Are Science Valleys and Clusters Panacea for a Knowledge Economy? An Investigation on Regional Innovation System (RIS) - Concepts, Theory and Empirical analysis

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Abstract

This research elucidates the concept of regional innovation systems (RIS). It argues that RIS can be a platform to apply classroom innovation ideas into practical context. Key definitions are given and distinctions drawn between national and regional innovation systems. Then, by suggesting to a number of important variables portraying innovation such as education, knowledge transfer, linkage and communications, regulatory quality, cost of doing business, trade openness, R&D expenditure and high-tech export for twenty emerging and developed knowledge based economies from Asia-Pacific, Europe and Latin America are differentiate. We empirically study these features of innovative ability in our sample regions by applying nonparametric robust partial frontier order-m approach in cross-section data analysis collected from the WDI and WCY-2011 dataset for the period 2011. The empirical results highlight that South Korea, Singapore and Malaysia are the frontier region or best practice nations and follower region can emulate the best practice nations by learning their policy implications while building up a successful regional innovation system. Moreover, our study reveals that techno or science valleys and high-tech clusters are one of the panacea for a regional and thus overall economic development.

Keywords: Regional Innovation System, Nonparametric Order-m Analysis, Techno and Science Parks, High-Tech Clusters

1. Introduction

The Regional Innovation System (RIS) concept is recently becoming one of the most powerful policy tools for designing regional development strategies. RIS concept derived from the former concept of National Innovation System (Freeman, 1987; Lundvall, 1992; Nelson & Rosenberg, 1993). National Innovation System (NIS) is often defined as the complex interaction of individuals, institutions and organizations to generate new ideas and innovation for creating wealth of nations. In other words innovation does not always follow a linear path where R&D institutions are producing new ideas and products rather national or regional innovation system indicates that within an innovation system we can define their elements, the interactions, the environment and the frontiers that produce economically useful ideas and components (Lundvall, 1992). The very idea of regional innovation system is to promote innovation culture, competition and competitiveness for regional economic development. The relationship among

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local University, government and business firm are extremely important in the RIS. Particularly, local university can play a predominant role to establish a successful RIS. Universities in general produce, nourish and build skilled human resources for the community by providing tertiary education, training, research facility so on and so forth. Once the a critical mass of skilled human resources has been build in any region, the next step is to create proper employment opportunities for the mass. In this regard establishing a university based science park in local community can play a significant role by creating huge employment opportunities in the form of technology transfer, innovation, spin-offs, R&D activities, business incubators etc in today's world.

Historically, Philipe Cooke is the earliest one to deeply research the regional innovation system, and published the “Regional Innovations Systems: The role of governances in a globalized world”, in Cardiff university in 1992, which got much attention in the academe. Another reason why the academes attach importance to the regional innovation system is the huge success of the Silicon Valley in USA; Cheaboll in Korea, the miracle improved the importance of region in the innovation system.

There are many concepts of RIS these years from the different aspect. From a regional point of view, innovation is localized and locally embedded, not placeless, process (Storper, 1997; Malmberg & Maskell, 1997, Cooke, 2003). This view specially emphasizes on the role of proximity, prevailing sets of rules through the process of knowledge creation and diffusion (Lung, 1999; Chen, 2008). Cooke (2003) conceptualized the RIS from social aspect of innovation. In the aspect, he stressed the learning process between different departments within a company, including the department of R&D and University. He also added that bringing innovation from University classroom to commercial showroom depends on education, knowledge transfer, R&D linkage, investment in venture capital and ICT communications. Additionally, there are other arguments, such as Ashim and Isaksen (2002) considered the RIS as the regional clusters which are surrounded by supporting knowledge organizations for instance, universities, research institutes etc. Where Doloreux, 2002) argued that the RIS can conducive to the generation, using the agglomeration concepts and diffusing the knowledge and technology through the interacting interests among formal institutions and other organizations. In short we can say, the theory and concept of RIS raises in late 1990s based on theory of agglomeration economies, cluster theory and national innovation system. In a knowledge-based economy (KBE), speed and first mover advantage are central aspects of industrial competition. Therefore, information, technology and network economy become the necessary conditions for regional industrial development.

