National and Regional Innovation Systems, Industrial Policies and their Impacts on Firm Innovation Strategies and Performance - Economic Role of Knowledge

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Abstract

Innovation and technological change have always been taken into account as engines of growth. Innovation in society and more specifically innovation systems have been studied at various levels and with various scopes. These include National innovation systems (Lundvall 1992, Nelson 1993), Regional innovation systems (Cooke et al. 1997, Howells 1999), Sector Innovation Systems (Malerba 2002), Innovative Milieus (Camagni 1995), and Technological Systems (Carlsson 1995).The concept of National Systems of Innovation (NSI) and Regional Innovation Systems are the main theoretical tools attempting to take into account and integrate the importance of the economic environment for firms' possibility to innovate. The NSI and RSI can be seen as for two important and interrelated issues. On the one side, they are used to show international differences or similarities in countries' ability to innovate and to be on the technological edge. On the other side, they become a normative tool implemented to give policy suggestions in order to support firms' innovative activities. The only way the those two approaches sticks to finance is by looking at the best financial instruments for innovative firms. Since, the financialization of the economy plays a strong and harmful role that affects innovations by changing firms' corporate governance. This paper is divided as follows. The first section talks about the developments of the NSI and RSI concepts from its early stages. At further section, by looking at the definitions of the 3 pioneering people, some main features of the NSI and RSI are presented. Section 3 concentrates on the role played by the state within the NSI and RSI, by looking at the way it has been portrayed in the literature, and their connections with narrow vs. broad national system of innovation. Section 4 looks for different country cases. Section 5 finally discusses and concludes the paper.

Keywords: National Innovation Systems, Regional Innovation Systems, Firm Innovation, Economic Role of Knowledge.

I. INTRODUCTION

The National System of Innovation (NSI) concept had its origins by the end of the 1980s and middle of the 1990s (Freeman 1987, 1988; Lundvall 1988, 1992a; Nelson 1988, 1992, 1993; Pelikan 1988). The collaboration between Chris Freeman, Richard Nelson and Bent-Åke Lundvall in the International Federation of Institutes for Advanced Study (IFIAS) project was crucial for the development of the concept. Further, Regional System of Innovation (RSI) has an influence on innovation at regional level and thus it can also be assumed to have an influence on the competitiveness and success of a region. Also policy and decision makers have recognized the importance of innovation to the competitiveness of cities, regions and nations and the growing interest can be seen in many strategies and indexes measuring and illustrating competitiveness at different levels. The agenda for the theoretical development of the regional innovation system approach has been influenced by different theories. The major contributions to this approach have come from evolutionary, institutional and regional economics, economics of learning, economics of innovation and network theory (Doloreux 2002, p. 244). In particular an important foundation of the theory of regional innovation systems is in the ideas of Lundvall (1992) on national innovation systems. The elements comprising the institutional structure of a regional innovation system can be identified. According to Howells (1999) regional innovation systems are readily identifiable and meaningful from national innovation systems, depending to what extent a nation can be said to have a homogenous regional structure relating to innovation. The same components as in national innovation systems exist at regional level and these components can be used for the analysis of regional innovation systems. Nevertheless, regional innovation system is treated as a separate unit of analysis because the components of national innovation systems are delivered and responded to differently at regional level. Like national innovation systems, regional innovation systems and their characteristics, including the institutional set-up, evolve through time to be distinctive to that certain region (Cooke et al. 1997, p. 479).

To Schumpeter (1912), innovation consists of any of the following: i) introduction of a new good; ii) introduction of a new method of production; iii) opening a new market; iv) conquest of a new source of supply of raw materials or half-manufactured goods; and v) implementation of a new form of organization. Novelty is the key point here. Innovation, therefore, means to look for "something new" without knowing if this "new" will ever be reached, will ever be sold, will ever be profitable. Uncertainty is, therefore, a key feature of the innovation process and also any other thing e.g. financial systems of economies, firms.

Yet, the concept could not have been developed without a new notion of firms and innovation, thus positioning itself immediately within the evolutionary tradition. Ever since its beginning, the evolutionary approach rejected all orthodox economic tools: the production function, the hypothesis of perfect rationality and complete information, and technology as a “freely available black box” costly to produce but not to transfer (Nelson and Winter 1974, 1982). Firms are not profit-maximizing agents choosing from a well-defined and exogenously given set of choices. They are, instead, agents dealing with an uncertain environment, especially as far as innovation is concerned. They learn through imperfect adaptation and mistake-ridden discovery, because it is not possible to believe that the best response has already been learned, but rather it is still to be learned. Firms face uncertainty, also due to innovation, and must learn how to deal with it. At that point, both systems' institutional structure facilitating innovation includes several elements: *industry specialization and structure*, *governance structure* and its autonomy including public and private administrative set-up and intermediating structures, *financial system* and its autonomy including finance of activities of firms, R&D and infrastructure, *structure of the research and development functions* as a part of knowledge generation, *training and competence building system*, *non-organizational institutions* such as contracts, laws and norms and *operational cultural factors* (Howells, 1999, Cooke, et al. 1997, Autio, 1998).

Moreover, a system of innovation is constituted by elements and relationships which interact in the production, diffusion and use of new knowledge (Lundvall, 1992, p. 2). This knowledge is exploited for practical, including commercial use (Cooke, et al. 1997, p. 478). Thus the knowledge created, diffused and used is not always in the form of commercial products or services but can have practical and social effects. More specifically knowledge may take the form of new ideas and concepts, new skills or competencies, or technological and organizational advances (Schienstock & Hämäläinen, 2001, p. 78). An innovation system is a social and dynamic system (Lundvall, 1992, p.2). The system is social because a central activity in the system, learning, is a social activity. Innovation in the system involves positive feedback and reproduction which makes it a dynamic system. Thus innovation is not a linear but a recursive process and the system is recursive by nature (Schienstock & Hämäläinen, 2001, p. 78). Moreover, in the evolutionary approach, novelty streams from new knowledge, thus making innovation an interactive social learning process. Only when new knowledge is created can innovation flourish. (Schumpeter, 1912)

Knowledge contains two dimensions: a “public” one, taking the shape of information easily codified in patents, blueprints, textbooks, etc.; and a “tacit” one, embodied in routines, skills, competencies, and specific practices (Nelson and Winter 1982, chapter 4; Polanyi 1967). The public aspect is costly to create but costless to transfer or to make available to others once it has been created. By contrast, the tacit one is not so easily transferred, being the result of different learning processes: learning by doing, by using, by searching, by imitation, by interaction, and by cooperation (Howells 2002). Due to this tacit aspect, new knowledge and innovations are partially context-specific and localized, thus calling for the introduction of geographical aspects. When the geographical distance is negligible, and the language and culture are common, the tacit aspects are easier to transfer. Thus, an interaction between space and innovation occurs, with the development of concepts such as national, regional, and local systems of production.

If NSI and RSI systems can be understood well; linearly the economic role of knowledge will exist and uncertainty will be avoided thus financial systems of economies and firms will learn more the environment. Learning is a central function in innovation systems.(Cooke et al. 1997). The most important learning processes for innovation are interactive and partially emanate from routine activities. These include learning-by-doing, learning-by-using and learning-by-interacting, or the experience-based mode of learning (Jensen et al. 2007). Encompassing these processes for continuous learning may emerge, which includes an efficient and embedded culture of knowledge sharing and circulation (Kautonen 2006, p. 270). Also more deliberate searching and exploring activities (Lundvall 1992, p. 11) and scanning and invention (Howells, 1999, p. 82) take place in innovation systems for expanding the knowledge of actors. And this is the main aim of this paper to show how NSI and RSI can be best learnt from all related parties to strengthen both firms take place in economies and economies themselves.

II. LITERATURE REVIEW

The concept of National Systems of Innovation was developed in the 1980s and is mainly incorporated with three authors: Freeman (1987), Lundvall (1992) and Nelson (1993). The concept presented a new approach to innovation and its governance and stimulation as compared to the more neoclassical, market failure approaches (Soete, Verspagen, and Ter Weel, 2010). Adopting a holistic view of innovation rather than relying on isolated aspects of the process, the NSI concept emphasizes the interaction of actors take place in innovation and analyses how these interactions are shaped by social, institutional and political factors (Fagerberg and Verspagen, 2009). The approach was totally became successful in a short period of time and is now being used in academia and policy contexts (Teixeira, 2013). It is often used as an analytical framework (Sun and Liu, 2010) for studying the differences between countries interested in their production and innovation systems (Álvarez and Marín, 2010). In order to understand the NSI concept, one can begin with the work of the three 'fathers' of the term, mentioned above, also acknowledging, however, Friedrich List.

The first person to use the expression 'the National System of Innovation' was Bengt-Ake Lundvall….However, as he and his colleagues would be the first to agree (and as Lundvall himself points out), the idea actually goes back at least to Friedrich List's conception of 'The National Systems of Political Economy' (1841), and this might just as well have been called 'The National System of Innovation' (Freeman, 1995:5).

