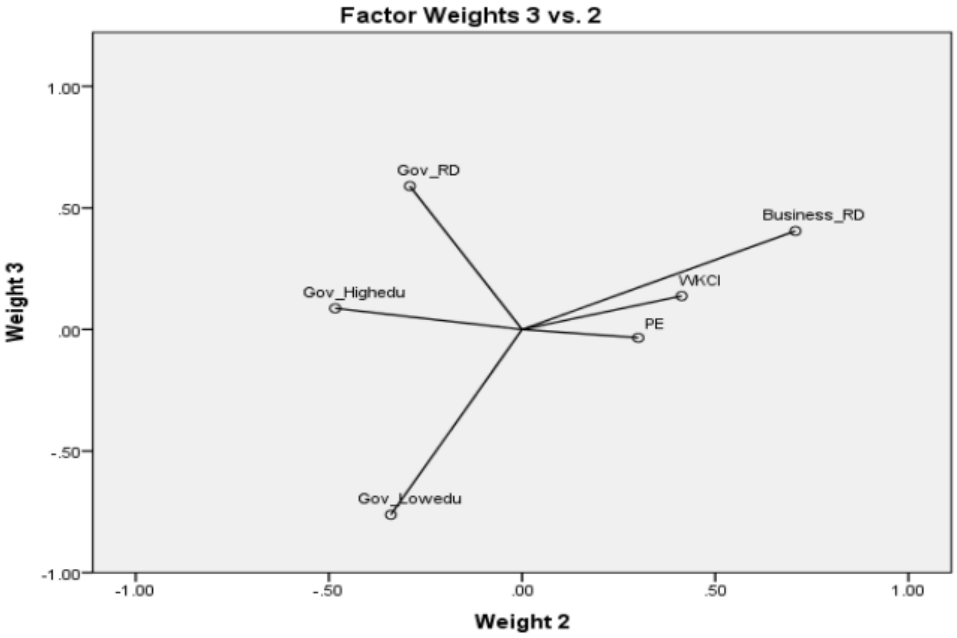
1.00
Gov_RD
Business_RD
WKCI
Gov_Highedu
PE
Gov_Lowedu



1.3 Regression with only government investments on higher education, business R&D investments and Private Equity investments on WKCI

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.891[a]	.795	.790	.1591573

a. Predictors: (Constant), PE, Gov_Highedu, Business_RD

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.617	3	4.539	179.191	.000[a]
	Residual	3.521	139	.025		
	Total	17.138	142			

a. Predictors: (Constant), PE, Gov_Highedu, Business_RD
b. Dependent Variable: WKCI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.593	.114		-5.215	.000
	Gov_Highedu	.017	.022	.038	.767	.445
	Business_RD	.192	.017	.600	11.246	.000
	PE	.087	.014	.343	6.084	.000

a. Dependent Variable: WKCI

Step 2

Step 2.1 Factor analysis

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.068	34.086	34.086	3.068	34.086	34.086	3.015	33.495	33.495
2	2.581	28.673	62.759	2.581	28.673	62.759	2.159	23.992	57.487
3	1.068	11.867	74.626	1.068	11.867	74.626	1.543	17.139	74.626
4	.671	7.458	82.084						
5	.523	5.811	87.895						
6	.389	4.317	92.212						
7	.344	3.818	96.030						
8	.215	2.385	98.416						
9	.143	1.584	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
Gov_RD	.630	-.269	.443
Gov_Lowedu	.873	.210	-.288
Gov_Highedu	.874	-.038	-.151
Business_RD	.619	.559	.279
PE	.740	.367	.007
HC_IT	-.210	.591	.674
HC_Bio	-.062	.703	-.192
HC_Mech	-.197	.723	-.436
HC_Elec	-.357	.806	.083

Extraction Method: Principal Component Analysis.
a. 3 components extracted.

Step 2.2 Put factor1 into regression analysis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.882[a]	.777	.769	.1561531

a. Predictors: (Constant), HC_Elec, REGR factor score 1 for analysis 1, HC_Bio, HC_IT, HC_Mech

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.159	5	2.232	91.532	.000[a]
	Residual	3.194	131	.024		
	Total	14.354	136			

a. Predictors: (Constant), HC_Elec, REGR factor score 1 for analysis 1, HC_Bio, HC_IT, HC_Mech
b. Dependent Variable: WKCI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.804	.053		15.244	.000
	REGR factor score 1 for analysis 1	.265	.014	.815	18.982	.000
	HC_IT	.117	.015	.396	7.978	.000
	HC_Bio	-.032	.020	-.081	-1.632	.105
	HC_Mech	-.003	.021	-.008	-.150	.881
	HC_Elec	.041	.024	.106	1.684	.095

a. Dependent Variable: WKCI

Step 3

3.1 Regression with four financial capital indicators without government investments on lower education, human capital in IT, and GUC on WKCI