Technology-driven competition is technically difficult and links with Higher Education Institute (HEIs) enable local industry to grow early entrée to knowledge-based economies. This will fulfill the objective of local and national government to develop high technology sector as a source of direct and indirect employment opportunities and HEIs are seen as essential to facilitating the growth of the local high technology cluster. This makes universities as most productive source of skill human resources provider and boost local science park development by creating regional employment. Very few countries in the world successfully implement this theory and become the frontier of technology driven development phenomenon. Among them, South Korea, Singapore, Taiwan, Hong Kong, Japan, U.S.A, Germany, U.K, France are most notable countries. Now, the question is how university or research institute driven science parks works in regional innovation system for a particular region or country? Let's consider a local firm innovating a specific kind of automotive components, becomes the partner of a local university engineering department. The partnership is centered on an innovative programme, administered by the university, but funded jointly by the national research council, the regional industry ministry and the firm itself. The university will advertise accordingly for the doctoral candidate to enable a doctoral student to write his or her thesis on a subject of direct relevance to the firm's innovation needs. As one student completes the dissertation and eventually may become an employee of the firm, the programme yields up a new doctoral candidate to solve the next generation of innovation problem. In this way university become the centre of regional innovation hub and part of regional economic resilience. Side by side regulatory quality cost of doing business, trade openness, Gov. R&D expenditure and high-tech export plays a crucial role in regional innovation development. Hence, no matter how we can divide the innovation system, the foundation and the target is the same, both of them, NIS and RIS aim at creating more innovation and speed the regional economic development.

1.1 Statement of the Problem of This Research

A consent to accept RIS as a regional development model seems to have been reached. The question is how to set benchmarking strategy for the follower countries. Which model or policy should follower regions follow: Silicon Valley model, one of the western European success model, model of Asian tigers for instance Singapore, Korea or hybrid Japanese model? A more fundamental question is whether valleys and clusters are a panacea for a nation and a region? For example, Singapore jumped from old and traditional industries to forge manufacturing, but South Korea moved into a mature industry and then tried to move to new industries as catching up regions. South Korea starting to invest mature industries for instance, steel, iron, cement during 1970 and forming a government guided Cheaboll industrial clusters. Samsung, LG, Hyundai are the results of this initiatives afterwards (Nelson, 1993). Another set of difficulties occur in the application of the RIS concept into diverse regional perspective. Therefore building a RIS in follower regions is extremely important and, by applying non-parametric frontier analysis, we can answer the question what follower regions can learn from frontier countries to become more competitive. To solve our questions above we apply frontier approaches in compare to production function approaches. This research paper comprises six major sections. Starting from introduction, problem statement in section 1, section 2 highlights theory, some concepts of RIS and the distinction between NIS and RIS, section 3 explain the variables and descriptive statistics of the sample, section 4 explains the quantitative methodology for empirical analysis of RIS, section 5 discuss the results findings, policy implications and finally section six draws the conclusion and contribution of this research.

2. Theory Behind RIS Concept

RIS concept is based on three main approaches of sources of innovation:

Firstly, models of idea-driven endogenous economic growth theory by Romer (1986) and Jones (1998). According to them economic growth depends on the production of the idea-generating sector of the economy. The rate of new ideas production is a function of the stock of knowledge which implies previous generated ideas and the extent of efforts meaning human and financial capital devoted to the ideas- producing portion of the economy (Furman, 2002).

Secondly, the cluster-based theory of national industrial competitive advantages by Porter (1990) regards the manner in which microeconomic process interact with macroeconomic environment and national institutions to affect the overall level of innovation capacity in an economy. Porter identifies four major drivers in the regional innovation clusters: the quality and specialization of innovation outputs, the context for firms' strategy and rivalry and the demand conditions.