Table 1 Some NSI Definitions

Freeman (1987, p. 1)	Over the last two centuries those scientific and technical activities which are intended to promote the flow of technical and organisational innovations and their diffusion have vastly increased in scale and have become highly specialised in a variety of institutions. At the same time national education and training systems, which may both encourage and disseminate advances in technology, have expanded largely to ensure that the labour force has the changing mix of skills needed to diffuse and operate these new techniques efficiently. The network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies may be described as 'the national system of innovation'.
Lundvall (1992, p. 12)	The narrow definition would include organisations and institutions involved in searching and exploring – such as R&D departments, technological institutes and universities. The broad definition […] includes all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring….
Nelson (1993, p. 4-5)	There is, first, the concept of a national system of innovation itself. […] Consider the term "innovation." In this study we interpret the term rather broadly, to encompass the process by which firms master and get into practice product designs and manufacturing processes that are new to them, if not to the universe or even to the nation. […] Then there is the term "system." […] Rather the concept is of a set of institutions whose interactions determine the innovative performance, in the sense above, of national firms. […] Rather, the "systems" concept is that of a set of institutional actors that, together, plays the major role in influencing innovative performance.

Definitions of National Innovation Systems

"... The network of institutions in the public- and private-sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1987)
"... The elements and relationships which interact in the production, diffusion and use of new, and economically useful knowledge... and are either located within or rooted inside the borders of a nation state" (Lundvall, 1992)
"... The set of institutions whose interactions determine the innovative performance of national firms" (Nelson and Rosenberg, 1993)
"... The national system of innovation is constituted by the institutions and economic structures affecting the rate and direction of technological change in the society" (Edquist and Lundvall, 1993)
"... A national system of innovation is the system of interacting private and public firms (either large or small), universities, and government agencies aiming at the production of science and technology within national borders. Interaction among these units may be technical, commercial, legal, social, and financial, in as much as the goal of the interaction is the development, protection, financing or regulation of new science and technology" (Niosi et al., 1993)
"... The national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country" (Patel and Pavitt, 1994)
"... That set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artifacts which define new technologies" (Metcalfe, 1995)

Source: Niosi, 2002, p. 292

By looking at these authors' definitions, some aspects are confusing and striking (Table 1). First, they all share institutional aspects: the NSI is embedded and/or encompasses institutions and/or the institutional set-up of the economy. Yet, drawing from the "old" and "new" institutional economics, the evolutionary tradition utilizes a very broad concept of institutions, encompassing almost everything: "They encompass not only simply organizations - such as corporations, banks and universities - but also other social entities such as money, language and law" (Hodgson 1998, p. 179). Habits, rules, customs, traditions, social conventions and norms are all institutions. Therefore and consequently, if institutions are everything, anything that impacts on "institutions" will also affect the NSI. Such broad definitions are sometimes useful in identifying the NSI key elements and the features affecting them. The NSI concept becomes such a broad one that it can explain almost everything, and that means nothing conversely. Furthermore, they present the idea that anything—meaning all aspects of a nation (social, political, legal, cultural, etc.)—must revolve around firms' ability to innovate.

Freeman (1987) used the concept to describe and explain Japan's innovation performance. He specifically focused on the linkages between technology, social embeddedness, economic growth and system-enforcing feedback loops (Soete et al., 2010). The emphasis in his work was placed on four elements of the Japanese NSI:

o the role of policy (in particular the role of the Ministry of International Trade and Industry),
o the role of corporate research and development (R&D) in accumulating knowledge and developing advantages from it,
o the role of human capital, the organization of work and the development of related capabilities,
o and finally the role of industrial conglomerates in being able to profit from innovations emerging from developments along with the whole industrial value chain.

Freeman has a definite normative approach, which can be captured by the subtitle of the book itself: "Lessons from Japan." The author's task is clearly stated in the Introduction: "This study is about some features of the Japanese system of innovation and their implications for other countries." (Freeman, 1987, p. 1). And, "The book concentrates on the analysis of Japanese experience in the belief that comparative international studies can yield lessons of great importance for policy-makers, whether in the public or the private sector." (Freeman 1987, p. 3). Yet some authors' words of caution about Freeman's awareness that policies and institutions which appear to have applied well in one country cannot be systematically transferred to a very different social, economic and cultural context, some crucial social and institutional innovations can be widely and successfully diffused to other countries, with a important time lag.

Lundvall has a more mixed approach. On the one side, the author claims that "one of the main purposes of this book is to contribute to a theoretical understanding of interactive learning and innovation" (Lundvall 1992a, p. 4), thus leading to a descriptive dimension. On the other side, the author carries on by stating that "the concept 'national system of innovation' may also be useful when it comes to inspire public policy at the national and international level" (Lundvall, 1992a, p. 4), thus leading to a normative dimension. Like Freeman, Lundvall (1992) underlines the role of interaction for the production and the dissemination of new and valuable knowledge, shifting away from a sectoral view towards a broader view of the national institutional environment. Emphasizing the role of the nation state, Lundvall presents three major building blocks of an NSI (see Fig. 1). The first building block deals with the sources of innovation and the actions of agents which lead to innovation, such as learning and exploration. The second building block distinguishes between two types of innovation, namely radical and incremental innovation. Finally, non-market institutions form the third building block. For these, Lundvall distinguishes between user-producer interaction as an significant form of knowledge exchange and institutions and their uncertainty reduction function. These institutions play a particularly main role in the NSI concept.

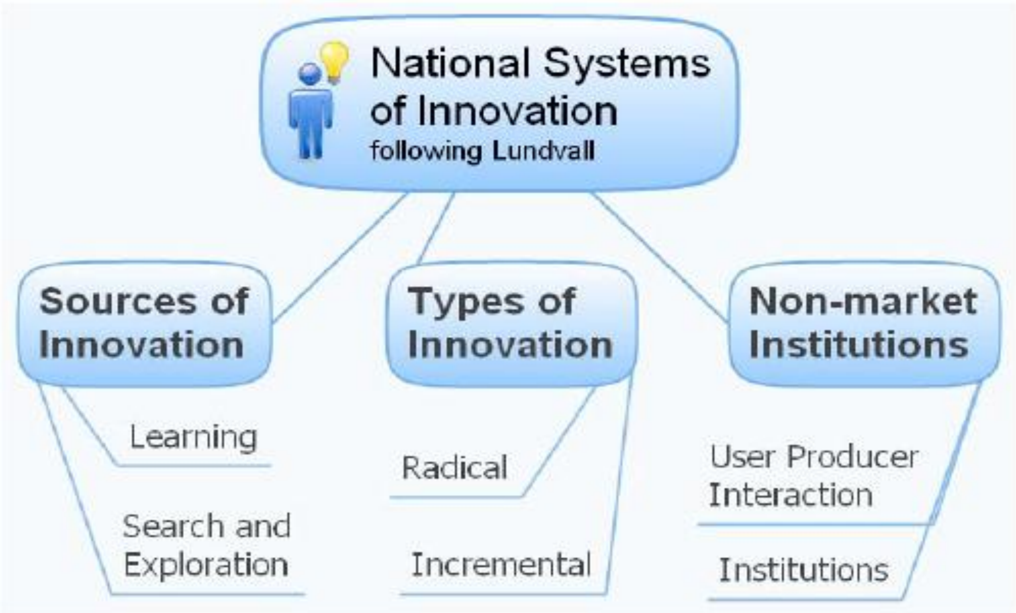


Fig. 1: National Systems of Innovation building blocks according to Lundvall (1992)

The third main author in the field, Richard Nelson (1993), relies on the set-up of actors and how and why they collaborate. He is mostly dealt with the institutions working in the science and technology sector or supporting it, especially universities conducting R&D. Nelson has a more definitive descriptive dimension. In a previous article summarizing the central context of his book, and Nelson (1992, p. 347) shows that “The studies were carefully designed, developed, and written to illuminate the institutions and mechanisms supporting technical innovation in the various countries, the similarities and differences across countries and how these came to be, and to permit at least preliminary discussion of how the differences seemed to matter.”

Relying upon these three major contributions, the NSI approach has been developed further over the past 20 years, and is now considered to be "one of the most important concepts to emerge in the field of innovation studies" (Martin and Bell, 2011: 896). The concept is widely utilized in country strategies for innovation – in both developed and developing countries. The first developing country to utilize the NSI concept in developing its overall innovation strategy was South Africa. Current work draws on Nelson when analyzing the institutions of an innovation system and how the system is organized, and on Lundvall when the focus is on knowledge creation and learning. In the latter case, the learning society, which creates knowledge, is considered to be the most important resource of an innovation system and learning its main mechanism. From this starting point, **the notion of the knowledge economy** was developed (Godin, 2006).

On the empirical side, the literature has been started to growing and expanding (Balzat and Hanusch, 2004). The empirical studies share the common methodological approach: the key elements of an NSI must be identified and, when possible, measured. This literature agreed upon that the most significant elements of any NSI are the following: innovative firms; public and private institutions conducting and supporting research and promoting the diffusion of knowledge and innovation; the systems of education and training of the personnel; and financial systems. For each of these components, statistical data are collected and utilized as proxies to measure all NSI elements, thus allowing international comparisons, caused to the search for “the best” NSI used as a benchmark for other countries (Patel and Pavitt 1994). So, the theoretical tool started to become a normative one, with strong policy suggestions, immediately adopted by policymakers (OECD 1988, 1997).

The NSI approach assumes homogeneity within countries, but this is not necessarily the case. On many indicators (e.g. economic performance, poverty, R&D investment) areas within countries can differ significantly (see Bavaria versus Saxony-Anhalt in Germany, for instance). Consequently, researchers and scholars of innovation systems have developed a regionally-based approach of innovation system thinking, with 'regions' mostly referring to a geographical area within a country. The research focus in the Regional Systems of Innovation (RSI) concept therefore rests on the relationship between technology, innovation and industrial location (D’Allura, Galvagno, and Mocciaro Li Destri, 2012). This spatial concentration continues to be important for innovative activities, despite the argument that modern information and communication technologies would render spatial distances between communication partners unimportant (Asheim and Gertler, 2005). Silicon Valley is normally used as the prime example for a region with great innovative potential.