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.921[a]	.848	.839	.1316794

a. Predictors: (Constant), GUC, HC_IT, Gov_RD, PE, Business_RD, Gov_Highedu

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.595	6	1.599	92.228	.000[a]
	Residual	1.717	99	.017		
	Total	11.312	105			

a. Predictors: (Constant), GUC, HC_IT, Gov_RD, PE, Business_RD, Gov_Highedu
b. Dependent Variable: WKCI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.090	.131		-8.313	.000
	Gov_RD	.003	.014	.010	.210	.834
	Gov_Highedu	.098	.026	.219	3.783	.000
	Business_RD	.178	.020	.487	8.935	.000
	PE	.070	.014	.290	4.961	.000
	HC_IT	.085	.013	.286	6.358	.000
	GUC	.030	.110	.013	.271	.787

a. Dependent Variable: WKCI

3.2 Regression with government investments on higher education, business firms investments on R&D, human capital in IT, and GDP per capital on WKCI

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.914[a]	.836	.830	.1335517

a. Predictors: (Constant), GDP_pp, HC_IT, Business_RD, PE, Gov_Highedu

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.010	5	2.402	134.668	.000[a]
	Residual	2.354	132	.018		
	Total	14.364	137			

a. Predictors: (Constant), GDP_pp, HC_IT, Business_RD, PE, Gov_Highedu
b. Dependent Variable: WKCI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.788	.498		-3.587	.000
	Gov_Highedu	.052	.024	.113	2.126	.035
	Business_RD	.178	.018	.490	9.760	.000
	PE	.073	.014	.282	5.333	.000
	HC_IT	.074	.012	.251	5.975	.000
	GDP_pp	.097	.059	.111	1.633	.105

a. Dependent Variable: WKCI

Step 4

4.1 Regression with government investments on higher education, business investments on R&D, private equity investments on knowledge , human capital investments on IT and two location dummies on WKCI

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.918[a]	.843	.836	.1313283

a. Predictors: (Constant), Dummy_EU, HC_IT, PE, Gov_Highedu, Business_RD, Dummy_North American

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.105	6	2.017	116.973	.000[a]
	Residual	2.259	131	.017		
	Total	14.364	137			

a. Predictors: (Constant), Dummy_EU, HC_IT, PE, Gov_Highedu, Business_RD, Dummy_North American
b. Dependent Variable: WKCI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.784	.133		-5.889	.000
	Gov_Highedu	.038	.025	.084	1.525	.130
	Business_RD	.178	.018	.489	9.841	.000
	PE	.093	.013	.359	7.069	.000
	HC_IT	.072	.012	.244	6.019	.000
	Dummy_North American	.052	.044	.081	1.180	.240
	Dummy_EU	-.037	.038	-.055	-.959	.339

a. Dependent Variable: WKCI

4.2 Regression with government investments on higher education, business investments on R&D, private equity investments on knowledge, human capital investments on IT and one location dummy on WKCI

4.2.1 North American and non-North American regions

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.926[a]	.858	.849	.1274656

a. Predictors: (Constant), Dummy_North American, GUC, HC_IT, PE, Business_RD, Gov_Highedu

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.703	6	1.617	99.536	.000[a]
	Residual	1.609	99	.016		
	Total	11.312	105			

a. Predictors: (Constant), Dummy_North American, GUC, HC_IT, PE, Business_RD, Gov_Highedu
b. Dependent Variable: WKCI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.915	.143		-6.388	.000
	Gov_Highedu	.063	.027	.139	2.283	.025
	Business_RD	.175	.019	.480	9.312	.000
	PE	.073	.013	.303	5.523	.000
	HC_IT	.090	.013	.303	6.882	.000
	GUC	.040	.103	.017	.385	.701
	Dummy_North American	.085	.033	.130	2.589	.011

a. Dependent Variable: WKCI

4.2.2 European and non-European regions

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.926[a]	.858	.850	.1272265

a. Predictors: (Constant), Dummy_EU, GUC, HC_IT, Business_RD, Gov_Highedu, PE

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.709	6	1.618	99.972	.000[a]
	Residual	1.602	99	.016		
	Total	11.312	105			

a. Predictors: (Constant), Dummy_EU, GUC, HC_IT, Business_RD, Gov_Highedu, PE
b. Dependent Variable: WKCI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.912	.143		-6.389	.000
	Gov_Highedu	.078	.025	.173	3.138	.002
	Business_RD	.167	.019	.457	8.650	.000
	PE	.084	.014	.348	5.891	.000
	HC_IT	.086	.013	.288	6.644	.000
	GUC	.021	.103	.009	.201	.841
	Dummy_EU	-.078	.029	-.115	-2.664	.009

a. Dependent Variable: WKCI

4.2.3 Asian-Pacific and non Asian-Pacific regions

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.921[a]	.849	.839	.1315554

a. Predictors: (Constant), Dummy_Asia-Pacific, Business_RD, HC_IT, GUC, Gov_Highedu, PE

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.598	6	1.600	92.433	.000[a]
	Residual	1.713	99	.017		
	Total	11.312	105			

a. Predictors: (Constant), Dummy_Asia-Pacific, Business_RD, HC_IT, GUC, Gov_Highedu, PE
b. Dependent Variable: WKCI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.108	.133		-8.315	.000
	Gov_Highedu	.103	.025	.230	4.173	.000
	Business_RD	.176	.020	.483	8.855	.000
	PE	.072	.015	.298	4.861	.000
	HC_IT	.084	.014	.282	6.221	.000
	GUC	.031	.106	.013	.293	.770
	Dummy_Asia-Pacific	.020	.041	.023	.480	.632

a. Dependent Variable: WKCI