Finally, The National Innovation System (NIS) approach by Nelson (1993), Dosi, 1998, Lundvall (1992) and Edquist (1997) emphasizes the array of national policies, institutions and relationships that drive the nature and extent of country innovative output in RIS (Lim, 2006). This literature highlights the nature of the university system, the extent of intellectual policy protection, the universities and government in R&D performance and funding. Finally a brief distinction between NIS and RIS is given in Table 1.

3. Variables and Sample Statistics

3.1 Data and Variables

Influencing factors of RIS efficiency (Table 2) involve a lot of elements, including demographic structure, ICT infrastructure, Knowledge Transfer between industry-university, firm-level and Government R&D and innovation activities, economic and market size, trade openness, reliance on natural resources, financial structure, market circumstance, and government level. This is conformed to the relevant arguments of NIS or RIS approach and the New Growth Theory (Balzat, 2004). Firm is the most active and important factor in the process of commercialization of innovation which is represents by the output variable high-tech export as % total manufacturing export. The more firms are involved in R&D and innovation activities, the better would the RIS efficiency be. This is according to the arguments of Austrian school and Lundvall where they said free interaction of knowledge can create, disseminate economically useful knowledge that develop the wealth of nation (Afzal & Lawrey, 2012a). Schumpeter named this process as creative destruction of innovation process (ibid).

The age structure of population affects the RIS efficiency as well, since young people are thought to be more creative than the old. ICT infrastructure and

Table 1 The distinction between NIS and RIS

	NIS	RIS
Elements of the system	Mass production economy, process innovation	Knowledge economy, outcome of NIS policy
Inter-firm relationships	Market, emphasis on competition	Network economics, cluster policy
The knowledge infrastructure	Formal R&D laboratories, public R&D funding mostly	University Research, triple helix model using University on top, government funding and focus new product R&D
Institutions of the financial sector	Formal financial sector	Venture capital, informal financial sector
Firm strategy, structure and rivalry	Difficult to start new firms due to government control and formal financial sector	Easy to start new firms and venture capital plays a big role

Source: Lim, (2006), Cooke, (2003)

Table 2 Potential influencing factors for RIS efficiency and their proxy input-output indicators year 2011

Input factors	Proxy Indicators	Abbreviation	Source of variable
Demographic structure	Population ages 15 to 65 (%of total) as labor force	Lab	World Development Indicators (WDI) 2011
ICT infrastructure	Computer users per 1000	CU	World Development Indicators (WDI) 2011
Financial structure	Domestic credit provided by banking sector(% of GDP)	DCP	World Development Indicators (WDI) 2011
Research and Development	R&D expenditure % GDP	RDE	World Development Indicators (WDI) 2011
Education	School enrollment, secondary(%gross)	SE	World Development Indicators (WDI) 2011
Market circumstance	Cost of business start-up procedure(%of GNI per capita)	CBS	World Development Indicators (WDI) 2011
Knowledge transfer**	Knowledge transfer is highly developed between companies and universities	KT	World Competitiveness Yearbook (WCY) 2011
Openness	Trade (%of GDP)	TO	Penn Table version 0.7
Natural Resources endowments	Total natural resources rents(% of GDP)	TNR	World Development Indicators (WDI) 2011
Output indicator			
Economically valuable knowledge creation	High-tech export as % total manufacturing exports	HTE	World Development Indicators (WDI) 2011

** (Updated: MAY 2011, IMD WCY executive survey based on an index from 0 to 10) trade openness would affect the speed and scope of knowledge diffusion and in turn affect RIS efficiency. Furthermore, economic size and degree of openness determine the scale of domestic and international market for firms. The economy of scale and economy of scope are much easier to be achieved in a bigger market, and in turn influence the RIS efficiency indirectly (Balzat, 2004). Moreover, overdependence on nature resources would reduce the innovation capacity and RIS efficiency. Finally we already explained the importance of knowledge transfer between university to industry in the introductory part for successful RIS.

The twenty emerging and developed countries that we have chosen have some characters in common, particularly high university-industry relationship, skilled labor force and high degree of trade openness. The above mention features of RIS presence in our sample economies more or less. Table 3 shows the descriptive statistics of our sample year 2011 (cross-section sample).