Even though many aspects of the NSI approach can be applied at the regional level, the RSI approach differs significantly from the former (Korres, 2012, 2013). The internal organization of firms, the relationships between firms, the role of the public sector and public policy as well as the institutional set-up of, for example, the financial sector, are amongst the features that can be explored in detail at a regional level. At a national level these aspects could differ decisively.

The RSI approach thus underlines the regional dimension of the production and the exploitation of new knowledge, thereby helping to define regional differences in innovation capacity and economic strength.

This framework supports the generation, exploitation and dissemination of knowledge and thus supports innovative activities on a regional level (B. T. Asheim, Coenen, and Svensson-Henning, 2003; Cooke, 2004; Doloreux, 2003). The RSI approach was developed mainly by scholars of geographic economy who were trying to understand the special role of institutions and organizations in the regional concentration of innovative activities (Asheim et al., 2003; Asheim and Gertler, 2005). At the same time, other closely connected concepts occurred such as the regional clusters (Porter, 1990), industrial districts (e.g. Becattini, 2004; Scott, 1988), Technopole (e.g. Benko, 1992), learning regions (e.g. Florida, 1995) and innovative milieu (Maillat, 1995; Crevoisier, 2004).

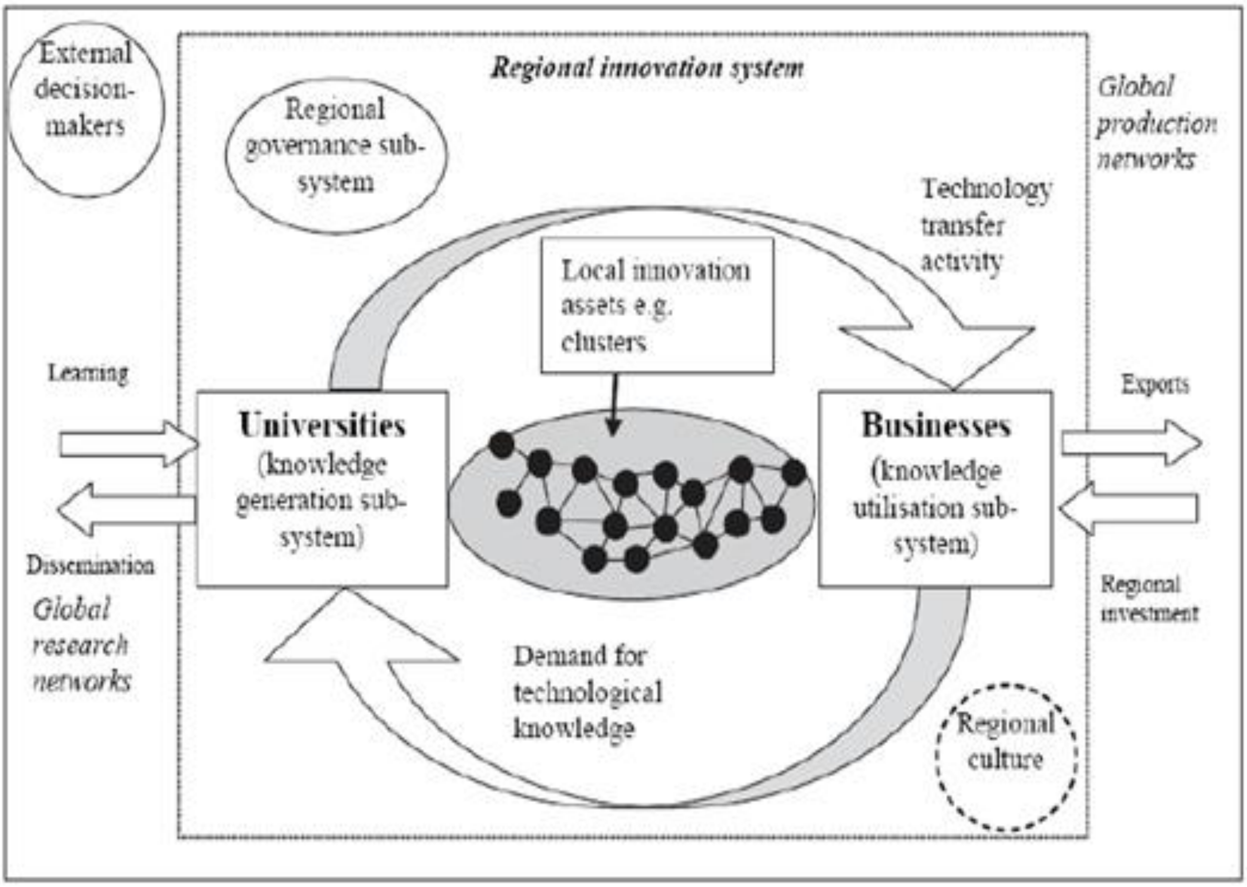
There have been several testing attempts to define and structure the research conducted under the umbrella of RSI (see for example D'Allura et al., (2012) and Asheim and Gertler (2005). According to Doloreux and Parto (2005), RSI research focuses on three main dimensions:

o firstly, the interactions between the actors of the innovation system in relation to the exchange of knowledge;

o secondly, the set-up and the role of institutions supporting knowledge exchange and innovation within a region; and

o thirdly, the role of RSI in regional innovation policy-making.

Fig 2: An ideal type of RSI (according to Cooke and Piccaluga, 2004)



The first dimension relies on the generation and exchange of knowledge within the region. Innovation is increasingly based on interactions and knowledge exchange between the different actors take place in the innovation process, such as firms (large and small), customers, research organizations (e.g. universities and research laboratories) and public agencies (e.g. technology transfer centers). Spatial proximity becomes crucial when one considers the idea that only small parts of innovation-relevant knowledge can be codified and thus shared easily over long distances, whereas the exchange of tacit knowledge (Polanyi, 1966) necessities short distances and face-to-face interactions which in turn ease learning-by-interacting (Asheim and Gertler, 2005). As such, it is so clear that the advantage of regional collaborations over national collaborations is the increased possibility for face-to-face interactions.

Within the RSI approach, interaction takes place in different forms, but most importantly in the form of organization-to-organization interaction within a network, which gives innovation its systemic dimension (Lundvall, 1992). The relationships between these networks show some degree of interdependence and – most importantly for the RSI approach – are very often regionally contained that is especially true for cases in which partners are more specialized and have a more specific knowledge base. Such specialization is associated with a high degree of tacit knowledge, and thus face-to-face interaction and trust-based relations become tremendously significant (Asheim and Gertler, 2005). It is the interactive learning in regional contexts and the dissemination of 'sticky' knowledge which make the regional concentration of actors the best environment for an economy which is knowledge- and thus innovation-driven (D'Allura, Galvagno, and Mocciaro Li Destri, 2012). Given that innovation is an interactive and dynamic process which focuses on the learning in networks (Lundvall, 2002), it is often argued that being locally embedded is especially crucial for small- and medium-sized companies (SMEs) (Audretsch and Feldman, 1996), and that communication within the networks is susceptible to a distance decay function (Howells, 1999). The strong focus on regional networks and on learning within these networks has also been criticized: Hess (2004) and Grabher (2006) warn of a danger of over-territorialization and a tendency to neglect the significance of non-local links (to other regional systems, to the national and the global systems), whilst at the same time over-stressing the benefits of proximate relationships. This causes the danger of lock-ins and a reduction in the capacity of the region to adapt to changes (Grabher, 1993).

The second dimension is dealt with the institutional set-up of a region, supporting the creation and dissemination of knowledge. Here, institution again shows to the broader definition, and hence 'institutions' include, for instance, laws, regulations, traditions and also governmental organizations. According to Uyarra and Flanagan (2013), the institutional environment in which the different actors are embedded is at the very heart of discussions on inter-firm relationships and thus of the RSI framework. The emphasis on institutions was mainly advanced in economic geography through the 'institutional turn'. Institutions are said to have great impact on firms in terms of how they interact with each other and, most importantly in terms of how networks between them become created and work.

The role of policy in the RSI approach is the **third important dimension** - one can even say that RSI is both a theoretical concept as well as a policy objective (Cooke, Uranga, and

Etxebarria, 1997). It is the policy level at which the national system puts huge influence over the regional systems (Korres, 2013).