4. Quantitative Methodology for Empirical Analysis of RIS

One of our objectives of this research is to do an empirical analysis of RIS model. Most of the existing works on RIS model are based on case study and descriptive technique. Very few of the studies use parametric or non- parametric methods to analyze RIS model in macroeconomic study for comparison on different emerging countries or regions (see Table 2B in Appendix section). Therefore as we mentioned earlier, this study apply non-parametric frontier technique to find out best practice region from our sample. Usually, Data Envelopment Analysis (DEA), Free Disposable Hull, partial frontier analysis technique are used under the umbrella of non-parametric analysis. To know more about DEA technique, we refer to Afzal & Lawrey (2012b, 2012c, 2012d, 2012e, 2012f). In this particular study, we apply unconditional partial order-m frontier approach. Nonparametric approaches have a clear advantage as the estimated functions can take almost any forms. In additionally, real world observations are often difficult to be described in a single dimension or dependent variable. One of the strength of the Non parametric technique is that it allows for an easy handling of multiple input factors as well as multiple innovativeness outcome or output factors. In contrast, the consideration of innovativeness measures as multiple dependent variables particularly is difficult to achieve relying on conventional regression technique (Broekel, 2008).

4.1 Unconditional Order-m Frontier Approaches

We discuss this technique in non- technical way so that common readers can understand the concept. In contrast to the FDH or DEA approach, the idea behind the order-m approach is that instead of evaluating a region's innovation performance with respect to the performance of all other regions/countries; Cazals (2002) propose to compare a region with a randomly drawn (sub-) sample of regions. The sub-sample size has to be specified by the researcher and is denoted by m, giving the name to the procedure. For instance, in our study we have 20 observations; therefore we can choose m= 5, 10, 15, 20 likewise in each step for calculating efficiency of the best practice region. This makes a partial frontier analysis by taking sub samples instead of all observations. Based on these partial

Table 3 Descriptive statistics of the input-output variables

	TO	TNR	SE	KT	RDE	LAB	HTE	DCP	CU	CBS
Mean	116.0	3.4644	88.63	5.38	1.98	67.30	21.71	130.78	565.73	9.2950
Median	88.720	2.343	92.23	5.02	1.97	67.0	16.09	132.8	798.91	3.300
Maximum	409.2	13.14	103.2	7.89	3.96	73.58	67.82	325.9	937.8	56.50
Minimum	29.31	0.0000	63.21	2.90	0.08	60.9	1.9	36.4	39.7	0.0
Std. Dev.	106	3.9	11.9	1.6	1.2	3.2	16.2	66.8	372.4	13.4
Observations	20	20	20	20	20	20	20	20	20	20

frontiers the evaluation of regions/country's' innovation performance are done in an identical style as in the DEA or FDH approach. Cazals (2002) exhibits order-m performance measure contains most of the characteristics of the FDH or DEA model; in addition, because the partial frontier is not enveloping all observations, it is less sensitive to outliers and noise in the data. For more technical details see Daraio and Simar (2007), Simar and Wilson (2006) for robust nonparametric frontier techniques and our appendix 1.1A.

5. Results and Discussion

The result presented in figure 01, 02, 03 and 04 are returned from software command namely FEAR (Frontier Efficiency Analysis with R) described by a Paul W. Wilson (2008). We select twenty emerging and developed knowledge-based economies to find out best practice country/region (see Appendix-1A). We try to demonstrate how empirical analysis can be done in the field of RIS. So far at our knowledge, no significant study has been done using our sample countries and order-m quantitative methodology. The obtained performance measure represents a Monte-Carlo rough calculation with 200 imitations (Cazals et al. 2002). Researchers have shown that in many applications, research conclusions are not really embroidered by particular choices of m, provided the value of m are less than the sample size, n (Simar and Wilson, 2006). To know how to calculate order-m efficiency, see package 'FEAR' by Paul W. Wilson (2010), p-27.

The first spider diagram (Figure 1) represents the order-m=5 partial frontier results where South Korea, Malaysia, Switzerland and Singapore are the best practice region in 2011 compare to other sample countries. The second diagram (Figure 2) exhibits the consecutive results of fig: 01 in the case of m=10. In Figure 3 China along with Asian 3 are appeared as best practice region in the case of m=15. The final Figure 4 show the full frontier analysis and South Korea, Malaysia and Singapore come as best practice frontier region in the RIS context. These 3 ASEAN (Association of South East Asian Countries) countries are consistently efficient in different partial frontier analysis (m=5, 10, 15 and 20). It implies that follower region or inefficient region (efficiency score less than 1) can learn the policy implications from them and apply according to the need of their economy. Our study briefly discussed South Korea, Malaysia and

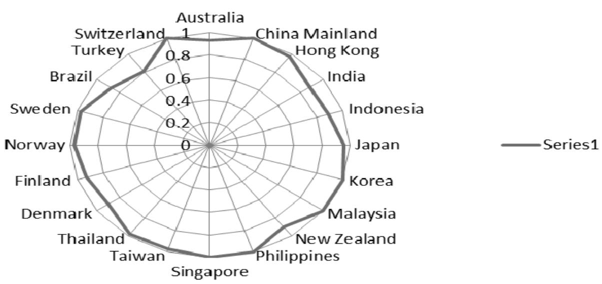

Figure 1 m=5 efficiency results

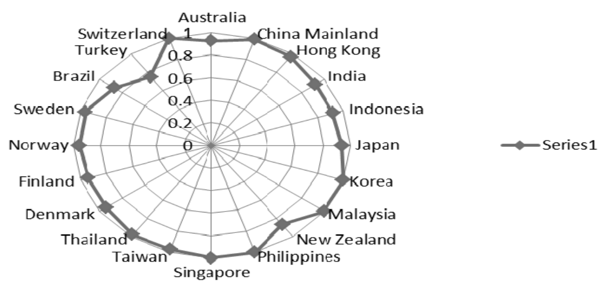

Figure 2 m=10 efficiency results

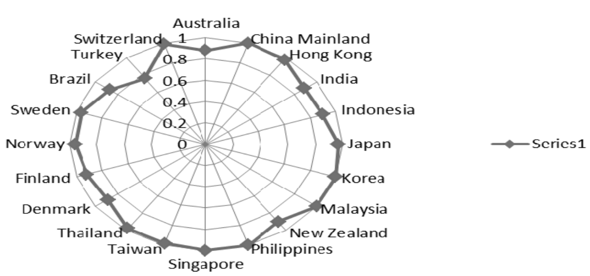

Figure 3 m=15 efficiency results

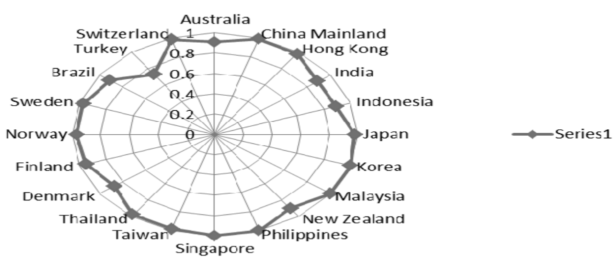

Figure 4 m=20 efficiency results

Singapore's RIS policies in the discussion section. We try to answer how these countries become best practice countries and achieve remarkable success in RIS using potential RIS input-output factors.