III. NARROW VS BROAD NATIONAL SYSTEM OF INNOVATION AND THE ROLE OF STATE

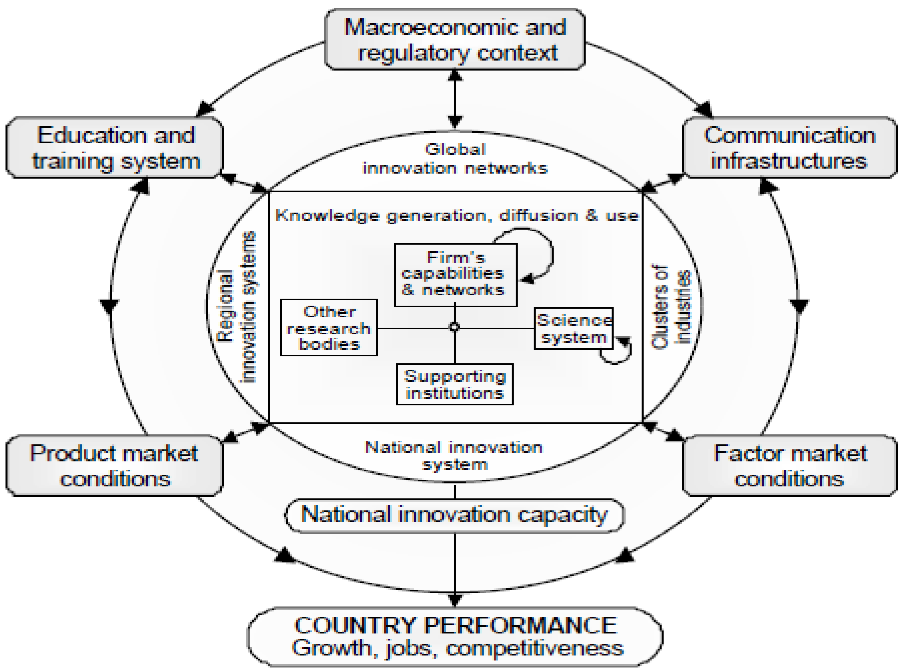
Different attempts have been made to illustrate the actors and linkages that does a system of innovation function, as well as the flows of information and resources within the system itself and between the system and its environment. An analytical distinction has been done between a "narrow" NIS concept, which includes the institutions and policies directly involved in scientific and technological innovation, and a "broad" NIS perspective, which takes extra into account the social, cultural, and political environment of the country being examined. The narrow version is an "integrated system of economic and institutional agents directly promoting the generation and use of innovation in a national economy" (Adeoti, 2002, p. 95) drawing on one or more of the strategies discussed above. While there is great differentiation between national economies and increasing complexity within the system itself, it is possible to identify the characteristics of key innovation actors. According to OECD, NIS institutions, explained in the narrow context, can be divided into five main categories:

• Governments (local, regional, national and international, with different weights by country) that play the key role in setting broad policy directions;
• Bridging institutions, such as research councils and research associations, which act as intermediaries between governments and the performers of research;
• Private enterprises and the research institutes they finance; Universities and related institutions that provide key knowledge and skills;

• Other public and private organizations that play a role in the national innovation system (public laboratories, technology transfer organizations, joint research institutes, patent offices, training organizations and so on). (OECD 1999)

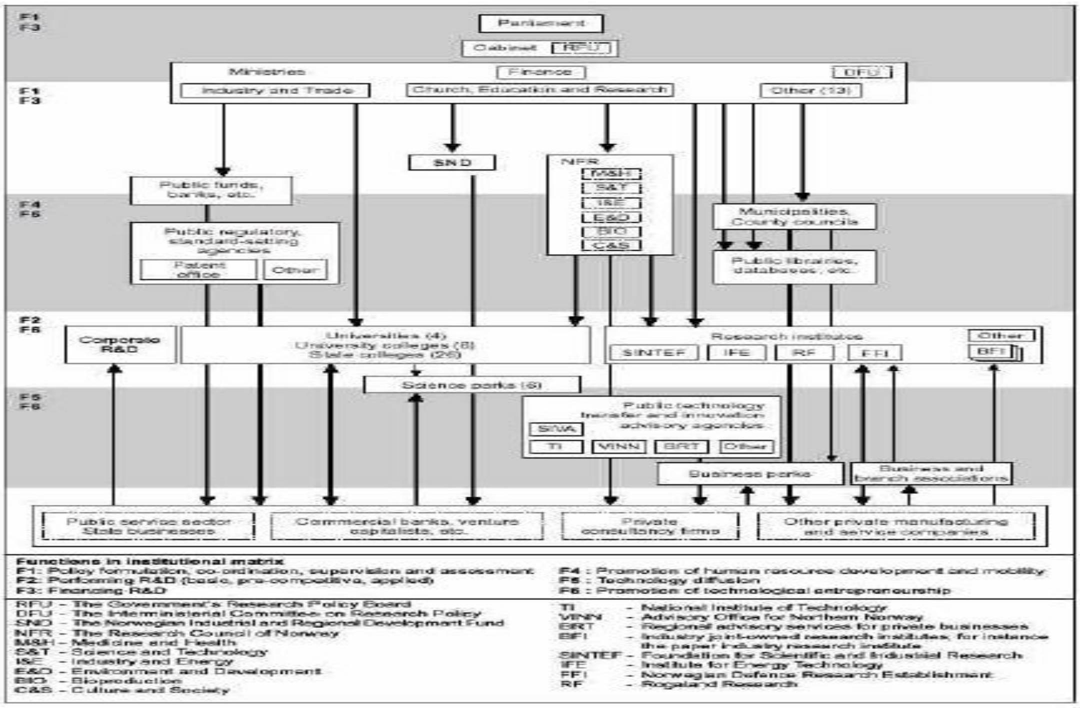
The broad definition of NIS includes, in addition to the components within the narrow NIS, all economic, political and other social institutions affecting learning, searching and exploring activities, e.g. a nation's financial system; its monetary policies; the internal organization of private firms; the pre-university educational system; labor markets; and regulatory policies and institutions. Conceptually, the narrow is attached to the broad system, as depicted in an OECD diagram in Figure 3 below. Along these lines, it has been suggested that policy-makers should change their interest from steady structures and absolute measures of innovative activities to the various types of interactions among actors within and beyond the boundaries of a national system." (Caloghirou et al., 2001, p. 14) Two specific examples of attempts to describe national innovation systems are found in the Norwegian and Australian systems below (figures 4 and 5).

Figure 3. Actors and linkages in the innovation system



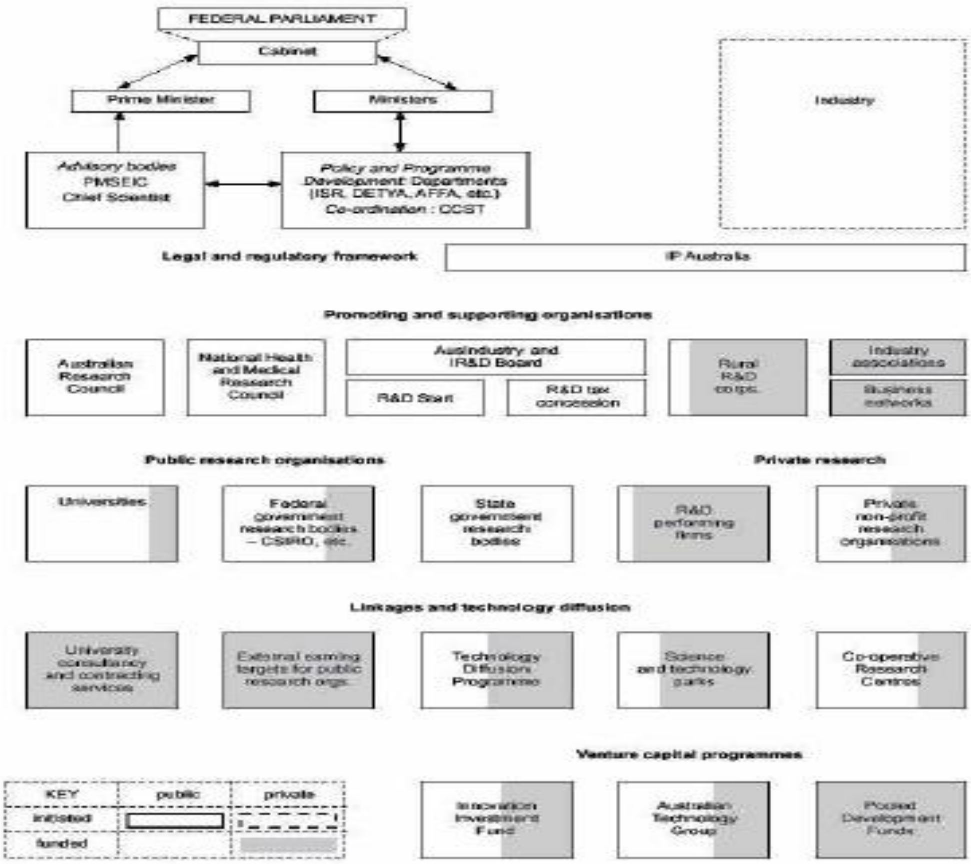
Source: OECD, Managing National Innovation Systems, 1999

Figure 4: The Norwegian System of Innovation



Source: STEP Group, 1997.

Figure 5 The Australian system of innovation – organisational structure



Source: Australian Department of Industry, Science and Resources, 1999.

The NIS linkages, which show the absorptive capacity of the system, are determined by the ways in which knowledge and resources flow between the narrow and broad levels, and amongst the institutions and organizations within both formal and informal routes. Christof Schoser has found a taxonomy (see figure 6) that aids to illuminate the significance of informal knowledge flows to the functioning of the whole system. With the distinction between formal and informal processes and links in mind, Figure 7 shows a simplified map of the NIS concept, beginning with the narrow version of NIS, designated as the National Innovation System. The broad aspect of NIS is known as the National Innovation Environment, while a third level, the Global Innovation Environment, shows the international arena in which national systems of innovation function.