5.1 Policy Discussion

At the beginning of our paper, we stated the research problems as which model or policy should follower regions follow? And find out a more fundamental question is whether valleys and clusters are a panacea for a nation and a region? Now from our empirical results we got three best practice countries namely South Korea, Singapore and Malaysia compare to other sample DMUs (countries) in RIS framework. Therefore follower regions can now follow or emulate one of the RIS policies of frontier countries. We shall discuss the key RIS policies taken by these frontier countries and try to give the answer whether science park, high-tech clusters or region are the answer of a successful RIS for a nation. We start with South Korea; in order to boost the regional economy and enhance national competitiveness South Korea has established number of techno parks in the country. The main mission of establishing science or Techno Park is to transforming industry structure; attracting foreign high-techs, creating more jobs, accelerate technological innovation through networking industry, college, university, research center and local government collaboration and increase Korean global competitiveness by regionally specialized high technology. South Korea has high speed internet service, high number of computer users per 1000 population, low cost of doing business, availability of venture capital and well-structured government regulatory policy (Seo, 2006; Nelson, 1993). By using these resources, South Korea has established 16 high-tech parks within 1998-2005 periods and forms a business cluster named Cheaboll. This Cheaboll grouped followed a Japanese Keiretsu cluster model where government deliberately facilitates the business group in order to promote high-tech export (Nelson, 1993). During this short period of time, Korea has achieved remarkable growth of high-tech export (42.9% high-tech export as total manufacturing share, WDI-2010). Establishment of Techno-parks not only increase the high-tech export, but also establish the incubation of business, increase research and development, equipment utilization, pilot production, information sharing and education and training. During 1998-2003, the Korean government first took the initiatives to build institutional network among university, industry and local government and start business incubation of high-tech firms while in the second stage after 2003 until now, government emphasizes regional development by decentralizing Techno-parks to provide a balance national development. Due to this reason South Korean skill labor force, financial infrastructure, ICT network, secondary and tertiary education enrolment has been remarkably up surged (Nelson, 1993).

In line with economic geography theory location factors positively influenced economic development in Singapore. Singapore has leveraged the location advantages in order to drive to technological development to become a regional hub for R&D (Monroe, 2006). In 1980, seeking to emulate the success of science and high-tech clusters like Silicon Valley and Route 128, the government established the Singapore Science Park (SSP). The SSP has since been an integral part of the technological policy that underpins Singapore's economic growth strategy. The primary reason to develop the SSP was to provide and upgrade local infrastructure to attract MNCs and new industries that favor locations with proximity to research institutions for instance universities (Monroe, 2006). In addition the SSP was perceived to serve as an incubator for high-tech industries and be the locus for R&D growth, skilled human resources development, well financial structured, availability of bank credit for new venture, employment generation and overall ensure high-tech driven growth. Venture capital is another important component for successful RIS in Singapore. The growth of new high-tech or medium tech manufacturing firms depends on venture capital availability in Singapore. In reality venture capital follows the innovation initiative (Lim, 2006). Theoretically venture capital is money provided by an outside investor to finance a new, growing or troubled business. The venture capitalist provides the funding knowing that there's a significant risk associated with the company's future profit and cash flow. Capital is invested in exchange for an equity stake in the business rather than given loan, and the investor hopes the investment will yield a better-than-average return. Venture capital typically looks for new and small businesses with a perceived long term growth potential that will result in a large payout for investors. Therefore it plays a vital role for generating finance to back idea driven venture in a knowledge -based economy. In 2011, Singapore scored 6.05 which are the highest in Asia-Pacific region in venture capital easily available for business index (Updated: MAY 2011, IMD WCY executive survey based on an index from 0 to 10).

Unlike Singapore, Malaysia which is one of our best practice regions from our calculation, develop and strengthen their country around the vision 2020, which also serve as the nation’s roadmap for economic development. Under this roadmap Malaysia has established number of key institutions that are related ICT growth and high-tech clusters. Malaysian Development Corporation (MDC) one of these key institutions that builds Multimedia Super Corridor (MSC), the country’s most prominent science and high-tech cluster. The MSC is Malaysia’s flagship science and high-tech research project. It encompasses Kuala Lumpur and five other key infrastructural projects that are PETRONAS Twin Tower, Putrajaya, Cyberjaya- an intelligent research and development city, Technology Park Malaysia and Kuala Lumpur tower. The main objectives of MSC are successfully developed science and high-tech parks in order to 1) raise the level of technological sophistication of local industries, through the promotion of R&D; 2) promote foreign investments, especially in higher value added activities and finally 3) accelerate the transition from a labor intensive to a knowledge-based economy (Nelson, 1993).

Hence, this discussion indicates that all three best practice countries from our calculation have bought into theories from economic geography, NIS and cluster approach that location does matter in RIS context. In other words, valleys and clusters are one of the panaceas for a regional development. These countries are following policy prescription to develop strong regional and national innovation systems by giving emphasize on Techno parks, high-tech clusters. In additionally these parks are leading the overall economic development by creating employment opportunities, increasing skilled human resources, widening market for high-tech products by high degree of trade openness, maintaining well financial structure and spur ICT driven growth. Initially South Korea, Singapore and Malaysia follow the policies of frontier regions in RIS for instance Silicon Valley, Route 128 or Japanese Keiretsu cluster models to build similar kind of strategy in their respective countries (see section 3C, the explanation of common socio-economic factors that encourage these countries to pursue best practice RIS policies). Hence, our methodology and policy discussion also indicates that there is a need of frontier analysis for successful RIS policy implication in the follower nations.

6. Conclusion

In this study, the strategic intellectual and policy concepts of regional innovation systems has been introduced, defined and put to empirical and action-related terms. The new world economic order now tends to privilege the regional as the correlate of global, because of the rise to prominence of globally competitive regional and local industrial high-tech clusters, Techno-Parks and science city. In applying the concept and empirical analysis to twenty developed and emerging knowledge-based nations, it was instructive to note how variable specific regional innovation systems may look. By looking at such variables or dimensions as education enrolment, knowledge transfer between university to industry, trade openness, ICT users, R&D expenditure, high-tech export growth, it is possible to detect more strongly the importance and performance of regional innovation systems. Our research tries to answer the research question as which model or policy should follower regions follow? And find out a more fundamental question is whether valleys and clusters are one of the panaceas for a nation and a region? By addressing this question, this paper contributed to the existing literature in two ways. First, we apply a robust non-parametric unconditional order-m partial frontier approach to identify best practice nations in RIS context. It was argued in the paper that a partial frontier such as order-m approach is more applicable for analyzing regional innovation system framework than traditional FDH (Free Disposable Hull) approach due to the advantage of overcoming outliers or extreme points from the sample. We apply a cross-section approach and use latest dataset from World Development Indicators-2011, World Competitiveness Yearbook-2011 and Penn world table for our analysis. We have found that South Korea, Singapore and Malaysia are the best practice countries among most of the emerging and developed knowledge-based countries from our sample. While doing a policy analysis of these three countries, our study reveals that location does matter for successful regional innovation system. Our findings indicate that investing on Techno-parks, Science city or high-tech clusters certainly generate more employment opportunity, build skilled labor force, well-structured financial systems, encourage venture capital in regional locations, and thus ensure a balanced economic development. By combining the strong policy points of each best practice nations (South Korea, Malaysia and Singapore), policy-makers of follower regions could produce an interesting, profitable yet flexible vision of the role regional innovation systems thought which can play significantly in their economic destiny. Hence, in order to transform ideas from classroom education to practical policy implication, we believe, it is essential to investigate regional innovation system and its applications for future knowledge based generations. In future research, we recommend conditional order-m and α (alpha) frontier analysis to observe the comparison of our sample regions with regions having similar values in an external factor z, e.g. the externality variable. In order to achieve (conditional order-m analysis), the m observations are not drawn randomly but conditional on the external factors. We believe, it is worth looking into how results vary when we put condition on the selection of m in order-m frontier analysis.

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Appendix

1A Technical Aspects of Unconditional Order-m Frontier Analysis:

The main idea of the unconditional *order-m* is simple. For instance, in a multivariate case consider (x_0, y_0) as the inputs and outputs of the unit of interest. (X_1,Y_1),.......,(X_m, Y_m) are the inputs and outputs of *m* randomly drawn units that satisfy $X_i \leq x_0$. $\tilde{\lambda}_m$ (x_0, y_0) measures the distance between point y_0 and the order-*m* frontier of Y_1,......, Y_m. It can be written as:

$$\tilde{\lambda}_m (x_0, y_0) = \max_{(i=1,.....,m)} \{\min_{j=1,......,q}(\frac{Y_i^j}{y^j})\} \quad (1A)$$

with $Y_i^j(y^j)$ with the *j*th component of Y_i(of y_0 respectively). The order-m efficiency measure of unit (x_0, y_0) is defined as

$$\lambda_m (x_0, y_0) = E[\tilde{\lambda}_m (x_0, y_0) \updownarrow X \leq x_0] \quad (2A)$$