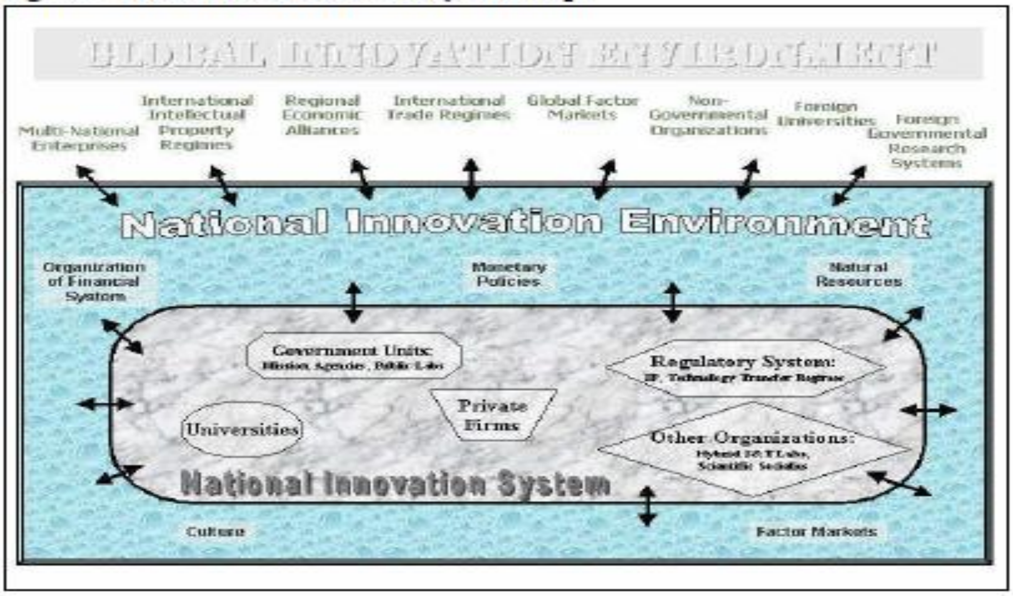
Figure 6 – NIS Taxonomy

DISTANCE FROM INNOVATION PROCESS

LEVEL OF FORMALITY	Narrow NIS	Broad NIS
Formal	(1) innovation network in a narrow sense - companies, patents - university and non-university research institutes, publications - technology transfer agencies, - technology policy and programs	(2) formal institutions in the back-ground of the innovation process educational and financial system, labor market, unions, legislation, taxes, policies like environmental and competition policy
Informal	(3) informal cognitive and behavioral patterns in the innovation process - quality of relationship between customers and suppliers, interactive learning - degree of competitive or cooperative behavior among companies, - companies' willingness to co-operate with scientific institutions, - closeness of relationship between companies and technology policy	(4) cultural and historical factors - values and attitudes (risk aversion, innovative spirit, mutual trust, time preference, attitude towards technology, consensus orientation) - historical development e.g. of the educational and financial system

Source: Adapted from Christof Schoser, 1999, p.5

Figure 7 – The National Innovation System Map

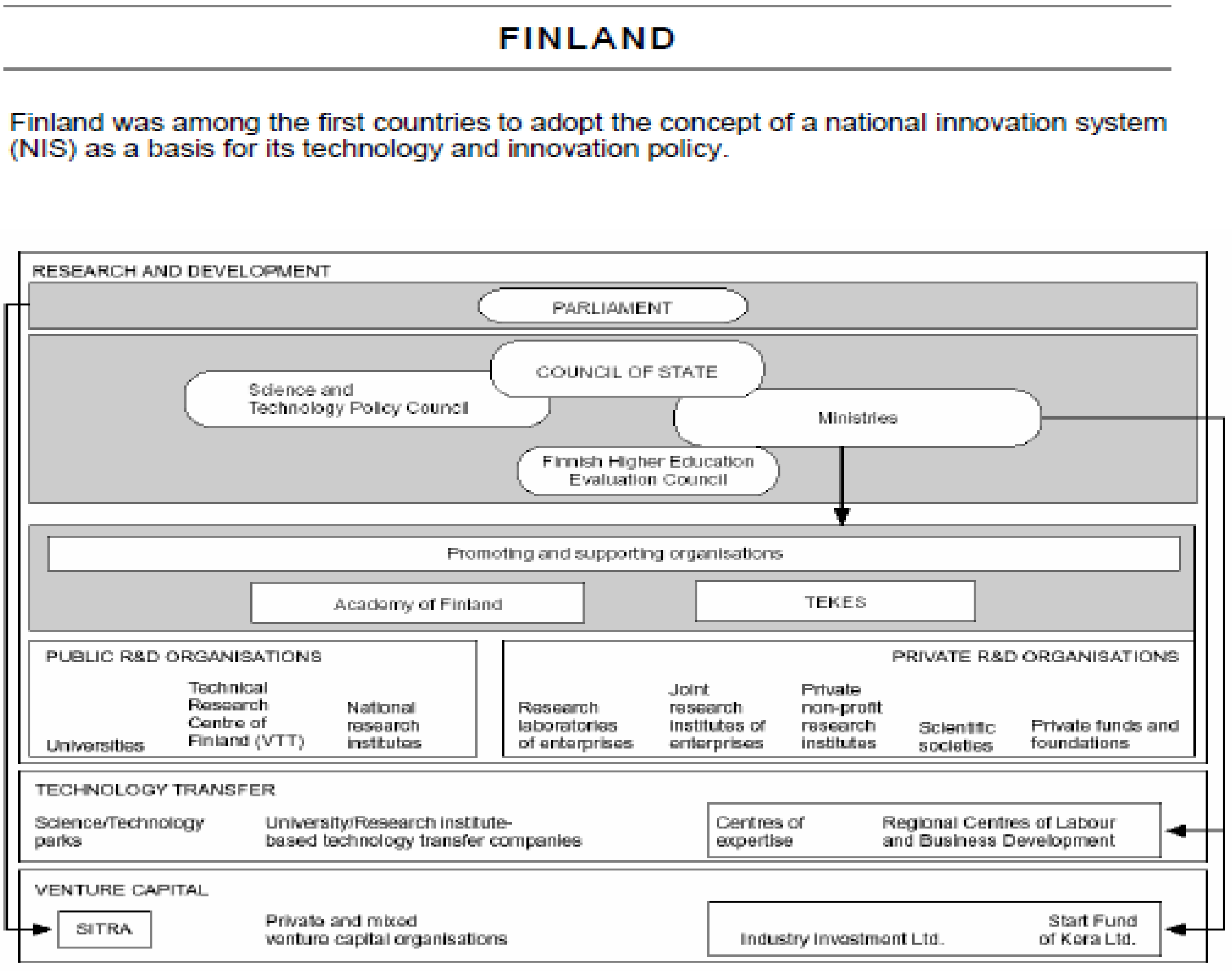


This level (Global Innovation Environment) includes intellectual property regimes, trade and labor systems, regional economic alliances, multi-national firms, and foreign sources of scientific and technological research such as NGO's, universities, and other governments' S&T systems. For many, if not most developing countries, catching up technologically relies on the extent to which they are able to position their national innovation systems and environments to best take advantage of knowledge flows originating at the global level. As one researcher notes, "many of the developing countries will have to move from natural resource extraction economies to knowledge-based ventures that add value to these resources. All these changes require a shift in public policy at the national and global level. Domestic innovation will not be possible without access to international markets; access to international markets will not be possible without domestic technological innovation. Local factors and global dynamics are thus intertwined in new ways requiring fresh approaches to domestic and international policy" (Juma et al., 2001, p. 638) This perspective heavily implies that attention to single issues or sources of knowledge flows, such as patents or adoption of a mix of technology transfer strategies that is passive rather than active in nature, will not produce required improvements in economic development.

In addition, as a final point it can be added that state comes indirectly, into an NSI only as an "institution" whose task is to supply the key elements for creating and remaining a wanted environment for firms' innovative activities. The State must only supply and adjust the "proper" physical and social infrastructures, in order to support firms' ability to innovate. Thus, government policy toward innovation is relegated to a regulative task, leaving private capitalist firms to deal with innovations themselves. The State must create and continue competitive market structures in order to let firms compete among themselves, so that the most innovative will survive.

IV. NSI and RSI COUNTRY CASES

Figure 8: Finland's National Innovation System



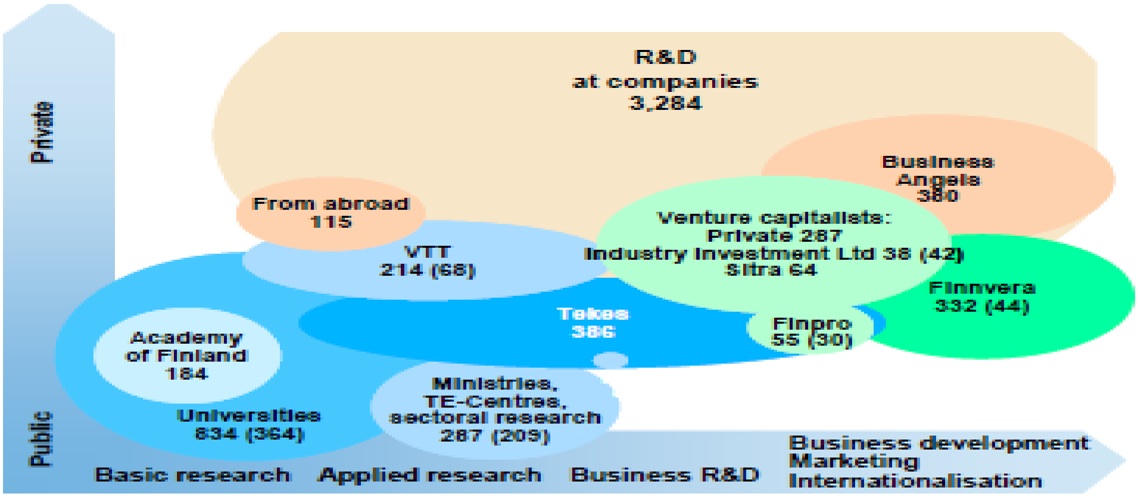
Key organizations in the Finnish system include (see Figure 8):

• Academy of Finland;

• National Technology Agency of Finland (TEKES);
• public research and development organizations;
• technology transfer agencies; and
• capital providers.

TEKES is the central organization for applying technology policy and is part of the Ministry of Trade and Industry in Finland. It supports companies take place in risk-bearing product development projects with grants and loans, and finances the projects of research institutes and universities in applied technical research. TEKES starts, co-ordinates and funds technology programs to be implemented together with companies, research institutes, and universities. Also, TEKES has expertise abroad including coordinating international cooperation in research and technology. The public research and development organizations include universities and polytechnics, national research institutes and the Technical Research Centre of Finland (VTT). The combined expenditure of these organizations is about 30% of the total national expenditure on research and development. The private sector's expenditure on research and development is approximately 2% of gross domestic product (GDP) and is growing. There are very strong linkages between the research and development efforts of business and universities and other public sector research and development groups. The Finnish NIS has always had a strong focus on regional development via technology transfer and there is a wide various range of capital providers for innovation, both private and public.

Figure 9: The Finnish Innovation System: Sources and Funding



One important specialty of the Finnish NIS is the operation and role of Finland's Science and Technology Policy Council (STPC). Chaired by the Prime Minister, the STPC has various significant facilitating roles in innovation policy making:

• it acts as a coordinating body between the Ministries on research and development issues;

• it provides a platform for policy discussion among Ministers, industry, funding organizations, unions, universities and government officials; and

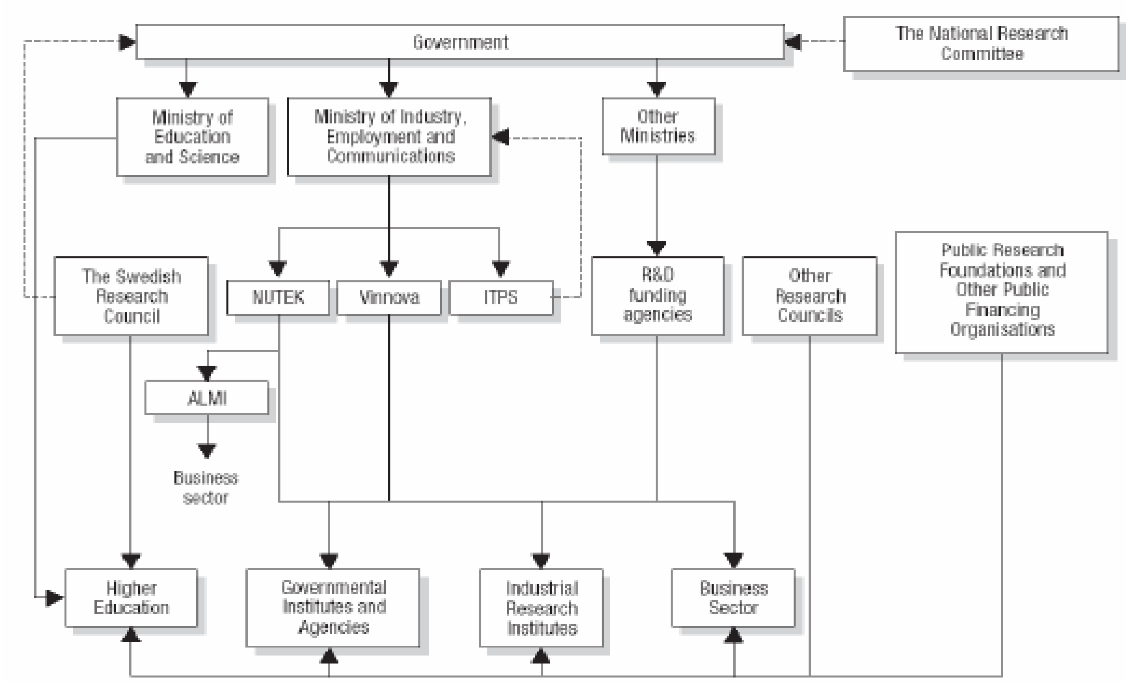
• it defines the overall guidelines for government research and development funding. (Roos, Fernström and Gupta, 2005)

Figure 10: Sweden's National Innovation System

SWEDEN

The Swedish national innovation system (NIS) is characterized by internationalized research; industrial orientation towards resource-intensive industries; rapid adoption of new techniques; high expenditures on education; and a relatively costly financial system. Large authorities aided by small ministries dominate the governmental part of this system. The authorities are independent units whose task is to carry out the plans of the government, but also to initiate relevant projects of their own, aiming at a specific goal. Most of the responsibility is allocated to the authorities rather than the ministries.

Sweden invests more in research and development than any other country in relation to its GDP. As a result, Sweden is a world leader in scientific output per head of population, measured in terms of scientific publications. In addition, Sweden plays a prominent role in registering patents. Yet despite undertaking considerable investment in research and development, Sweden's long-term economic growth rate is low.



The Swedish NIS recently underwent restructuring in order to decrease the number of agencies and clarify their mission. The former NUTEK has been divided into:

- Swedish Business Development Agency (NUTEK);
- Swedish Agency for Innovation Systems (VINNOVA); and
- Institute for Growth Studies (ITPS).

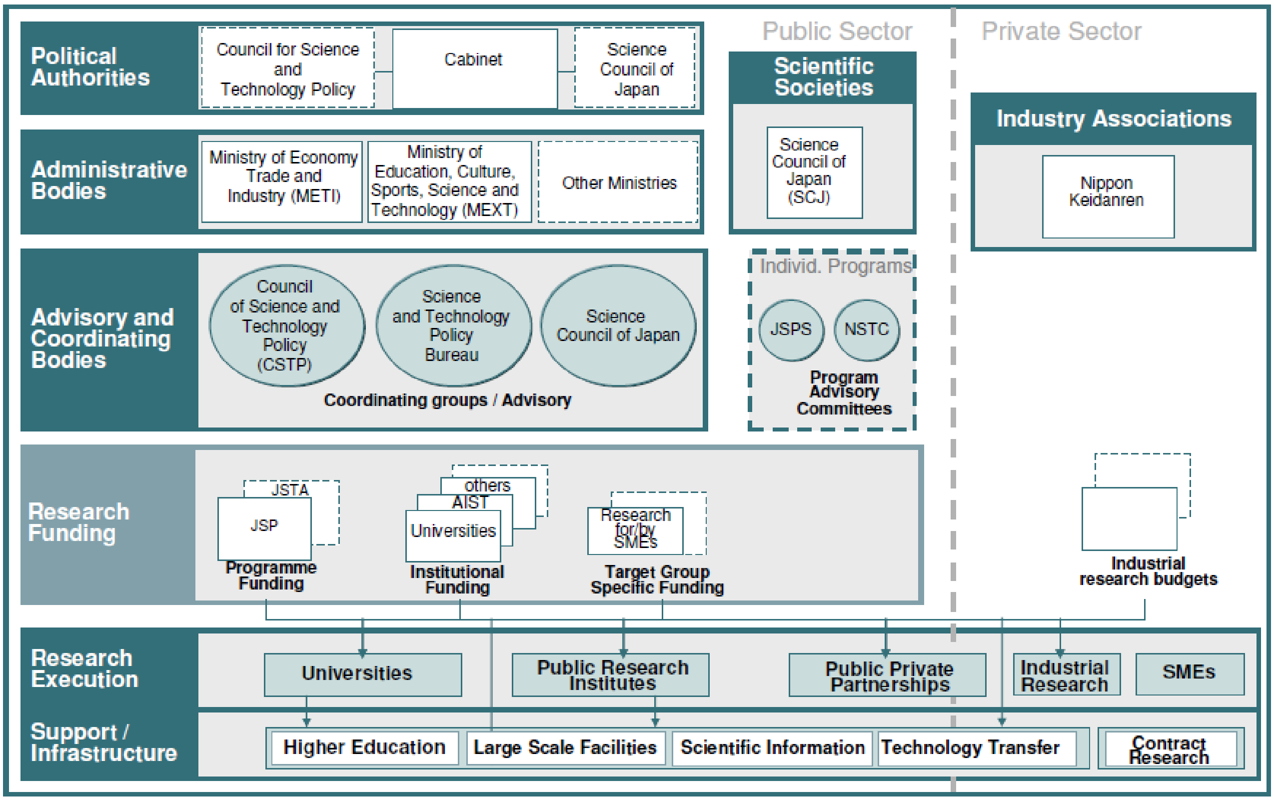
NUTEK is Sweden's main public authority for questions related to economic development. Its functions include financing for companies, regional economic development, information and advice services, as well as networking and meeting places. It aims at cluster building. Seed-financing is one of the central instruments of NUTEK. It does not finance research and development.