The obtained performance measure the radial distance of the unit to the order-m frontier. Note that in any case a unit is at least compared to itself which results in a performance score of one. For an extensive treatment on the conditional and unconditional *order-m* approach see Simar and Wilson (2006).

2A Common Factors that Enable RIS Growth in Best Practice Countries

The most obvious similarity among South Korea, Singapore and Malaysia while becoming high-performing economies of South East Asia are the high proportion of GDP devoted to investment. These economies have relied heavily on foreign direct investment (FDI), which accounted for a high proportion of total capital formation in these economies over the last two decades, and especially from 1986 onward when the revaluation of the yen, the won and the Taiwanese dollar led to a marked acceleration in outward foreign investment flows from North East Asia into other parts of the region. Therefore RIS economists point out that much of the growth in output per worker in South East Asia can be accounted for by growth in capital stock per

Table 1A Efficiency scores for order-m from FEAR software

Country	Order m=05	Order m=10	Order m=15	Order m=20
Australia	0.93	0.9283	0.88	0.91
China Mainland	1	0.99	1	0.99
Hong Kong	0.97	0.97	0.98	0.98
India	0.88	0.92	0.89	0.89
Indonesia	0.89	0.92	0.9	0.89
Japan	0.96	0.94	0.97	0.98
South Korea	1	1	1	1
Malaysia	1	1	1	1
New Zealand	0.9	0.87	0.9	0.9
Philippines	0.9	0.98	0.9	0.9
Singapore	1	1	1	1
Taiwan	0.97	0.97	0.98	0.98
Thailand	0.98	0.98	0.98	0.98
Denmark	0.9	0.94	0.89	0.87
Finland	0.93	0.94	0.92	0.95
Norway	0.97	0.96	0.96	0.97
Sweden	0.97	0.96	0.96	0.97
Brazil	0.87	0.87	0.87	0.91
Turkey	0.81	0.75	0.76	0.73
Switzerland	1	1	0.99	0.98

Table 2A Different empirical approaches to RISs

Country	Order m=05	Order m=10	Order m=15	Order m=20
Australia	0.93	0.9283	0.88	0.91
China Mainland	1	0.99	1	0.99
Hong Kong	0.97	0.97	0.98	0.98
India	0.88	0.92	0.89	0.89
Indonesia	0.89	0.92	0.9	0.89
Japan	0.96	0.94	0.97	0.98
South Korea	1	1	1	1
Malaysia	1	1	1	1
New Zealand	0.9	0.87	0.9	0.9
Philippines	0.9	0.98	0.9	0.9
Singapore	1	1	1	1
Taiwan	0.97	0.97	0.98	0.98
Thailand	0.98	0.98	0.98	0.98
Denmark	0.9	0.94	0.89	0.87
Finland	0.93	0.94	0.92	0.95
Norway	0.97	0.96	0.96	0.97
Sweden	0.97	0.96	0.96	0.97
Brazil	0.87	0.87	0.87	0.91
Turkey	0.81	0.75	0.76	0.73
Switzerland	1	1	0.99	0.98

worker, together with growth in education. Hence, the best practice countries for instance South Korea, Singapore and Malaysia achieved a rapid growth in innovation infrastructure is mainly due to high capital accumulation in early stage of economic development and well educated labor force. Moreover, it argues that South Korea, Singapore and Malaysia all grew fast in national or regional innovation system because their economic managers have got the macroeconomic fundamentals right or where these fundamentals were clearly wrong, governments were prepared to change tack (Rodrik, 1995; Rastin, 2003; Booth, 1998; Afzal & Manni, 2013).