The Swedish Agency for Innovation Systems, VINNOVA, funds needs-based research and development to aid innovation systems and sustainable development and growth by means of problem-oriented research and the development of effective innovation systems. It is funded by the Government. Activities comprise support for research and development in technology, transport, communication, and the labor market.

The Institute for Growth Studies, ITPS, aims at increasing the competence of future oriented growth policy, by analyzing the economic and technical changes, evaluating political actions and ensuring the quality and availability of data related to growth politics. The ALMI Group aims at stimulating and motivating SMEs for ongoing growth and development, mainly by offering loans to SMEs. ALMI also offers management programs, business-development consultation and advice for the companies, from its 21 regional offices spread out over the country. The state and county councils direct the regional ALMI companies. In the very beginning of 2001, the ALMI mother company was merged with NUTEK. The challenge is now to combine effectively the culture of a corporate commercial entity with the culture of a public agency.

The Swedish Research Council, which is to support fundamental research in all scientific fields, comprises several separate councils: the liberal arts and social sciences, natural sciences and technology and medicine and also an education committee. These bodies separate funds within their own areas of responsibility. The Swedish Research Council has own responsibility for maintaining the quality of Swedish research and providing analyses of research policy and advice on research issues for the Government. Other public-sector sources of research funding include different research foundations. The Swedish Foundation for Strategic Research supports research in natural science, engineering and medicine. The Foundation for Knowledge and Competence Development (KK-Foundation) is to support information technology, research at Sweden's institutes of higher education, and bridge the gap between the academic and the business worlds. Since 1994 it has invested approximately 500 projects. (Roos, Fernström and Gupta, 2005).

Figure 11: Japan's National Innovation System



The Cabinet Office represents all ministries. It is actively working in the instigation and design of research and technology policy. The Cabinet Office has mainly a coordinating role, compiling different ministries' and agencies' research policy strategies. The Council of Science and Technology Policy (CSTP) is the main advisory body to the Cabinet Office. CSTP is responsible for research and technology policy formulation and budget allocation for applying these policies. Recently, the promotion of Private Sector research and scientific research has been assigned to CSTP as one of its main tasks.

In the Japanese government, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Ministry of Economy, Trade and Industry (METI) are the most crucial ministries with respect to research and technology policy. Other ministries have minor roles in research and technology policy; still some of them finance comparatively smaller units of highly specialized research bodies. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) is the major Japanese ministry responsible for research and development policies in Japan. The Science and Technology Policy Bureau (STPB) is a MEXT function, responsible for the planning and design of basic research and technology policies.

The Research Promotion Bureau is responsible for supporting scientific research via creation and supervision of PROs as well as making better the coordination between industry, academia and government. For this purpose, the Research Promotion Bureau regularly look for consultations with Private Sector bodies. The Research and Development Bureau is another MEXT function responsible for large-scale research projects.

The Ministry of Economy, Trade and Industry (METI) is responsible mostly for the promotion of industrial R&D activities through formulation and implementation of policies. Such policies support SME innovation activities, the promotion of regional innovation clusters and R&D tax deduction schemes. METI research and technology policy measures account for 7% of Japanese public research and technology spending. Sector specific research policies are designed by the respective ministry.

Other countries stated below:

Malaysia’s NIS are orchestrated around Vision 2020, which serves as the nation’s roadmap for economic development. The key institutions in Malaysia that are belonged to ICT are the Malaysia Science, Technology, and Innovation Ministry, the National Information Technology Council of Malaysia (NITC), the Ministry of Information, Ministry of Science Technology and the Environment, and the Malaysian Development Corporation (MDC). The National Information Technology Council of Malaysia (NITC), which was established in 1994, functions as the primary advisor to the government on ICT matters. Chaired by the prime minister of Malaysia, the council comprises representatives from the public, private and community sectors. The MDC is actually a private entity that was established by the government to act as a catalyst for the ICT industry. The MDC operates via provisions that involve fiscal incentives for setting up ICT companies. The MDC's most significant operation is the Multimedia Super Corridor (MSC), the country's most prominent science and high-tech cluster. The Multimedia Super Corridor (MSC) is a prominent initiative being taken by Malaysia to develop a world-class IT industry. The MSC is Malaysia's flagship science and high-tech research project. The MSC encompasses Kuala Lumpur and five other key infrastructural projects that are Petronas Twin Towers, Putrajaya, the new government administrative capital, Cyberjaya an 'intelligent' research and development city, Technology Park Malaysia; and Kuala Lumpur Tower. Beginning in the 1990s, the Malaysian government intensified efforts to position Malaysia as a global hub for ICT by introducing a series of development plans focused on developing ICT infrastructure and institutions. Altogether the government has planned eight flagship MSC projects aiming to attract leading companies to establish research and development facilities. Recently the government has introduced major initiatives to help develop the performance of knowledge flows throughout society and the economy. With the MSC NET LEAP program, which began in 2004 and is scheduled through 2010, the MSC initiative is being expanded to serve the national ICT need. This expansion will culminate in a series of networked cyber cities and cyber centers to be created in phases. The hub for this network is the Central Incubator at Multimedia University, which offers seminars and training in topics like courting venture capital, business plan development, accounting, and marketing. Another key initiative towards enhancing knowledge flows is the 'My Malaysia, My MSC' campaign which was recently launched in January 2005 as part of the 'MSC Net Leap' program. 'My Malaysia, My MSC' aims to spread MSC benefits and value propositions nationwide, narrowing the digital divide, and reaching both industry and general society.

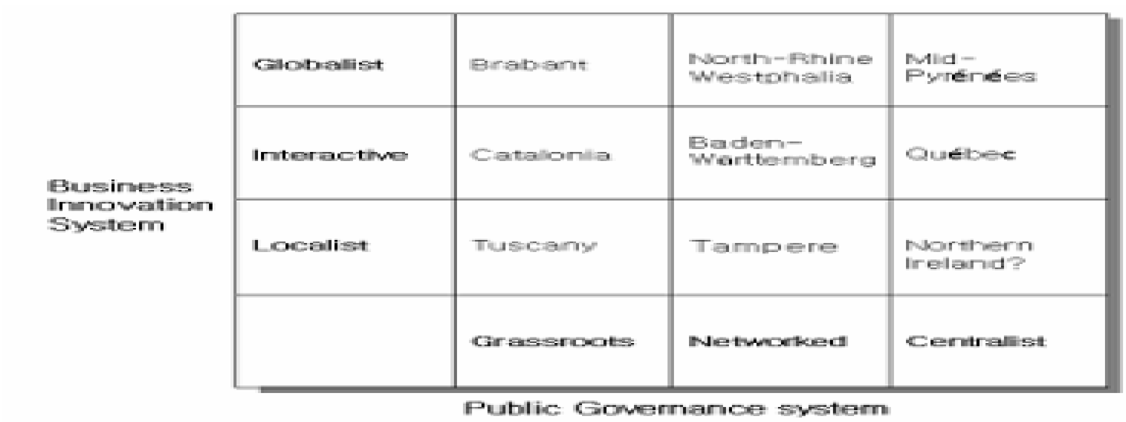
Table 2: Comparison of Selected Countries – Major Characteristics of and Major Events/Factors Shaping the National Innovation System

Brazil	China	India	South Africa	Thailand	Southern Africa
Lopsided and uneven characteristics, with distinctive national patterns of evolution. Influence of macroeconomic liberalization of the 1990s. NIS going through major changes, but continues to be lopsided and uneven. Aggravates even further the uneven and lopsidedness of economy and society.	Lopsided and uneven characteristics, with distinctive national patterns of evolution. Influence of macroeconomic reforms and opening up of economy from the mid 1980s. Resulted in two-tier NIS – higher efficiency level and lower efficiency level. Aggravates social, rural/urban and regional inequalities.	Lopsided and uneven characteristics, with distinctive national patterns of evolution. Influence of the shift from inward looking to outward looking NIS since early 1990s. Islands of excellence in selective civil and dual-use sectors. Aggravates social, rural/urban and regional inequalities.	Lopsided and uneven characteristics, with distinctive national patterns of evolution. Stratified by racial, and first economy (advanced industrial) and second underdeveloped economy. Aggravates rural/urban, social and regional inequalities.	Lopsided and uneven characteristic, with distinctive national patterns of evolution. Weak, fragmented and even stagnant, slow technological learning. Undergoing *system transition* since 2001 due to major shift in government policies and practices.	Weakly formed institutional arrangements for building national systems of innovation. Making and designing of innovation systems at South African Regional level may be the most likely route to organize capacity and innovative learning.

RIS in Europe

RIS has been generally applied in advanced countries even though it is aimed at regional growth. The European Union has implemented RIS programs for many regions in Europe. Figure 2 analyzes the characteristics of regions along two dimensions, namely business innovation system (three types) and public governance system (three types). This model can be implemented to regions outside Europe too. The identification of types may be various, but the two dimensional classification above can serve as a good reference to analyze RIS of other regions and countries.

Figure 12: Typology of RSI according to Braczyk et al. (1998)



RIS in the U.S.

In terms of the classification model of Figure 2, most regions of the U.S. may fall in the cell representing "grass roots" and "globalized" types. Two successful regions of the US are the Silicon Valley and Route 128 in Boston. However the patterns and characteristics of these two regions are quite different, as shown in Table 3. According to Saxenian (2000), Silicon Valley has a better environment than Boston in every respect. (Lim, 2006)

Table 3: Silicon Valley and Route 128

	Silicon Valley	Route 128
Structure	Internationally competition based	Internal competition
Network approach	Network-based industrial system	Autarkic corporations
Work attitude	Laid-back	Button-down
Network vs System	Regional network system	Firm based system
Recoveries from recession	Resilient	Hard
Examples	Sun Microsystems, H-P	Apollo Computer, Digital Equipment

Source: Saxenian (2000)

One question that arises immediately is why a Silicon Valley doesn't happen in every country and every region. Is it possible and plausible? In reality, almost all countries and regions have been trying to copy the Silicon Valley model. However these efforts have been unsuccessful, except in only a few cases. The closest to being like Silicon Valley may be the Shinju case. The question that arises next is what kind of alternatives can be found, if replication of Silicon Valley is not possible. Do we need a different model than Silicon Valley?

RIS in Japan

The terminology of RIS is not usually used in Japan. Instead the term cluster has been more frequently used in the past as well as in the present. Table 4 shows the structure of Japanese innovation systems.

Table 4: Mechanisms used by Japanese firms for functional integration in innovation

Mechanism	Characteristics
Organizational intelligence	Technical, commercial and financial intelligence obtained through a variety of channels. This is processed and disseminated to various departments
Technology fusion	Fusing diverse technologies to obtain new, more innovative technologies
Concurrent engineering	Overlapping the phases of development to facilitate information exchange, performance feedback and technological improvements
Horizontal information flow structures	Job rotation, teams for new product development and technology assimilation, large trading houses
Corporate networking	Quick exchange of data, information, designs, and other knowledge
Technology forecasting	An integrated, long-term vision of technologies, competencies and markets
Organizational learning	In-house, on-the-job training, new product subsidiaries, learning by doing, learning by using, learning by selling

Source: Modified from Bowonder and Miyake (1993; 148; table1)

Two more characteristics of Japanese systems are as follows. The first is the systemic thinking ease hybrid technologies and technology fusion in a systemic manner. And the second is that sources of knowledge for innovation are different. Such sources include workers' accumulated knowledge, integration of technology within the firm, and networks of other firms, especially along the value chain. However there are weaknesses in the Japanese system.

Some of these are as follows:

①The universities are weak in comparison with corporate R&D labs.

②Unsuccessful technopolis policies in the past.

③Unsuccessful decentralization of R&D function in Tokyo.

④Flexible in adapting to new knowledge over time, but inflexible in relocating production system abroad.

Japan tried various regional policies, but these have not proved that successful so far. More recently a new cluster policy has emerged (Ishikura et al. 2003). This policy is based on Porter's cluster theory. Cities and regions are to be revitalized via innovation, which will lead to revitalization of Japan as a whole. Since Japan has a long history of manufacturing industry, the new system seems to be successful so far to a certain extent.

V.DISCUSSION AND CONCLUSIONS

More interesting discussion can be about market-driven innovations of private firms vs. social-driven innovations by the state (or other public agents). To be clear, the deal here is not for the state to just create public knowledge that private firms can use. The point is that the state should first carry out innovations directly (than means creating new knowledge and implementing it to production processes in a wholly public value chain), and second, address these innovative activities toward more basic social needs, which may be better off in public hands than in free market competition, thus becoming an innovator of first resort. “First” refers here that the innovative state should do something different from what private firms do, having in mind some primary social needs.

The strategic intellectual and policy concept of regional innovation systems has been introduced, defined and put to work in analytical and action-related terms. It has been shown to be a new concept, postdating that of national systems of innovation, which has been intellectually significant, if not easy to apply empirically except in small, regional-scale countries. For some time, possibly because of this, the idea of regional innovation systems was rather neglected, if not resisted. However changes in the macro-economy in the 1990s mean that the idea of national economic sovereignty, if it ever had any real meaning, has certainly lost it with the rise of global competitiveness in a world order of liberal trade and instantaneous financial transactions flows. The new world economic order now look for privilege the regional as the correlate of global, because of the rise to prominence of globally competitive regional and local industrial clusters. These are often followed versions of regional and even national innovation systems, especially where science-based, as with ICT.

Administrations vary in the nature and degree of their autonomy. The strongest in developed country settings, such as states in the United States or Australia, for example, or the *länder* of Austria and Germany, are incorporated with rich, regionalized intermediaries like chambers of commerce, trade associations, regionalized union branches, banks, etc. They also look for active innovation policies. Elsewhere regions are weakly developed or, as in Italy, democratically controlled but with limited innovation support capacity and, in most cases, a passive stance towards it. Most small countries are weakly regionalized, and may well have a government science and technology policy, but linkage with industry may be weak or focused on traditionally leading sectors dominated by large firms. This is especially due to mission-rather than diffusion-oriented systems. A mission-oriented system is highly concentrate on innovation in a specific technology-set, such as aerospace, and a particular goal such as making a moon landing, or building supersonic commercial aircraft. A diffusion-oriented system is more geared to generic process innovation that can spread into many sectors. In implementing this analysis to four developing regions in Asia, Europe and Latin America, it was instructive to note how variable specific regional innovation systems may look, even if they may not yet warrant being designated systems but show signs of some kinds of cooperation or limited systemic interaction.

Some of the most promising lines of future research on national systems would appear to be in the study of catch-up failure and falling behind in economic growth. In cases such as Britain and Argentina, both of which slowed down and fell behind in the 20th century, many of the explanations offered point to the lack of congruence between different sub-systems of society, social institutions which have been favorable to economic growth in one period of technological development may not be so favorable when there are main changes in technology.

These kinds of points indicate that various "out of synch" phenomena had emerged towards the close of the 19th century in Britain—between technology and culture, technology and politics, technology and the economy and even between technology and science. In the mid-19th century, very few people foresaw this relative British decline. Even Friedrich List, the outstanding exponent of catch-up theory on the Continent of Europe, died believing that Germany could never overtake Britain. Much later on, in the 1960s, the "Dependency" theorists were so impressed by the advantages of the United States and Western Europe that they thought it impossible for countries in Asia, Latin America or Africa ever to catch up. The advantages of fore-runners may indeed appear overwhelming at first to late-comers. Not only do they apparently command an unassailable lead in technology, but they also enjoy many static and dynamic economies of scale and privileged prestigious positions in world markets. It is for this reason that successful catch-up is often referred to as a "miracle" (The German and Japanese "miracles" of the 1950s, 1960s and 1970s; the Korean and Taiwanese "miracles" of the 1980s and 1990s). But if any process is to be regarded as a "miracle" it should be "forging ahead" rather than catching up.

At the time (late 1990s) the United States appears to have enormous advantages compared to its principal competitors. The successful catch-up of Japan and other East Asian countries was based on their intensive active learning in hardware design, development and manufacturing. Now, however, it is increasingly software design, development, production and marketing which is the key to commercial success. Here the United States has some considerable fore-runner advantages. It has by far the strongest software industry in the world with major advantages in scale economies in business applications. This has led in turn to English language domination in software generally and especially on the Internet—a global infrastructure, dominated by US service providers and content providers. This power can be utilized to protect the interests of US firms world-wide including their intellectual property.

It is impossible to predict however how long these advantages can be retained despite the tightening of intellectual property restrictions. Very many countries have rapidly growing young software firms including Eastern Europe, as well as Eastern Asia, Latin America and countries with strong English language capability, such as India. Moreover, political and social events may predominate over more narrow technological and economic factors. Social scientists face a more complex problem than biologists because the "selection environment" confronting innovators is not simply the natural environment but also several various sub-systems of human societies—scientific, technological, economic, political and cultural. Each of these has its own unique characteristics and successful diffusion depends on the establishment of some degree of successful linkages between them.

The great variety of new possibilities in science, technology, economics, politics and culture means that despite the present-day predominance of the United States, permanent convergence based on US hegemony is a rather unlikely scenario. The natural environment confronts all living creatures but the accumulation of scientific knowledge and of technological knowledge and artifacts are uniquely human processes even though they may have originated, as with other animals, in the search for food and shelter and the communication associated with this search.

Economists often use a biological analogy to analyze the competitive behavior of firms in a capitalist economy and the survival of the supposedly "fittest" firms. This is an example of the borrowing back of an analogy which Darwinian theory originally took over from economics. But again the selection environment which faces firms in their competitive struggle is actually very varied from the natural environment confronting animals and plants and this economic environment is itself rapidly changing in ways which are unique. Finally, the political system and the cultural milieu are again uniquely human and powerfully influence the evolution of the economy, as they also reciprocally influence the evolution of science and technology. Evolutionary theories which deal only with the survival of firms (Alchian, 1951) or only with the survival of artifacts or of nations are inadequate for the study of economic growth (Freeman, 1994).

We have no alternative choice but to face the unique features of human history, even though we may quite search for patterns of recurrence and for explanations of recurrence and of non-recurrence. One of the most obvious unique features is the rate of knowledge accumulation in human societies and the varying modes of disseminating this knowledge between individuals and groups. These features are ubiquitous and supply continuous attention by historians of economic growth, searching both for regular patterns as well as for the emergence of new features.

This is the aim of everyone that emergence of new features for economic growth via dissemination of knowledge. This was also the aim of that paper and it is hoped that related parties will gain enough knowledge through reading this paper in order to avoid 21st century's biggest problem for all which is uncertainty. Further research may be done on group author basis and can include different themes like uncertainty avoidance theories, more detailed cases from related countries and empirical evidences from global companies.

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